सत्यमेव जयते

GOVERNMENT OF INDIA

AERB SAFETY STANDARD

INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICES AND SOURCE CHANGERS

ATOMIC ENERGY REGULATORY BOARD

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

INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICES AND SOURCE CHANGERS

Atomic Energy Regulatory Board
Mumbai-400 094
India

November 2007

Price

Orders for this Standard should be addressed to:

The Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400 094
India

FOREWORD

Activities concerning establishment and utilization of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act, 1962. In pursuance of the objective of ensuring safety of 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.

Ionizing radiations such as gamma rays are extensively used in non destructive examination (NDE) techniques to detect any defects in the material. For this purpose approved Industrial Gamma Radiography Exposure Device(s) (IGREDs) are extensively used. Several of these devices are presently being used in the country. 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. One of the ways to meet these responsibilities is to develop and enforce specific codes and standards dealing with radiation safety aspects of various applications of ionising radiation to cover the entire spectrum of operations, starting from design of radiation equipment, their installation and use, to their ultimate decommissioning/disposal.

In view of the fact that regulatory standards and requirements, techniques of radiation safety engineering and type of equipment changes 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) entitled “Radiological Safety for the Design and Construction of Industrial Gamma Radiography Exposure Devices and Source Changers, AERB/SS-1” issued in 1992 has been useful to the manufacturers of industrial

gamma radiography exposure devices and source changers. Although this Standard covered all relevant requirements of design principles, equipment for tests and procedures, certain further improvements in built-in safety 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-1 of 1992.

Consistent with the accepted practice, "shall" and " should" are used in the standard to distinguish between a firm requirement and desirable option respectively. Appendices are an integral part of the document, whereas bibliography is included to provide further information on the subject that might be helpful to the user. Approaches for implementation different to those set out in the guide may be acceptable, if they provide comparable assurance against undue risk to the health and safety of the occupational workers and the general public, and protection of the environment.

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 belongs to Department of Atomic Energy.

Specialists in the field drawn from the Atomic Energy Regulatory Board, the Bhabha Atomic Research Centre, the Board of Radiation and Isotope Technology and other consultants have prepared this guide. It has been reviewed by experts and the Standing Committee on AERB's 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

The terms used in this Standard have the following meaning. Terms used in this Standard and not defined in this section convey the technical meaning as intended in the context.

A_1 (Transport of Radioactive Materials)

Maximum activity of special form radioactive material, permitted in a Type A package;

A_2 (Transport of Radioactive Materials)

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

Accessible Surface

Any surface of the source housing that can readily be reached by any part of the human body without the use of tools or without removal of any part of the housing;

Ambient Equivalent Dose Rate

Dose rate measured as an average over sensitive volume of the detector.

- Measurements of the ambient equivalent dose rate shall be made at 1 m from the surface, additionally at the surface and at 5 cm from the surface of the source housing. The ambient equivalent dose limits are given in Safety Standard, AERB/SS-1.
- Measure the ambient equivalent dose rate at surface of the source housing, using, a x-ray film or other appropriate device with cross sectional area not greater than 10 cm^2. Measure the ambient equivalent dose rate at 5 cm from the surface using a detector with a cross sectional area not greater than 10 cm^2 and no linear dimensions greater than 5 cm. Measure the ambient equivalent dose rate at 1 m from the surface using a detector with a cross sectional area not greater than 100 cm^2 and no linear dimension greater than 20 cm;

Applicant

Any person who applies to the competent authority for consent to undertake any of the actions for which the consent is required;

Approval

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

Automatic Securing Mechanism

Device designed to automatically restrict the source assembly to the secured position;

Beam Limiting Device

Shielded device located at the working position designed to reduce the radiation dose rate in directions other than the directions intended for use;

Capacity (Source Housing)

The maximum activity in becquerels specified for a given radionuclide that shall not exceed in a source housing or a source changer;

Collimator or Field Limiting Diaphram

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

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;

Control

A mechanism attached to an exposure device, which, upon actuation, causes the source to be exposed or retracted. Controls may be operated manually or by other means;

Control Cable

Cable or other mechanical means used to project and retract the source assembly out from and into the exposure device by means of remote control;

Control Cable Sheath

Rigid or flexible tube for guiding the control cable from the remote control to the exposure device and for providing physical protection to the control cable;

Exposure Head

Device, which locates the sealed source included in the source assembly, in the selected working position, and prevents the source assembly from projecting out of the guide tube;

Guide Tube or Projection Sheath

Flexible or rigid tube for guiding the source assembly from the exposure device to the working position and having necessary connections for attachment to the source housing and to the exposure head, or including the exposure head itself;

Industrial Gamma Radiography Exposure Device (IGRED)

An assembly of components necessary to make radiographic exposures and which includes the source housing, mechanism for securing the source assembly, exposure mechanism, that includes source drive associated system, positioning devices and guide tubes;

Leakage Radiation

Any radiation coming out of the source/tube housing, except the useful beam or primary beam;

Package

The packaging with its radioactive contents as prescribed for transport;

Packaging

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

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;

Reserve Sheath

Sheath containing the length of the control cable, necessary for driving the source assembly;

Scattered Radiation

Radiation that, during the passage though the matter, gets deviated in direction (it may have been modified by a decrease in energy);

Sealed Source

Radiography 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 conditions of use and wear for which the source was designed, as also under foreseeable mishaps;

Secured Position

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

Simulated Source

Facsimile of a radioactive sealed source, the encapsulation of which has the same construction and is made with exactly the same material of a sealed source that it

represents, but containing in place of the radioactive material, a substance with mechanical, physical and chemical properties, as close as possible to those of the radioactive material and containing radioactive material of tracer quantity only.

Source Assembly

An assembly of components consisting of gamma radiography source and a mechanism for connection with the drive system;

Source Changer

A device for transferring of radiography source from or to the exposure device and suitable for transport and storage of the source;

Source Holder

A device used to support and retain the source in position;

Source Housing

Shielding provided in any device containing a sealed source, in order to

- define the useful beam; and
- limit the radiation level outside the useful beam to maximum permissible leakage levels, as specified by the competent authority;

Special Form Radioactive Material

It is either indispersible solid radioactive material or a sealed capsule containing radioactive material, conforming to the requirements specified and approved by the competent authority for special form radioactive material;

Stray Radiation

The sum of leakage and scattered radiation;

Type A Package

A package designed to withstand normal and accidental conditions of transport without loss or dispersal of its contents or loss of shielding integrity. The radioactive material may be transported in a Type A Package, either in special form radioactive material or other form, with the provision that the activity shall not exceed the applicable limits prescribed in the relevant Code on “Transport of Radioactive Materials”;

Type B(U) Package

A package designed to contain an activity in excess of A_1, if special form radioactive material, or in excess of A_2, if not special form radioactive material, that is designed to withstand normal and accidental conditions of transport specified in the relevant Code on “Transport of Radioactive Materials”;

Type Approval

Approval, issued by the Competent Authority, based on evaluation of the device to ensure that it conforms to safety standards;

Uranium - Natural, Depleted, Enriched

Natural uranium: Chemically separated uranium containing the naturally occurring distribution of uranium isotopes (99.28% of uranium-238 and 0.72% of uranium-235 by mass).

Depleted uranium: Uranium containing lesser mass percentage of uranium-235 than in natural uranium.

Enriched uranium: Uranium containing greater mass percentage of uranium-235 than 0.72%. In all cases, a very small percentage of uranium-234 is present;

Useful Beam or Primary Beam

Part of the emergent radiation from a source housing, which is capable of being used for the purpose for which the equipment in intended.

CONTENTS

1. INTRODUCTION

1.1 General

The multiferous applications of ionising radiation sources (i.e. radioactive materials and radiation generating equipment) have registered the phenomenal growth all over the world. The industrial radiography, inter alia, is an indispensable, versatile and well-established non destructive testing (NDT) technique for quality assurance has been in use in all types of industries. Varieties of industrial gamma radiography exposure devices (IGREDs) are being deployed for carrying out radiography work. These devices shall incorporate built-in-design safety features, interlocks and effective locking mechanism to ensure that the operation, servicing and maintenance meet acceptable standard of safety. This standard classifies the IGREDs based on the location of source assembly when the device is in working position and according to mobility of radiography devices. The specifications for design, construction of IGRED, source changer and test requirements are outlined in this standard. The establishment of quality assurance programme (QAP) and the set of documents required for obtaining type approval of AERB have been addressed in the standard.

1.2 Objective

This standard specifies the main design and performance requirements including quality assurance aspects for the design and manufacturing of various types of exposure devices, source changer and tests on prototype for demonstration of compliance with requirements contained in this standard for the purpose of obtaining type approval from the competent authority. The objective of this standard is to provide all the requirements and documentation necessary for demonstrating the compliance with this standard. The demonstration is mandatory to the designer/manufacturer/supplier of exposure device/source changer/sealed radiography source for obtaining AERB type approval. Compliance with this standard ensures acceptable level of safety of persons associated with the use and operation of such devices under normal and accident conditions

1.3 Scope

This standard specifies the radiological safety requirements for the design, construction and operation of a portable, mobile and fixed industrial gamma radiography exposure device using a sealed source. This standard specifies the design criteria for the exposure device and tests on prototype (prototype means the unit designed and manufactured to demonstrate compliance with this standard for the purpose of approval by the competent authority). All units manufactured subsequently shall conform to the prototype in all respects for demonstration of compliance.

Specifications for source changer used with the industrial gamma radiography exposure device are also included in this standard. It also specifies the design criteria for the source changers and tests on prototype for demonstration of compliance.

For transport of exposure device containing the sealed source, the requirement of AERB safety code on Transport of Radioactive Materials, AERB/SC/TR-1 in respect of transport packaging and sealed source as special form radioactive material, as applicable, shall be complied with. The same requirements are also applicable for the transport of source changer containing sealed sources.

For manufacture and use of gamma radiography sealed sources in the exposure device as well as in the source changer, the requirement of AERB Standard Specifications on Testing and Classification of Sealed Radioactive Sources, AERB/SS/3 (Rev. 1), 2001 shall be complied with.

This standard is based on International Standard ISO-3999-1 (2000) E on Radiation Protection - Apparatus for Industrial Gamma Radiography - Part-1: Specifications for Performance, Design and Tests.

This standard covers specifications for land based exposure devices.

2. CLASSIFICATION OF EXPOSURE DEVICES

For the purpose of this standard, two types of exposure devices are considered depending on the source assembly, operational features and exposure mechanisms. These exposure devices are further categorised according to their mobility.

2.1 Classification of Exposure Devices

Exposure devices are classified according to the location of the source assembly when the device is in the working position (working position means the condition of the source assembly in the industrial gamma radiography exposure device at the position intended for performance of industrial gamma radiography).

2.1.1 Category-I

The exposure device which does not allow the source assembly to be moved out of the source housing, but causes exposure by opening a shutter and/or by moving the source assembly within the device (Figure 1)

2.1.2 Category-II

The exposure device in which the source assembly is driven out of its secured position in the source housing to an essentially unshielded position at its working position for radiography exposure, either mechanically, electrically, pneumatically or by other means by an operator at a distance away from the source housing. This type of exposure device using a remote control (remote control means a device enabling the source assembly to be moved to and from the exposure device to the working position by operation from a distance away from the exposure device) mechanism shall also require source guide tube (Figures 2 and 3).

2.1.3 Category-X

Exposure devices for gamma radiography designed for special applications where the unique nature of the application precludes full compliance with this standard. These are self-propelled intra-tubular gamma radiography exposure devices such as pipeline crawler and gamma radiography exposure devices for under-water use.

2.2 Classification of Exposure Devices According to their Mobility

2.2.1 Class P

Portable source housing designed to be carried by one person only. The gross weight of a portable exposure device shall not exceed 30 kg.

2.2.2 Class M

Mobile, but not portable, source housing designed to be moved easily by suitable means, such as caster wheels or a trolley provided for the purpose, but does not qualify for portable category.

2.2.3 Class F

The exposure device designed for installation in a fixed location or with mobility restricted to the confines of a particular working area.

3. MARKING, LABELLING AND IDENTIFICATION

3.1 Source Housing or Source Changer

Each source housing and source changer shall have a metallic plate fixed on it permanently, conspicuously and indelibly marked with the following:

(a) The basic ionising radiation symbol as prescribed under the Atomic Energy (Radiation Protection) Rules, 2004.

(b) The warning legend 'RADIOACTIVE' in letters not less than 10 mm in height;

(c) The maximum capacity of the source housing or source changer for the intended radionuclide(s) in becquerels (curies);

(d) The clause of this standard and year of edition, to signify the compliance with this standard. This standard marking indicates the manufacturer's claim that the exposure device or source changer conforms to this clause of this standard. This claim shall be stated in the manufacturer's manual.

(e) The manufacturer's name, model and serial number of the exposure device or source changer;

(f) The class of the exposure device;

(g) The gross weight of the source housing without the removable accessories or source changer, and the gross weight of the depleted uranium, if applicable;

(h) The type approval certificate number issued by the competent authority conforming to this standard; and

(i) The package design approval identification mark issued by the competent authority of the country of origin, if applicable.

3.2 Source Holder or Source Assembly

Each source holder or source assembly shall be marked with serial number. It shall also contain the word "RM" (indicating that it is RADIOACTIVE MATERIAL), or the ionising radiation symbol and serial number, where applicable, the manufacturer's identification mark, the type designation of the source holder/source assembly.

The symbol and inscription shall withstand fire, water and a 10^8 Gy dose of gamma radiation.

Each word or symbol should be fully visible to an operator/observer located at a distance of 50 cm from the source holder/source assembly marking.

3.3 Identification of the Sealed Source in the Source Housing

The source housing shall be designed with a provision for attachment of a label, bearing the following information for the sealed source used in the exposure device.

(a) Chemical symbol and mass number of the radionuclide;

(b) Activity and date on which activity was measured, in becquerels (curies);

(c) Identification number of the sealed source;

(d) Identity of the sealed source manufacturer; and

(e) Source classification designation.

Consideration shall be given to the durability of the label and its fixing, including thermal and corrosion resistance.

4. SPECIFICATIONS FOR DESIGN AND CONSTRUCTION OF EXPOSURE DEVICES AND SOURCE CHANGERS

Exposure device or a source changer shall be designed with due consideration for the conditions which may be encountered in use, storage and transport, and which may adversely affect safety in handling and operation.

Specifications

4.1 General Design Requirements

(a) Industrial gamma radiography exposure device or a source changer shall be designed for the conditions likely to be encountered in use.

(b) The design of class P and M exposure device shall ensure that the exposure device withstands the effects of corrosion under intended conditions of use.

(c) The design of class P and M exposure device shall ensure continued operation under environmental conditions of moisture, mud, sand and other foreign materials.

(d) The design of the exposure device or source changer shall ensure satisfactory operation over the temperature range –10ºC to 45ºC.

(e) The operating voltage and insulation resistance of electric circuits of power-operated industrial gamma radiography exposure device shall comply with the relevant national/international standards.

(f) The design of the exposure device shall ensure that any non-metallic components (such as rubber, plastics, jointing and sealing compounds, lubricants) will not suffer any damage from radiation that will diminish the safety of the exposure device during its design life as specified by the manufacturer.

(g) Positioning the sealed source outside or inside the source housing at the secured position shall be possible without interposing parts of the human body in the radiation beam.

(h) Connecting and disconnecting the guide tube and/or the remote control from the source housing or source changer shall be possible without interposing parts of the human body into areas where the ambient equivalent dose rate exceeds 2 mSv/h (200 mrem/h).

(i) The design of any replacement component, including the source assembly, shall ensure that its interchange with the original component does not compromise the design safety features of the exposure device.

(j) For class P and M source housings, the design of the exposure device shall provide appropriate means for secure mounting of the remote

control and guide tube (if applicable) to the source housing in different positions of use.

(k) The source housing shall be designed in such a way as to discourage dismantling by unauthorised personnel. Those components which cause source assembly to be retained in the secured or locked position (locked position means the condition of the source housing ensuring the source assembly in the secured and locked position) shall be so designed that they can be dismantled only by using a special tool or removing a seal or removing a label that gives a warning of the significance of the dismantling. The exposure device shall be so designed that it is impossible for the source assembly to be extracted from the back of the source housing whilst operating the exposure device, or connecting or dismantling the remote control.

(l) All materials providing radiological protection shall maintain their shielding properties at a temperature of 800º C. When using materials with melting temperatures below 800º C, the designer shall take into account the need to completely contain the shielding materials at this temperature. When using materials with melting temperature above 800ºC, the designer shall take into account the possible eutectic alloying of the shielding materials with the surrounding materials at temperature below 800º C.

(m) Wherever depleted uranium is used for shielding, it shall be clad or encased with non-radioactive material of sufficient thickness to absorb the emitted beta radiation and to limit corrosion and prevent contamination. The source tunnel through depleted uranium shall also be clad or encased with non-radioactive material to limit abrasion, corrosion and consequential deformation. Limitation of abrasion shall be demonstrated by satisfactory performance of a test consisting of the examination of the dummy source assembly, to demonstrate that there is no abrasion of the source tunnel which could lead to contamination by depleted uranium; and

(n) The source housing of the exposure device shall be designed in such a way as to maintain its shielding properties specified in Table 1 under the conditions of tests specified in subsection 4.8, except the accidental drop test (subsection 4.8.4.6).

4.2 Sealed Sources for Industrial Gamma Radiography Exposure Device

Sealed sources incorporated in the industrial gamma radiography exposure device shall comply with requirements of AERB Standard Specification on Testing and Classification of Radioactive Sources, AERB/SS/3 (Rev.-1), 2001.

4.3 Ambient Equivalent Dose Rate Limits in the Vicinity of Source Housing

Source housing of the exposure device shall be made in such a way that when it is in the locked position with the protective cap installed, if applicable, and loaded with a sealed source corresponding to the maximum capacity of the radionuclide, the ambient equivalent dose rate, when checked according to the shielding adequacy test prescribed in subsection 5.4.1, shall not exceed the limits specified in Table 1 for appropriate class of source housing.

TABLE 1 : AMBIENT EQUIVALENT DOSE RATE LIMITS

1	2	3	4
Class	Maximum ambient equivalent dose rate mSv/h (mrem/h)		
	On external surface of source housing	At 5 cm from external surface of source housing	At 100 cm from external surface of source housing
P	2 (200)	0.5 (50)	0.02 (2)
M	2 (200)	1 (100)	0.05 (5)
F	2 (200)	1 (100)	0.1 (10)
Source changer	2 (200)	-	0.1 (10)

4.4 Safety Devices

4.4.1 Securing Devices

4.4.1.1 Locks

All the source housing shall be equipped with a key-operated integral lock (lock means a mechanical device with a key used to lock or unlock the exposure device) to ensure that the change of state of the source housing from the locked position can only be achieved by a manual unlocking operation using the key.

The lock shall be either lockable without the key, or of a type from which the key can only be withdrawn when the source housing is in locked position. The lock shall retain the source housing and the source assembly in the secured position and shall not, if the lock is damaged, prevent the source assembly when it is in the working position from being returned to the secured position. The lock shall comply with lock breaking tests described in subsection 4.8.4.2 and 5.4.2.

4.4.1.2 Operation of the Automatic Securing Mechanism

The source housing shall be designed so that it is only possible to release the

automatic securing mechanism by means of a deliberate operation on the source housing, which may be remotely activated.

When the source assembly is returned to the location of the secured position in the source housing and it shall automatically get secured in the device. It shall not be possible to lock the source housing unless the source assembly is in the secured position.

For category-II source housing, it shall not be possible to release the source assembly from the secured position unless a secure attachment is made between the control cable and the source assembly, between the control cable sheath and the source housing, and between the guide tube and the source housing, as applicable.

For a source housing or source changer using a remote control, it shall not be possible to completely detach the remote control unless the source assembly is in the secured position.

4.4.2 Indication of Secured Position

The exposure device shall be designed such that it is possible for the operator to determine if the source holder is in the secured position from a distance of at least 5 m. If these indications are on the source housing, they shall be clearly recognizable at a distance of 5 m in the direction of the attachment of the remote control in normal conditions of use. If colours are used, green shall indicate that the source holder is in the secured position and red shall indicate that the source holder is not in the secured position. Colours shall not be the sole means of identification. All indications shall be clear and reliable. There shall be a provision for sealed source position indicators on the source housing.

4.4.3 System Failure of the Remote Control in Normal Conditions of Use

The remote control system, which is not manually operated shall either:

(a) be designed so that a failure of this system causes the source housing and source assembly to revert to the secured position; or

(b) be accompanied by an emergency device (preferably manual) and/or a procedure, permitting the return of the source assembly to the secured position.

4.5 Handling Facilities

4.5.1 Class P source housings shall be provided with carrying handle.

4.5.2 Class M source housings shall be provided with lifting mounts by which they can be easily hoisted.

If trolley is used for moving class M source housing, its conditions for safe use shall be specified and operating instructions shall be supplied.

Where a trolley is used, it shall be tested with any immobilising device engaged to ensure that it is not capable of moving alone down a smooth steel plate with a slope of 0.1, and it shall not be capable of tipping on the same surface.

4.6 Source Assembly Security

4.6.1 Source holder shall be designed in such a way that it cannot release the sealed source in normal conditions of use, and shall provide it with positive retention. For a reusable source holder, the sealed source shall be fitted in the source holder by at least two mechanical actions having different and combined effects such as screw and clip, or screw and pin.

4.6.2 It shall be possible to connect or disconnect the source assembly from the end of the control cable without the use of any tool, with the exception of a source assembly, which is inseparably attached to the control cable.

4.6.3 The source housing shall be designed in such a way that the sealed source or source assembly will not be released inadvertently.

The sealed source or the source assembly in a category-I source housing shall only be removed during routine replacement by at least two actions having different and combined mechanical effects such as screw and clip or screw and pin.

If the unloading of the source assembly of a category-II source housing does not involve driving out in a specially fitted source changer, the above requirements for category-I source housing shall apply.

4.7 Remote Control Security

4.7.1 The remote control shall have a stop on the control cable to prevent loss of control and disengagement of cable from the remote control.

4.7.2 Control mechanism of the remote control shall be clearly marked to indicate the directions of control movement to expose and retract the source assembly.

4.7.3 The remote control shall comply with International Electrotechnical Commissions (IEC) standards for electromagnetic compatibility, where applicable.

4.8 Resistance to Normal Conditions of Service

4.8.1 General

The design of the exposure device shall ensure continued operation under normal conditions of use. This shall be demonstrated by satisfactory performance of the tests indicated in this clause.

These tests shall be carried out on prototypes that shall comply with the

design requirements stated in paras 4.1 to 4.7. Two entire exposure devices (A) and (B) are required (subsection 5.1)

If the tests required for type B(U) packages on the source housing have been passed, the test described in 4.8.4.6 (accidental drop test) is not necessary. The other tests can be carried out with one exposure device only.

4.8.2 Endurance Test

This test shall be carried out on the entire exposure device (B), equipped with a dummy source assembly. After having undergone the endurance test described in subsection 5.2, the exposure device shall remain operable without any visible sign of fatigue. In particular, it shall be ensured that:

(a) the automatic securing mechanism remains operational, and

(b) the lock operation remains effective and in accordance with the requirements of subsection 4.4.1.1.

4.8.3 Projection Resistance Test for Category-II Exposure Devices

This test is carried out before and after the following tests:

(a) on source housing (B) having undergone the shielding adequacy, vibration and shock tests;

(b) on dummy source assembly (B) having undergone the vibration and tensile tests;

(c) on remote control devices (B) having undergone the crushing and bending, kinking and tensile tests; and

(d) on guide tubes (B) having undergone the crushing and bending, kinking and tensile tests.

The maximum force which shall be applied to the control lever to move the source assembly from the secured position to the working position and return it to the secured position shall not be greater than 125% of the maximum force which is necessary to be applied to move the source assembly in the same configuration before starting any of these tests.

4.8.4 Tests for Source Housings

4.8.4.1 Introduction

The tests referred to in subsection 4.8.4.2 to 4.8.4.5 shall be carried out in the order shown on the same individual class P and class M source housing (B) which has already undergone the endurance test described in subsection 5.2 (subsection 4.8.2).

The test referred to in subsection 4.8.4.6 shall be carried out on the second

class P and class M source housing (A) which has already undergone the shielding adequacy test described in subsection 5.4.1 (subsection 4.3).

A source housing shall remain operable (the source assembly shall be brought into the working position and back to the secured position) and still comply with the corresponding requirements of this subsection and subsections 4.3 to 4.6 after having undergone each of the following tests, except the accidental drop test.

4.8.4.2 Lock Integrity Test

The lock shall remain operational and effective after having undergone the lock breaking test (subsection 5.4.2), the vibration-resistance test (subsection 5.4.5) and the horizontal shock resistance test (subsection 5.4.6.1).

4.8.4.3 Handle, Attachment Part or Lifting Mount

Each handle, attachment part or lifting mount (subsection 5.4.3) which could be used for securing a class P source housing or each lifting mount of class M source housing shall be designed to withstand a force equivalent to 25 times the gross weight of the source housing. The handle or lifting mount shall remain attached to the source housing.

4.8.4.4 Vibration Resistance Test

This test shall be carried out on the source housing (B) having undergone the shielding adequacy test (subsection 5.4.1)

After completing the test procedure, the exposure device shall be fully operational in its intended manner.

4.8.4.5 Shock Test

After having undergone the shock resistance tests described in subsection 5.4.6, the exposure device shall be fully operational in its intended manner.

4.8.4.6 Accidental Drop Test

After the source housing has been subjected to the accidental drop test in subsection 5.4.4, the sealed source shall be retained in the source housing and ambient equivalent dose rate shall not exceed 1.5 times the limits specified in column 4 of Table 1.

Conformity with the specification laid down shall be checked by extrapolation from tests carried out using a sealed source of activity, which is sufficient for the results obtained to be significant, taking into account the sensitivity threshold of the measuring methods and instruments.

4.8.5 Tensile Test for Source Assembly and its Connecting Devices for Category-II Source Housings

The test shall stress each individual part of the source assembly (B).

The source assembly shall remain operable and maintain its structural integrity after having undergone the tensile test.

At the conclusion of this test, the complete system shall remain operable.

4.8.6 Crushing and Bending, Kinking and Tensile Tests for Remote Control

These tests shall be performed on the same individual remote control (B) in the order indicated.

At the conclusion of these tests, the remote control shall maintain its integrity.

Additionally, the remote control shall remain operable and source housing shall comply with the requirement of Table 2.

When the remote control is laid out as shown in Figure 4, the maximum force which shall be applied to completely drive out and retract the control cable through the source housing (the guided tube in the rectilinear position) shall not be more than 125% of the maximum force which had to be applied before the test, when the remote control was in the same configuration before the tests.

At the conclusion of these tests, the complete system shall remain operable.

4.8.7 Crushing and Bending, Kinking and Tensile Tests for Guide Tube

These tests shall be performed on the same individual (B) guide tube in the order indicated.

The guide tube shall remain completely and safely operable (the guide tube shall not have suffered any damage which would prevent the source assembly from sliding through the guide tube) and still comply with the requirements of this subsection after having undergone each of the crushing and bending (subsection 5.7.2), kinking (subsection 5.7.3) and tensile (subsection 5.7.4) tests.

At the conclusion of these tests, the guide tube shall maintain integrity and it shall be demonstrated that any elongation will have no detrimental effect on safety.

At the conclusion of these tests, the complete system shall remain operable.

5. TESTS REQUIREMENTS

5.1 Performance of the Tests

Approval of prototype testing shall be carried out in compliance with the national standard (IS-14000) or international standard (ISO-9000) by:

(a) either a body independently accredited in accordance with IS-14000/ ISO-9000, or

(b) a body which is recognised by a national government as being qualified to make a full and impartial assessment.

The organisation carrying out the tests shall have access to the documents listed in subsection 6.6.

Unless the test organisation has already carried out identical tests or more constraining tests for other regulations, the two prototype exposure devices referred to as (A) and (B) shall be subjected to the tests given in Table 2 in the order indicated, and shall fulfil the criteria for the individual tests specified in subsection 4.8.

If the source housing is designed for use in more than one class and/or category, the prototype shall be subjected to the tests of each appropriate class and/or category.

5.1.1 Quality Assurance on each Source Housing and Source Assembly

In addition to these prototype tests, a test to prove the shielding adequacy shall be carried out by the manufacturer on each source housing manufactured. Similarly, test for checking the quality of the source assembly shall be carried out by the manufacturer on each source assembly manufactured, according to section 7.

5.2 Endurance Test

5.2.1 Objective

The test aims to check the resistance to fatigue and wear of the different components utilised during the movement, of the state of the source housing, from the secured position to the working position, and its return to the secured position (in particular, the automatic securing mechanism, connecting devices between the remote control and source assembly and any related indicators).

5.2.2 Principle

The test shall be carried out in such a manner that the normal operating sequences of the exposure device shall be alternatively reproduced by the inversion of the movement of direction.

TABLE 2 : TESTS

Equipment							Specifications sub-section	Test	
Type #		Category		Class				Type	Sub-section
		I	II	P	M	F			
Entire exposure device	(B)	X	X	X	X	X	4.8.2	Endurance	5.2
	(B)		X	X	X	X	4.8.3	Guide tube resistance before and after endurance tests	5.3
Source housing	(A) & (B)	X	X	X	X	X	4.3	Shielding adequacy	5.4.1
	(B)	X	X	X	X	X	4.8.4.2	Lock breaking	5.4.2
	(B)	X	X	X	X		4.8.4.3	Handle, attachment part or lifting mount	5.4.3
	(B)	X	X	X	X		4.8.4.4	Vibration resistance	5.4.5
	(B)	X	X	X	X		4.8.4.5	Shock	5.4.6
	(A)	X	X	X	X	X	4.8.4.6	Accidental drop	5.4.4
Source assembly and its connecting device			X	X	X	X	4.8.5	Tensile	5.5
Remote control	(B)		X	X	X	X	4.8.6	Crushing and bending	5.6.1
	(B)		X	X	X	X	4.8.6	Kinking	5.6.2
	(B)		X	X	X		4.8.6	Tensile	5.6.3
Guide tubes	(B)		X	X	X	X	4.8.7	Crushing and bending	5.7.2
	(B)		X	X	X	X	4.8.7	Kinking*	5.7.3
	(B)		X	X	X	X	4.8.7	Tensile	5.7.4
# The tests are performed on two different exposure devices, indicated (A) and (B).									
* Test to be carried out only on flexible guide tube									
X -Indicates it applies									

During each cycle, the automatic securing mechanism shall be released and the source assembly shall move from the secured position to the working position and then return to the secured position.

Movement rate:

(a) The minimum movement for the category-I source housing shall be

30 revolutions per minute for rotating type device or one cycle per second for shutter type device. The movement rate shall remain constant until the source assembly is stopped at each half of the cycle.

(b) The minimum movement rate for the category-II source housing shall be 0.75 metre per second of linear movement of the source assembly. The movement rate shall remain constant until the source assembly is stopped at each end of the cycle.

The force required to perform the test shall be twice that measured in accordance with subsection 5.3 (projection resistance test).

5.2.3 Procedure

The complete category-II source housing fitted with the remote control and guide tube shall be set up coupled to the test device. The drive cable length shall be the maximum length recommended by the manufacturer in the specification.

The mounting of these accessories on the exposure device shall be according to the configuration given in Figure 5.

For categories-I and II, the testing shall be carried out for the total number of cycles according to Table 3.

TABLE 3 : CYCLES FOR ENDURANCE TEST

Types of cycles	Number of cycles
Normal cycles	50,000
Cycles for the remote control emergency device(s), if any*	10
Total number of cycles	50, 010
* Cycles carried out on the emergency device for non-manually operated remote controls	

For category-I source housings, the entire normal cycle consists of changing the remote control from the secured position to the working position and back to the secured position. For category-II source housings, the entire normal cycle consists of moving the source assembly from the secured position to the working position and back to the secured position.

The test shall not be interrupted before the first 10, 000 cycles and not more than four times during the whole test to carry out the common maintenance operations (cleaning and lubrication only).

No maintenance on the source assembly or its connection to the remote control shall be permitted before the source assembly has been subjected to a number

of test cycles equal to twice the number of cycles for which it is designed. The number of cycles shall not be less than 10,000 as specified in the documentation referred to in section 6. In all other cases, no maintenance shall be permitted before the end of the test (50,000 cycles). In addition, endurance for connection and disconnection of the drive cable to source holder assembly shall be carried out as stipulated below to ensure the smooth functioning of the associated parts in the drive cable and the source holder assembly:

(a) 500 times for disposable $^{192}Ir/^{75}Se$ source holder assembly; and

(b) 5000 times for all other source holder assemblies. .

5.3 Projection Resistance Test

This test shall be performed on the category-II exposure device before and after the operational tests (subsection 4.8.3).

5.3.1 Principle

The purpose of this test is to determine the resistance offered to drive out control cable by:

(a) the source housing after vibration and shock resistance tests (subsection 5.4.5 and 5.4.6),

(b) the source assembly after the tensile test (subsection 5.5),

(c) the remote control and the cable after the crushing and bending, kinking and tensile tests (subsections 5.6.1 to 5.6.3), and

(d) the guide tube and its exposure head after crushing and bending, kinking and tensile (subsections 5.7.2 to 5.7.4).

5.3.2 Equipment

The source housing shall be equipped with a source assembly having the largest diameter and greatest length compatible with guide tube undergoing examination (in accordance with the manufacturer's instructions that accompany the equipment).

The crankshaft driving motor of the test equipment shall be provided with a force or torque measuring and recording device.

5.3.3 Procedure

Connect the remote control to the source housing following the configuration given in Figure 5.

Connect the maximum length of the guide tube, (as stipulated by the manufacturer) to the source housing, which has undergone tests. For flexible guide tubes, use the configuration shown in Figure 5. The bending radius

stipulated for each change of direction is the minimum bending radius as specified by the manufacturer.

If the maximum length of the guide tube is not sufficient to accommodate the complete configuration, the guide tube shall follow this configuration as closely as possible.

Before and after tests indicated in subsection 5.3.1, 10 complete cycles of moving the source assembly from the secured position to the working position and returning it to the secured position shall be carried out, recording the driving force on each cycle. The linear movement rate shall be that specified in subsection 5.2.2.

5.4 Tests for Source Housing

5.4.1 Shielding Adequacy Test

5.4.1.1 Principle

The test shall consist of checking the radiation leakage from the source housing to ensure that the radiation doses are within the limits specified in this standard (see Table 1 in subsection 4.3)

5.4.1.2 Procedure

Remove the remote control and guide tubes and carry out the test on the source housing alone in the locked position with the protective caps, plugs or similar devices in place. Before measuring the levels on the surface or at 5 cm from the surface, check by a smear test (in accordance with AERB/SS/3, Rev.-1, 2001) that the surface of the source housing has no radioactive contamination.

Load the source housing with a sealed source in the source assembly of appropriate radionuclide and known activity. Measure the ambient equivalent dose rate over the entire surface of the source housing, at 5 cm from the surface, and at 1 m from the external surface of the source housing to determine that the ambient equivalent dose rate limits given in subsection 4.3 are not exceeded at any place and in any direction.

Measure ambient equivalent dose rate at surface of the source housing using an x-ray film or other appropriate device with cross sectional area not greater than 10 cm^2. Measure the ambient equivalent dose rate at 5 cm from the surface using a detector with a cross sectional area not greater than 10 cm^2 and no linear dimensions greater than 5 cm. Measure the ambient equivalent dose rate at 1 m from the surface using a detector with a cross sectional area not greater than 100 cm^2 and no linear dimension greater than 20 cm.

Extrapolate ambient equivalent dose rate obtained to derive the dose rates for

a maximum rating of the source housing. Extrapolation shall take into account the sensitivity of the radiation measuring instrument, and ideally the maximum design activity shall be used.

In the case of a class F source housing, the ambient equivalent dose rates in inaccessible positions need not be measured.

5.4.2 Lock Breaking Test

5.4.2.1 Principle

The test shall consist of checking that source housing's lock or source changer's lock withstands a breaking force when it is in the locked position with the key removed.

5.4.2.2 Equipment

A device is fitted to the component of the source housing or source changer which is secured by the lock. The device shall be capable of applying a measured force or torque.

5.4.2.3 Procedure

Determine the most vulnerable part of the locking mechanism. Gradually apply a force so as to obtain 400 N after 10 s. Then release it gradually over 10 s. Repeat the test 10 times in succession. Check that the source housing or source changer cannot be opened without unlocking.

5.4.3 Handle, Attachment Part or Lifting Mount Test for Class P and M only

5.4.3.1 Principle

The test shall consist of determining that each carrying handle, attachment part or lifting mount is able to withstand a static force equal to 25 times the weight of the source housing.

5.4.3.2 Procedure

Apply a force equal to 25 times the weight of the source housing to the most vulnerable portion of the carrying handle, attachment part or lifting mount. Ensure that the carrying handle, attachment part or lifting mount remains functional and attached to the source housing.

5.4.4. Accidental Drop Test

5.4.4.1 Principle

The test shall consist of subjecting the source housing in the locked position (including protective caps, plugs or similar devices) to free drop to simulate accident conditions, with a view to ensure that the source assembly is not exposed as a result of accidental drop.

The test shall consist of a single drop onto an unyielding target, meant for such a drop test in conformity with transport regulations.

5.4.4.2 Procedure

(a) The source housing shall drop onto the target so as to suffer the most significant effect on radiological safety.

(b) The height of the drop measured from the lowest point of the source housing to the upper surface of the target shall be 1.2 m

(c) The target shall be a flat horizontal surface such that any increase in its resistance to displacement or deformation upon impact by the source housing would not significantly increase the damage to the source housing.

One example of a target of this type is a steel plate on the upper surface of a block of concrete, the mass of which is at least 10 times that of any specimen to be dropped onto it. The block shall be set on firm soil and the steel plate on its upper surface shall be at least 1.25 cm thick and wet floated onto the concrete so as to be in intimate contact with it. The target shall have plane dimensions at least 50 cm larger on all sides than any specimen that is to be dropped onto it and it shall be as close to cubic in form as practicable.

5.4.5 Vibration Resistance Test for Class P and Class M Only

5.4.5.1 Principle

The purpose of the test is to determine the natural frequencies, which are characteristic of the source housing and to study the change in these natural frequencies in order to determine whether the source housing is able to withstand vibrations experienced during transportation.

Note-1: Natural frequencies are defined as frequencies whose mechanical resonances deviate by more than 30% from the maximum acceleration given in 5.4.5.4 (a) (caused by assembly and mechanical connection of constituting elements, or when other signs of response, such as impact noise or internal hammering occur).

Note-2: The conditions and values of vibratory parameters applied are generally characteristic of usual transportation conditions.

5.4.5.2 Equipment

The testing device (vibrating platform) shall be in accordance with IEC standard 68-2-6 to vibrate the parts of the exposure device under test along three orthogonal axes, while respecting the usual transport position of the source housing.

5.4.5.3 Assembly: This test shall be applied to the source housing loaded with a

simulated (dummy) sealed source assembly in the locked position including protective caps, plugs or similar devices, with the remote control and guide tubes removed.

(a) Mounting of the source housing : The source housing shall be rigidly mounted on the testing device, in accordance with IEC-68-2-47, so that it cannot move independently of the platform. This mounting shall not alter the natural frequency of the source housing under test.

(b) Positioning and mounting of the accelerometers : Accelerometers shall not be located on riveted pieces, in their immediate vicinity, or on devices with rotating or translating mechanisms such as cylindrically operating shutter(s), or side operating shutter(s). Accelerometers shall be adequately located, and in a sufficient number, so that the obtained accelerometric response provides sufficient data to test for mechanical resonances. They shall be mounted on the source housing under test in accordance with IEC-68-2-47.

5.4.5.4 Procedure

The source housing including a simulated source assembly shall be subjected to vibration test.

The testing procedure shall consist of three test runs:

(a) Test for endurance through sweeping to determine natural frequencies;

(b) Test for endurance at natural frequencies; and

(c) Test for endurance.

Each test shall be applied successively along two orthogonal axes.

(a) Endurance Through Sweeping (Determination of Natural Frequencies)

The source housing shall be subjected along two orthogonal axes (for a category-II source housing, one axis must be parallel to the direction of the source assembly movement) to vibratory severity defined by the combination of the following three parameters

- frequency range : 10 ± 1 Hz to 150 ± 3 Hz;
- maximum acceleration : 9.8 m/s^2;
- duration of stress : 1 sweeping cycle (frequency range is from 10 Hz to 150 Hz and back to 10 Hz) by a sweeping rate of 1 octave per minute within 10%.

The sweeping shall be continuous (continuous change of the

frequency according to the time) in order to avoid sudden rise of frequency which generates spurious natural frequencies.

(b) Endurance at Natural Frequencies

The source housing shall be subjected to each natural frequency obtained during the test described in subsection 5.4.5.4 (a) for a period of 30 ± 1 minute at the same maximum acceleration as in subsection 5.4.5.4 (a). The test shall be carried out in a frequency range of ± 10% around the obtained natural frequencies.

In case where several natural frequencies are detected along the same axis, the time period shall be equally distributed on each of the frequencies (with not more than three frequencies per axis).

(c) Endurance

The source housing shall be subjected, in the same way as in subsection 5.4.5.4 (a), to

- 15 sweeping cycles if the endurance test at natural frequencies has been performed, or
- 25 sweeping cycles if no natural frequency has been detected.

5.4.6 Shock Resistance Test

This test shall be performed after the vibration test. It shall be performed on the source housing (B), including a simulated source assembly, without the remote control and guide tube, but locked and with the protective caps in place. The test shall consist of simulating the different shocks which an exposure device may undergo, either when carried at arms length (horizontal shock when colliding with an obstacle), or when carried on a trolley (vertical shock when passing over an obstacle), in order to determine its resistance to such shock.

5.4.6.1 Class P Source Housing - Horizontal Shock Test

(a) Equipment

The target shall consist of the flat vertical end face of a 5 cm diameter steel bar, 30 cm in length lying horizontally, that is fixed or welded to a rigid mass at least 10 times the mass of the source housing.

The device used for suspension shall not produce undesirable rotation of the source housing around the vertical axis prior to the shock.

(b) Procedure

Select the areas on the source housing which, if impacted, will have

the most significant effect on radiological safety. Suspend the source housing from the fixed points so placed that, when at rest, one of the selected areas just touches the target. Move the source housing from its resting position until its center of gravity is 10 cm higher than in the resting position and let it loose, so that it swings in a pendulum movement against the target. These shock tests shall be carried out 20 times on each of the selected areas.

5.4.6.2 Class P Source Housings - Vertical Shock Test

(a) Equipment

The rigid target such as steel or concrete, shall consist of a mass at least 10 times that of the source housing and shall have a flat horizontal surface covered with a sheet of hard plywood 2.5 cm thick (7 or 9 ply) as defined in ISO-818.

(b) Procedure

From its normal carrying position, source housing shall be allowed to fall 100 times from a height of 15 cm onto the rigid target. The test shall be carried out either manually or with the aid of suitable mechanical device.

5.4.6.3 Class M Source Housing

This test shall be carried out by letting the source housing positioned on its trolley, or other suitable device provided for ease of movement, moving at a speed of at least 1 m/s, drop freely down a step of height 15 cm. The edge of the step shall be such that it will not be distorted by the operation.

The ground at the bottom of the drop shall be hard and solid such as concrete or flagstones. If this is not the case (e.g. wood or beaten earth), the ground shall be covered with a steel sheet at least one cm thick.

Repeat this test 100 times.

5.5 Tensile Test for Source Assembly

5.5.1 General

This test shall be performed on the category-II source housing before and after the operational tests described in subsection 4.8.5.

5.5.2 Principle

The purpose of this test is to determine the ability of the source assembly, with a dummy source, to withstand the tensile stress to which it is subjected during use.

5.5.3 Procedure

Perform the following two tests:

(a) Attach the control cable to the source assembly to be tested. Restrain the opposite end of the source assembly. Apply a tensile force gradually to the control cable so as to obtain 1000 N after 10 s and maintain the force for 5 s.

Repeat this test 10 times.

(b) Attach the control cable to the source assembly to be tested. Restrain the largest diameter of the source assembly, that portion which is used to stop the retraction of the source assembly when it reaches the secured position within the source housing. Apply a tensile force gradually to the control cable so as to obtain 1000 N after 10 s and maintain the force for 5 s.

Repeat this test 10 times.

5.6 Tests for Remote Control

5.6.1 Crushing and Bending Tests

5.6.1.1 Principle

The test simulates the crushing and bending of the sheath by the heel of a person's shoe (footwear).

5.6.1.2 Equipment

The test surface shall be plane and horizontal with a mass of 150 kg and sufficiently hard not to be deformed when the steel heel is applied to it without the presence of test pieces.

The device consists of a crank 1 m long, attached such that it can swing at its upper end and fitted with a 7 cm x 7 cm steel plate at the lower end of the crank. The ends of the heel are rounded to 2 mm radius on the horizontal edges and 5 mm radius on the vertical edges (see Figure 6). The heel and crank shall have a mass of 15 kg. In addition, two steel bars, each 5 cm in diameter and 30 cm in length, shall be required for testing rigid guide tubes.

In the case where the driven out (projection) and reserve sheaths are attached to each other (construction-bound sheaths), the test surface is fitted with lateral guides preventing the relative movement of the sheaths during impact. The sheaths shall have the following characteristics:

(a) length greater than two heel lengths: and

(b) height between 0.5 and 0.75 times the sheath height for juxtaposed

sheaths and between 1.5 to 1.75 times the sheath height for superimposed sheaths.

5.6.1.3 Procedure

For flexible sheaths, place the sheath (with control cable inserted) flat on the test surface. Place the heel at a point on the sheath. If two sheaths are juxtaposed, the heel is dropped on both sheaths simultaneously.

For rigid sheaths, place the two steel bars parallel to each other and separated by a distance of 50 cm between the axes. Place the rigid sheaths in a direction perpendicular to the bars along the mid-plane of the bars. Place heel at a point on the sheath midway between the steel bars.

By lifting the crank, raise the bottom of the heel 30 cm higher than the upper surface of the sheath. Drop the crank in a free-swinging movement. Repeat this test once on 10 randomly selected points on the sheath, one of which shall be on a joint if there is one.

For construction bound sheaths, the test is performed on the control cable inserted in the two sheaths at random points as follows:

(a) five points when the sheaths are laid out juxtaposed, with the heel dropping onto both sheaths simultaneously; and

(b) five points when both sheaths are superimposed in a vertical plane with the heel dropping onto the top sheath. (In both cases, the sheaths are laterally held by guides.)

5.6.2 Kinking Test

5.6.2.1 Principle

The purpose of this test is to subject the remote control to the stress that it may undergo as a result of kinking forces that may occur during setting up of the remote control for use.

5.6.2.2 Procedure

Arrange the control cable and sheath rectilinearly on a plane horizontal surface. Secure one end of the sheath so that it does not move in any way during the test. With the sheath, make a loop 50 cm in radius on the horizontal surface. Pull the free end of the sheath, without allowing to rotate along the axis of its original line, at a speed of 2 m/s until the loop disappears and until the sheath regain its rectilinear position.

Repeat this test 10 times at each equidistant point over the length of the sheath tested, each point being the origin of the loop.

5.6.3 Tensile Test

5.6.3.1 Principle

The test shall consist of simulating the tensile stress which may be experienced by the unit composed of the control cable sheath(s), control cable and connectors, and its control mechanism, during use.

5.6.3.2 Procedure

(a) The control cable sheath shall be fitted on the remote control mechanism.

- Secure the remote control so that it cannot move during the test without immobilising the control mechanism such as control lever.
- Apply a tensile force of 500 N for 30 s to the end of the control guide tube connected to the source housing.

  Repeat this test 10 times.

(b) The control cable shall be fitted to the control mechanism.

- Secure the remote control so that it does not move during the test. Immobilise the control mechanism such as the lever. Connect a source assembly to the control cable. Apply a force of 1000 N for 10 s to the free end of the source assembly.

  Repeat this test 10 times.

5.7 Test for Guide Tube and Exposure Head

5.7.1 Introduction

Rigid guide tubes shall be subjected to tests described in subsections 5.7.2 and 5.7.4 in that order.

Flexible guide tubes shall be subjected to tests described in subsections 5.7.2, 5.7.3 and 5.7.4, in that order.

The criteria for passing these tests are specified in subsection 4.8.7.

5.7.2 Crushing and Bending Tests

5.7.2.1 Principle

The test simulates the crushing and bending of the guide tube by the heel of a person's shoe (footwear).

5.7.2.2 Equipment

The same as described in subsection 5.6.1.2

5.7.2.3 Procedure

The same as described in subsection 5.6.1.3

5.7.3 Kinking Test

5.7.3.1 Principle

The purpose of this test is to subject the guide tubes to the stress that it may undergo due to kinking forces that may occur during setting up for use.

5.7.3.2 Procedure

Place the guide tube without a connection between two parallel plates separated by not more than 5 times the outside diameter of the guide tube. Form a flat, closed loop and fix one of the ends so that it does not move in any way during the test.

Apply a tractive force to the free end, at a tangent to the loop, reducing the diameter of the loop. This force is applied via a dynamometer in such a way that it reaches 200 N in 5 s. It is then maintained at this level for 10 s.

Repeat this test 10 times, undoing and redoing the loop at the same point for each test.

If the guide tube is composed with various sections of connections, restart the test including a connection in the loop.

Close the loop as above so that the connection and the crossing point are opposite each other.

5.7.4 Tensile Test

5.7.4.1 Principle

The test shall consist of simulating the tensile stress which the guide tube undergoes in use. The test is applicable only to class P and class M source housings.

5.7.4.2 Procedure

Connect the end of the guide tube to the source housing. Fix the source housing so that it cannot move during the test.

Apply a tractive force of 500 N to the final section of the guide tube or, if this section ends in a connection, apply the tractive force to the exposure head part of the connection.

Maintain this force for 30 s.

Repeat this test 10 times

6. ACCOMPANYING DOCUMENTS

All industrial gamma radiography exposure devices shall be accompanied by documentation referred to as "Accompanying Documents" which shall always be provided with the exposure device, intended for the users.

(a) Description and technical characteristics of the exposure device or source changer;

(b) Certificates of the manufacturer;

(c) Instructions for use;

(d) Inspection, maintenance, repair and emergency procedures; and

(e) Instruction for disposal of decayed sealed source, disposal of depleted uranium and disposal of the source housing and its accessories.

6.1 Description and Technical Characteristics of the Exposure Device or Source Changer

6.1.1 Description

The following information shall be provided:

A clear indication of the intended use of the exposure device with the warning against its use by unqualified/unauthorised personnel or when safety procedures are not fully met, stating that "life-threatening dangers could result" particularly when there is a possibility of driving in and driving out the source assembly from the source housing or source changer:

(a) Suitable paragraphs or drawings to allow the identification of each of the main elements and parts of the exposure device or source changer, including the source assembly;

(b) Basic diagram of the source housing or source changer, remote control, guide tube and exposure head;

(c) Explanation of operation, with reference diagrams, clearly indicating the sequences during which the source assembly is partially or completely outside the source housing or source changer, and exposure head; and

(d) Explanation of the operation, with reference to diagrams, and description of the means by which, the requirements in indications 4.4.2 are met; such means may be visual, audible or mechanical.

6.1.2 Technical Characteristics

The following essential information for the correct use and operation of the exposure device or source changer shall be provided:

(a) shielding material(s) used in the exposure device or source changer;

(b) reference of the remote control(s) and guide tube(s) that may be used with the source housing;

(c) minimum bending radius allowable for this (these) tube(s);

(d) specifications of characteristics of sealed sources that can be used in the source housing or source changer including the suitable classification and other essential specifications (AERB/SS/3 (Rev.1), 2001);

(e) specifications of the source holder(s) that can be used in the source housing;

(f) maximum activity of each of the radionuclides that can be used in the source housing or source changer;

(g) retention device for the source holder or source changer;

(h) where beam limiting device(s) are provided, maximum transmission factor of the possible beam limiting device(s) and geometric characteristics, such as size and shape, of the emitted beam;

(i) maximum driving length with remote control(s) that can be used on category-II source housings;

(j) nature, type, voltage and capacity of batteries and cells and/or bulbs, where applicable;

(k) nature, voltage and intensity of feed current which may be required for operating the equipment or recharging the accumulator batteries; and

(l) basic diagram for the electrical circuits, if any.

6.2 Certificate of the Manufacturer

The manufacturer shall provide with each exposure device:

(a) a certificate of conformity to show compliance with this standard/ current ISO-3999 from the competent authority of the country of origin; and

(b) a certificate of ambient equivalent dose rate measurements, extrapolated to the maximum rating, taken on the source housing.

Based on the performance tests carried out on the prototype to demonstrate that the exposure device meets the requirements of this standard, the manufacturer/supplier of the industrial gamma radiography exposure device or source changer shall obtain type approval from the competent authority. The format of the application for type approval of industrial gamma radiography exposure device or source changer is given in Appendix-I. If the source housing

or source changer is designed to transport radioactive material and demonstrate its ability to withstand Type B(U) package design approval, the manufacturer shall obtain the package design approval for the industrial gamma radiography exposure device.

6.3 Instructions for Use

The following instructions shall use only the terms defined in this standard:

(a) instructions for assembling various parts of the exposure device in its various configurations including exposure heads;

(b) instructions stating the order in which the various operating phases are to be carried out, once the assembled exposure device is in use, with warning of the risk of radiation exposure that may result from non-adherence to these instructions;

(c) instructions on the storage of the source housing or source changer;

(d) instructions on the use of protective caps, plugs or similar devices on the exposure devices or source changer while not in use, so as to avoid accidental penetration by foreign bodies/particles.

6.4 Inspection, Maintenance, Repair and Emergency Procedures

The manufacturer shall provide the following information:

(a) instructions on replacing the loaded source assembly/source holder and packaging of the decayed sealed source for transportation and disposal at a waste management facility;

(b) instructions on the procedure and frequency of maintenance operations;

(c) instructions for remote control maintenance;

(d) instructions for checking the exposure device or source changer (including the source housing, remote control, guide tubes, exposure head) for internal cleanliness, deformation, breakage or wear (provision for go/no-go gauge); and

(e) instructions to be followed in the event of foreseeable accidents, with an indication of their probable causes.

6.5 Instructions for Disposal

The manufacturer shall inform the user that when the source housing or source changer or sealed source has reached the end of its working life, they shall be disposed of in a safe and proper manner in accordance with the Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987, in particular for packaging

and transportation. The user shall comply with the provisions of AERB Safety Code on Safe Transport of Radioactive Material, AERB/SC/TR-1 for packaging and transportation of radioactive material.

6.6 Supplementary Documents for the Test Laboratories to Conduct the Conformity Study

In addition to the documents provided to the user, the manufacturer shall provide the following documents to the agency(ies) for carrying out the prototype testing of the exposure device:

(a) complete detailed drawing of the construction for the prototype source housing, source assembly and its accessories;

(b) description of construction with figures and dimensions of the source housing and designation of all the elements;

(c) list of tests for maintenance and repair to be carried out by the manufacturer;

(d) attenuation factor for the minimum thickness of shielding material for each of the radionculides to be contained in the source housing or source changer; and

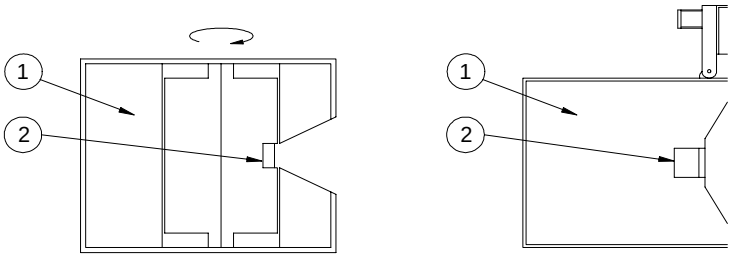
(e) description of the tensile test used for checking source assembly and its connecting device.

7. QUALITY ASSURANCE PROGRAMME

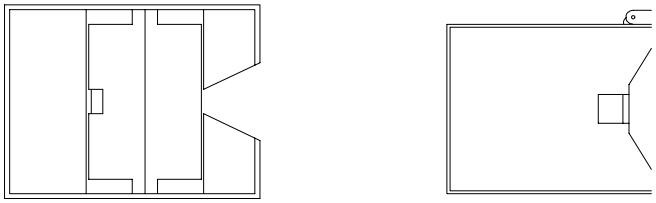
A quality assurance programme (QAP) shall be established according to national standards IS-14000 to 14004 or international standard ISO-9000 to 9004 to ensure that the industrial gamma radiography exposure devices manufactured according to the quality assurance programme have the performance equal to or better than that of prototypes tested as per this standard. An important aspect of the quality assurance programme is the documentation covering the design review, use of approved drawings for manufacture, establishment of audit procedures, testing, safety during transport, inspection, and documentation of traceability of materials and components as well as records of installation, and servicing and maintenance.

The manufacturer of industrial gamma radiography exposure devices shall provide to the competent authority its QAP in detail.

FIGURES



Working Position

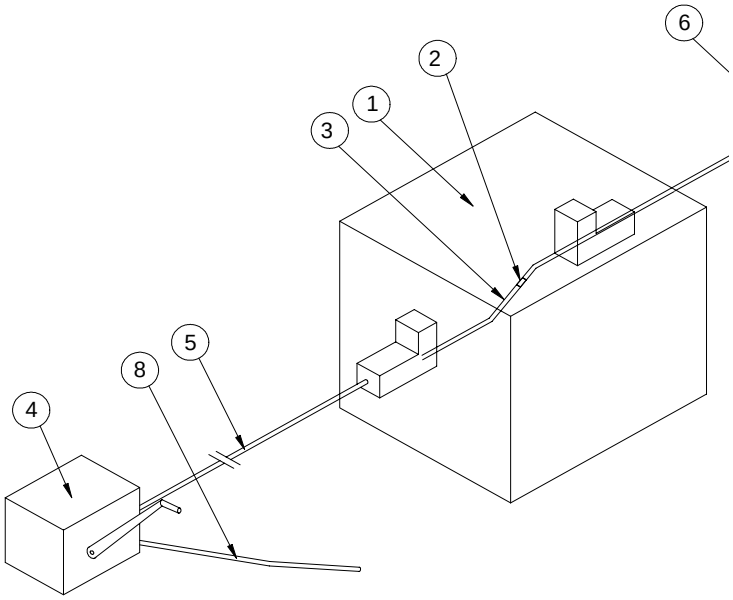


(a) Rotating Type (b) Shutter Type

Secured Position

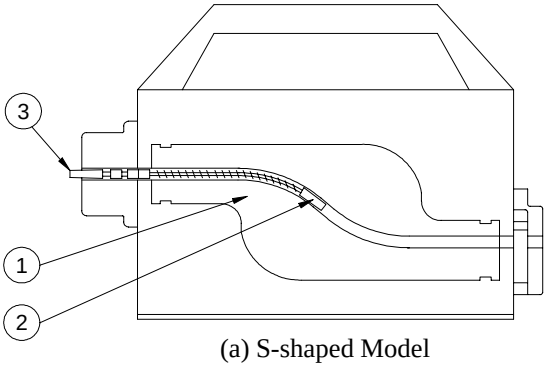
Key
1. Source Housing
2. Radioactive Sealed Source

FIGURE 1 : SKETCHES OF CATEGORY-I INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICE

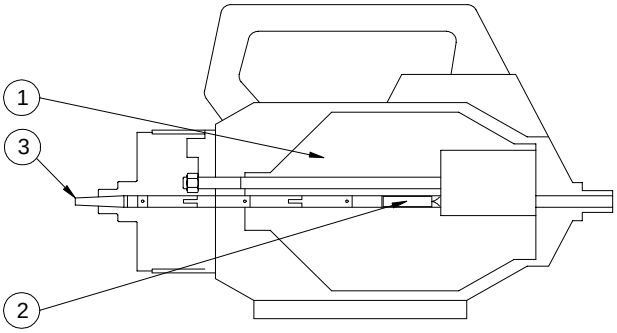


Key
1. Source Housing
2. Radioactive Sealed Source
3. Source Holder
4. Remote Control
5. Control Cable and Sheath
6. Projection Sheath
7. Exposure Head
8. Reserve Sheath

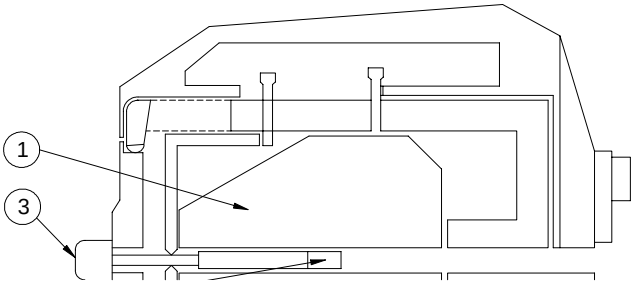
FIGURE 2: SKETCH OF CATEGORY-II INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICE



(a) S-shaped Model



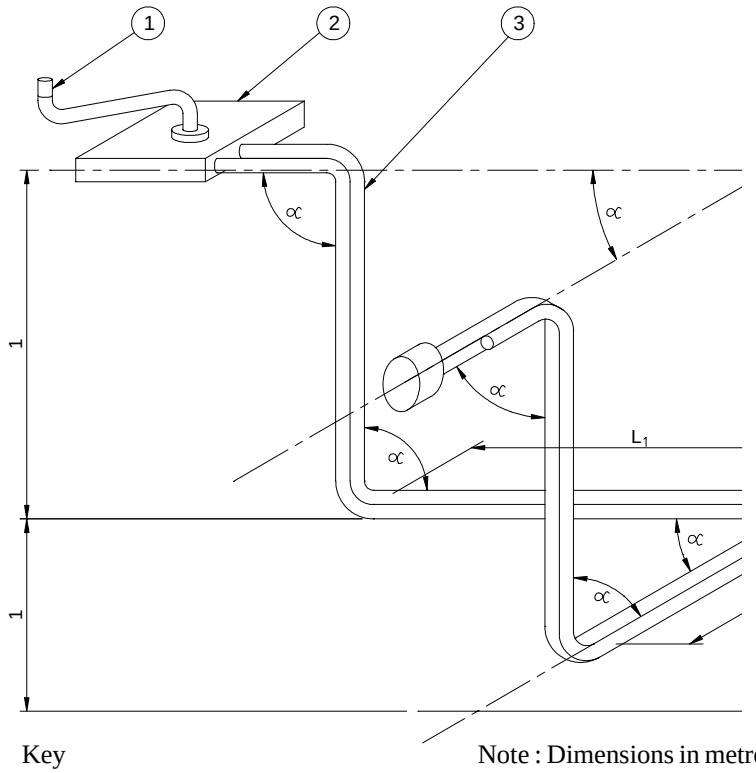
(b) Rotating Model



(c) Finger-type Model

Key
1. Shield
2. Radioactive Sealed Source
3. Attachment for Control Cable and Sheath

FIGURE 3 : EXAMPLES OF CATEGORY-II SOURCE HOUSINGS



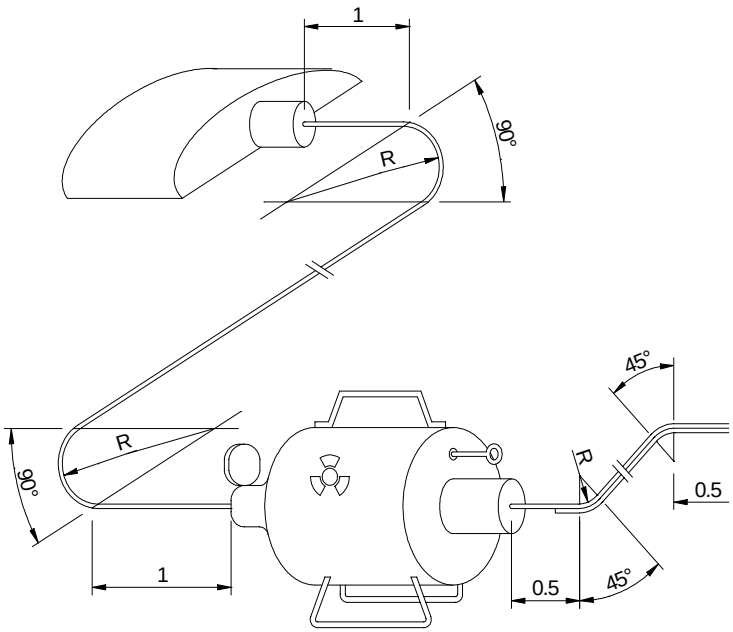
Key
1. Control Lever
2. Control Mechanism
3. Control Cable and Sheath(s)

Note : Dimensions in metres

$\mu = 90^0$ change in direction, with the minimum bending radius allowable for the remote control sheath, as indiated in accompanying documents.

The control cable and reserve sheath are presented bonded as construction-bound sheaths.

FIGURE 4 : REMOTE CONTROL TEST GEOMETRY

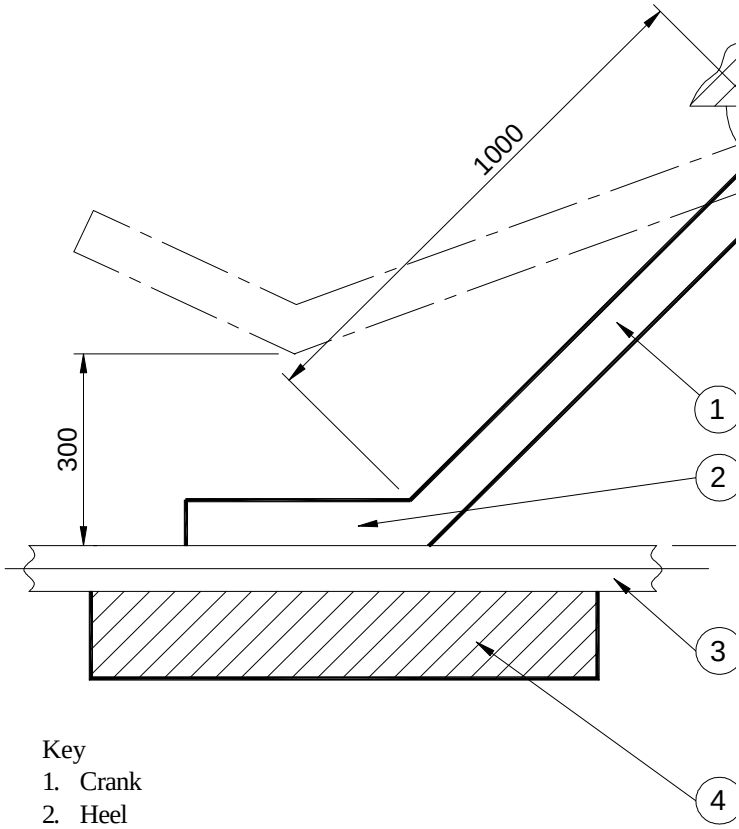


Note: Dimensions in metres

Remote Control
- For lengths 3 m: 3 bends with 45^0 into 2 planes and 2 levels (H=1 m);
- For lengths < 3 m: Follow above as closely as possible, but reduce straight section equally if necessary.
- With minimum bending radius 'R' stated by the manufacturer.

Projection Sheath(s)
- For lengths 3 m: 2 bends with 90^0 in horizontal plane;
- For lengths < 3 m: 1 bend with 90^0 in horizontal plane;
- With minimum bending radius 'R' stated by the manufacturer.

FIGURE 5 : TEST CONFIGURATION FOR THE ENDURANCE TEST AND FOR PROJECTION-RESISTANCE TESTS



Key
1. Crank
2. Heel
3. Testing Sheath
4. Test Surface

Note : Dimensions in millimetres

FIGURE 6 : EXAMPLE OF DEVICE FOR CRUSHING TEST

APPENDIX-I

Government of India
Atomic Energy Regulatory Board

FORMAT OF THE 'APPLICATION FOR TYPE APPROVAL OF INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICE AND SOURCE CHANGER'

To be submitted by the applicant to the Chairman, Atomic Energy Regulatory Board, Niyamak Bhavan, Anushaktinagar, Mumbai-400094

A. Manufacturer/Vendor

1. (a) Name and address of the applicant with PIN code (in block letters):

(b) Mode of communication:

Telephone with STD code													
Fax													
Telex													
Telegram													
E-mail													
Mobile													

2. (a) Name and address of the manufacturer with PIN code

(b) Mode of communication

Telephone with STD code													
Fax													
Telex													
Telegram													
E-mail													

3. Person to be contacted regarding this application

Telephone with STD code														

4. Name and type of gamma radiography exposure device to be type approved

5. This application is for

Type approval				
Renewal of type approval		Ref No.:	Date:	Valid till:

B. Exposure Device

1. Name and type

2. Class of exposure device : Portable/Mobile/Fixed

3. Gross weight : ..... kg

4. Overall external dimensions : x.....mm (l) x .....mm (h) x ....mm (w)
(provide detailed drawing of the device)

5. Maximum source capacity : ..... GBq of .....
(specify the radionuclide)

6. Exposure mechanism : .....

C. Source Housing

1. Material of shielding : .....

2. Maximum thickness and : ..... mm, maximum
minimum thickness : ..... mm, minimum

3. Location of source from external : .....cm .....
reference points (specify)

4. Leakage radiation levels measured at maximum source rating

(a) at 5 cm from source housing
averaged over an area of 10 cm^2 : ..... mSv/h

(b) at 100 cm from source housing
averaged over an area of 100 cm^2 : .....mSv/h

D. Safety Features

1. Locks (describe briefly the types of safety locks provided, locking mechanism etc.)

2. Can the source assembly be pushed/ pulled out of the equipment without operating the driving mechanism : Yes/No

3. Collimators (specify the type of collimator such as panoramic/straight beam/diaphragms, their radial angles, material of construction etc.) : .....

4. Any other safety device

E. Radioactive Source Assembly

1. Name and address of the manufacturer with PIN code & email

2. Name and address of supplier with PIN code & email

3. External dimensions : x.....mm (l) x .....mm (h) x ....mm (w)

4. Gross weight : ..... g

5. Materials of construction (specify the materials of source capsule, and source holder, and provide a separate drawing giving the dimensions of various components of the source assembly)

   (a) Source capsule : .....

   (b) Source holder : .....

6. Classification number and certificate issued along with the source : C/E.....

7. Type of coupling provided between the source assembly and driving mechanism .....

F. Source Drive System

1. Model/type

2. Gross weight : ..... kg

3. Overall external dimensions : x.....cm (l) x ..... cm (h) x .... cm (w)

4. Source guide tube assembly

   (a) Material : ..... (b) Diameter : ..... mm

   (c) Length : ..... cm

5. Source drive cable

   (a) Material : ..... (b) Diameter : ..... mm

   (c) Length : ..... cm

6. End fittings (Specify material, dimensions of end fittings to source guide tube and drive cable)

   (a) Material : ..... (b) Diameter : ..... mm

   (c) Length : ..... cm

7. Maximum distance between exposure device and control unit : ..... m

8. Maximum distance between exposure device and source in extreme exposure positions when guide tube is connected : .....m

9. Operational mechanism of remote control (describe briefly about any special lock, source position indicator, mechanical counter etc. provided in the cranking unit) :

10. (a) Is the guide tube flexible or rigid ? : Flexible/rigid

    (b) Material and dimensions of the of guide tube : .....

11. Type of mounting provided for cranking unit (stand type/spool type/pistol grip type/any other) : .....

G. Quality Assurance

(a) For first approval

Furnish quality assurance procedures for entire manufacturing as well as procedures for servicing and maintenance

(b) Renewal of type approval

(i) Number of devices supplied on the date of application. (Give serial numbers) : .....

(ii) Any modification to the present design or changes in components/ materials of construction/QA procedures incorporated in the approved model. If so, give details : .....

(iii) Any change in the radioactive material or its quantity in the approved model : .....

(iv) Field use feedback on performance of devices supplied so far (Attach details on the following) : .....

(a) Availability of spares : .....

(b) Servicing and maintenance : .....

(c) Average frequency of failures or radiological malfunctions; : .....

(d) Common failures in the order of frequency of their occurrence; : .....

(e) Generic deficiencies/operational problems reported by the users; and : .....

(f) Major incidents and causes : .....

H. Specify the National/International Standards to which the equipment, source changer and source comply and give details of tests conducted and their results

I. Any other relevant information

J. List of supportive documents (such as instruction manual, drawings, etc.) attached with the application

I certify that all the information furnished by me is correct to the best of knowledge and belief.

Place :
Date :

Signature of the applicant : .....
Name : .....
Designation : .....
(Seal of the institution)

BIBLIOGRAPHY

1. The Atomic Energy (Radiation Protection) Rules, G.S.R-303, 2004.
2. The Atomic Energy (Safe Disposal of Radioactive Waste) Rules, G.S.R.-125, 1987.
3. Safety Code for Transport of Radioactive Material, AERB/SC/TR-1, 1986.
4. Safety Standard for Testing and Classification of Sealed Radioactive Sources, AERB/SS/3 (Rev-1), 2001.
5. Safety Code for Industrial Radiography, AERB/SC/IR-1, 2001.
6. International Standard-Radiation Protection-Apparatus for Industrial Radiography-Part-1: Specifications for Performance, Design and Tests, ISO-3999-1, 2000 (E).
7. IAEA Safety Standard Series on Regulations for the Safe Transport of Radioactive Material, No. TS-R-1, 2000

LIST OF PARTICIPANTS

WORKING GROUP FOR PREPARATION OF AERB SAFETY STANDARD FOR RADIOLOGICAL SAFETY FOR DESIGN, CONSTRUCTION OF INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICES AND SOURCE CHANGERS

Members and Invitees of Working Group:

Shri A.R. Sundararajan (Chairman)	:	AERB (Former)
Shri A.K. Lahiri (Convenor)	:	L & T, Mumbai
Shri T.K. Jayakumar	:	BRIT, Mumbai
Shri V.G.R. Subramanian	:	BRIT (Former), Mumbai
Late Dr. D. Singh	:	AERB (Former)

Late Dr. I.S. Sundara Rao, AERB (Former), Shri K.D. Pushpangadan and Shri A.U Sonawane, Atomic Energy Regulatory Board, Mumbai are the authors of the first draft of this Standard.

COMMITTEE TO REVIEW/REVISE AERB SAFETY STANDARD FOR RADIOLOGICAL SAFETY FOR DESIGN, CONSTRUCTION OF INDUSTRIAL GAMMA RADIOGRAPHY EXPOSURE DEVICES AND SOURCE CHANGERS, AERB/SS-1, 1992

Dates of meeting	:	January 8 & 9, 2004
Shri K. Balu (Chairman)	:	Director, NRG, BARC (Former)
Shri T.K. Jayakumar (Convenor)	:	BRIT, Mumbai
Shri P.A. Varkey	:	BRIT, Mumbai
Shri R. Kannan	:	BARC
Shri K.D. Pushpangadan	:	AERB

STANDING COMMITTEE ON REVIEW OF RADIATION SAFETY DOCUMENTS (SCRSD)

Dates of meeting	:	February 17, 2004 June 15, 2004
Dr. A.R. Reddy (Chairman)	:	Defence Research and Development Organisation, New Delhi (Former)
Dr. P.S. Iyer	:	BARC (Former)
Shri R.J. Pardikar	:	Bharat Heavy Electricals Limited, Thiruchirappalli
Dr. B.C. Bhatt	:	BARC (Former)
Dr. D.N. Sharma	:	BARC
Shri P.K. Nema	:	BARC
Dr. U.N. Nayak	:	BARC
Shri V.G.R. Subramanian	:	BRIT (Former), Mumbai
Dr. A.N. Nandakumar	:	AERB
Shri T.K. Jayakumar (Co-opted Member)	:	BRIT, Mumbai
Shri K.D. Pushpangadan (Member Secretary)	:	AERB

ADVISORY COMMITTEE ON RADIOLOGICAL SAFETY (ACRS)

Date of meeting	:	April 20, 2006
Dr. U.C. Mishra (Chairman)	:	BARC (Former)
Dr. A.R. Reddy	:	Defence Research and Development Organisation, New Delhi (Former)
Dr. Gurusharan Singh	:	BARC
Dr. B.C. Bhatt	:	BARC (Former)
Dr. S.K. Shrivastava	:	Tata Memorial Hospital, Mumbai
Dr. (Smt.) Meera Venkatesh	:	BARC
Shri S.P. Agarwal (Member Secretary)	:	AERB

PROVISIONAL LIST OF RELEVANT REGULATORY DOCUMENTS ON RADIOLOGICAL SAFETY

Safety Series No.	Title
AERB/SC/IR-1	Industrial Radiography
AERB/SC/TR-1	Transport of Radioactive Material
AERB/RF-IR/SS-1 (Rev.1)	Industrial Gamma Radiography Exposure Devices and Source Changers
AERB/SS-3 (Rev-1)	Testing and Classification of Sealed Radioactive Sources
AERB/SG/IN-3	Handling of Radiation Emergencies in Industrial Radiography
AERB/SM//MED-2	Handbook for Medical Management of Persons Exposed in Radiation Accidents

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

Published by: Atomic Energy Regulatory Board,
Niyamak Bhavan, Anushaktinagar.
Mumbai – 400 094