



DEPARTMENT OF HEALTH
Republic of South Africa

CODE OF PRACTICE FOR INDUSTRIAL RADIOGRAPHY (GAMMA RADIOGRAPHY)

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DEFINITIONS

- i) "*Approved*" means approved by the Director-General: Department of Health.
- ii) "*Directorate*" means the Directorate Radiation Control, Department of Health.
- iii) "*Enclosed exposure facility*" means a permanent, shielded installation or structure designed for industrial radiography, which incorporates a fixed exposure device and in which such work is regularly performed.
- iv) "*Gamma radiography*" means industrial radiography performed with radioactive nuclides.
- v) "*Guide tube*" means a flexible or rigid sheath or tube for guiding the source assembly from the source container to the working position.
- vi) "*Industrial radiographer*" means a person authorised by the Department to perform industrial radiography.
- vii) "*Industrial radiography*" means work involving the examination of the structure of materials by non-destructive methods, utilising ionising radiation. Specifically included in the definition of industrial radiography work are all procedures which are significant from a radiation safety point of view, such as the detachment and attachment of winding cables to source assemblies, the winding in and out of radioactive sources, the monitoring of radiation levels, etc.
- viii) "*Operator*" means a person who performs industrial radiography in an enclosed exposure facility.
- ix) "*Overexposure*" means any exposure of a person to ionising radiation to an extent that an annual dose limit is exceeded.
- x) "*Radiography in open areas*" means radiography not performed in an enclosed exposure facility.
- xi) "*Remote control system*" means the device which enables gamma radiography apparatus to be operated at a safe distance, and which comprises a winding cable, winding cable sheath and winding control mechanism (e.g. reel with crank handle).
- xii) "*Source assembly*" means the pen-shaped device or pigtail into which a sealed radioactive nuclide is incorporated for the purposes of industrial radiography.
- xiii) "*Source container*" means the shielding container in which a sealed radioactive nuclide is transported and stored.
- xiv) "*Source encapsulation*" means the small outer metal sheath which surrounds a radioactive source and which connects it to the source assembly.
- xv) "*Trainee*" means a person who has successfully completed an approved examination in industrial radiography, but who has not yet obtained the necessary 480 working hours practical experience under the supervision of an approved and authorised industrial radiographer.

1. INTRODUCTION

Radioactive nuclides used in industrial radiography are subject to regulatory control in terms of Article 3A of the Hazardous Substances Act, 1973 (Act 15 of 1973), as amended. The body responsible for administering this legislation is the Directorate: Radiation Control, Department of Health.

Industrial Radiography units emit sufficient ionising radiation to constitute a significant health hazard unless adequately shielded and handled with proper care. This code of practice has been drawn up in order to limit the risk of overexposure of workers and members of the public, and to keep radiation doses as low as is reasonably achievable (ALARA principle). **Wherever the word must is used in this document, it implies that the requirement in question is compulsory. Where the word should is used, compliance is strongly recommended, but is not mandatory.**

The holder of an authority must ensure that the requirements laid down in this code are adhered to at all times, refer to Regulation 5 of the Regulations relating to Group IV Hazardous Substances (No 247 of 26 February 1993).

The latest version of this document as well as all radionuclide forms and guidelines can be downloaded from:
<http://tinyurl.com/pne5nyv> .

2. ADMINISTRATIVE AND MEDICAL REQUIREMENTS

- 2.1 An application for an authority to possess and use a radioactive nuclide must be submitted to the Directorate on form RN 787. The applicant must show that he possesses the necessary equipment, facilities and trained personnel to ensure that the radiographic work will be performed in a safe manner. Should the holder of the authority wish to import or export a radioactive nuclide, an application must be submitted to the Directorate on form RN781 or form RN782.
- 2.2 The person nominated to act as the Radiation Protection Officer (RPO) must either be a full-time employee or the owner. The person nominated to act as the Acting Radiation Protection Officer (ARPO) must either be a full-time employee or a contract worker. Persons nominated to act as RPOs or ARPOs must pass an approved examination before they can assume these positions. **Candidates must have an approved Level II Industrial Radiography qualification with two years' experience.** A service contract must be compiled between the holder and the RPO/ARPO in terms of Regulation 6(5) of the Group IV Hazardous Substances Regulations (No 247 of 26 February 1993). Responsibilities for the transfer of duties when resigning or when the contract expires must be included in the service contract.
- 2.3 Should the radiation protection officer (RPO) or acting RPO change at any stage, the Department must immediately be informed of the change on form RN 785. A copy of the required service contract between the holder and the new RPO/ARPO compiled in terms of Regulation 6(5) of the Group IV Hazardous Substances Regulations (No 247 of 26 February 1993) must be attached.
- 2.4 An application for registration with the Directorate as an industrial radiographer must be made on form RN 778. Certified copies of documents must be included to show that a course at an approved educational institution has been successfully completed. The course must include both the technical and safety disciplines. Candidates must **subsequently** undergo a practical training period of 480 effective working hours under the supervision of an approved and authorised industrial radiographer. The practical training must be confirmed in a logbook signed by the supervisor. The logbook must give a description of the work performed.
- 2.5 The holder of the authority must ensure that a document is drawn up outlining correct working procedures. The document must include details of all relevant safety procedures laid down by the Directorate (i.e. it is recommended that this code form a major part of the document) and must specify what actions are to be taken in the event of an emergency. The holder of the authority must take steps to ensure that his employees adhere to the correct working procedures.

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- 2.6 A separate health register must be established for each radiation worker. This register must be retained in safe custody, protected and safeguarded from fire, theft or destruction for a period of at least 5 years by the holder of the authority.
- 2.7 When the South African Bureau of Standards (SABS) reports to the authority holder that an employee's personal dosimeter (Thermo Luminescent Dosimeter (TLD)) has registered more than the pro rata dose allocation (4 mSv) for the wearing period, the holder must complete form RC010 and forward it to the Directorate. The holder must furthermore ensure that a copy of this form is entered into the health register of the worker in question.
- 2.8 Radiation workers must be declared medically fit by a company appointed doctor before employment. A copy of this pre-employment medical evaluation must be entered into the health register of the worker concerned. A medical examination must also be performed at termination of radiation work with the employer. A copy of the post-employment medical evaluation must be kept in the health register of the relevant worker.
- 2.9 Medical examinations must be carried out:
- during registration/deregistration of radiation workers
 - when a radiation incident is suspected
 - when the Director General or a medical practitioner deems it necessary
 - when the radiation worker has a reasonable suspicion that his/her health may be detrimentally affected by certain occupational factors.
- 2.10 When the SABS reports to the authority holder that an employee's personal dosimeter (TLD) has registered more than 50 mSv for the wearing period or if the Directorate so requires, a blood sample must be drawn from that employee and be sent to iThemba Labs (previously known as the National Accelerator Centre) at Faure for biological dosimetry within 30 days of being notified by the SABS. The procedure for the taking and sending of the blood sample must be discussed with the Directorate.
- 2.11 When a radiation worker ceases to be employed by the authority holder, the holder must provide that worker with a copy of his/her complete dose record. Such complete records can be obtained from the SABS on request.
- 2.12 Once a year the holder of an authority must furnish the Directorate with a return on form RN784, confirming that the details on his/her current authority are complete and correct. This return is due each year before the end of January.
- 2.13 The holder of the authority shall not transfer any industrial radiography sources unless this is done with the prior approval of the Directorate. This requirement refers to situations where sources are transferred between companies and when sources are permanently transferred between different sections of a company.

3. EQUIPMENT SPECIFICATIONS

- 3.1 The source container must in general (unless otherwise specified by the Director-General) comply with the requirements of the international standards ISO 3999, as well as the IAEA requirements for a type B(U) container. These documents must be submitted to the Directorate for approval. Validated Type A source containers may be used but this will limit the activity of radioactive sources that may be loaded as well as the movement of these sources.
- 3.2 The source container must be capable of being locked in the shielded or "off" position.
- 3.3 The container must be indelibly marked with the trefoil symbol, the word "radioactive", the maximum rating of the container, as well as the manufacturer's type and serial number. These markings may not be covered by any other labels.
- 3.4 In addition, the container must bear an IAEA approved transport label, in accordance with the radiation levels associated with the unit (See fig 1 annexure 1), as well as a durable (e.g. metal or plastic), legible label indicating the type of nuclide, the activity on a specified date, and the serial number of the sealed radioactive source (See fig 3 annexure 1). These labels may not cover any other required labels or

information on the container. Transport over packs must be used where transport labels will obscure other required markings and labels on the source container.

- 3.5 When the source assembly is in the shielded or "off" position, the dose rate must not exceed the following limits:
- 3.5.1 2 mSv/h (200 mR/h) at any point on the surface of the container.
- 3.5.2 At any point 1 m from the surface of the container:
- portable containers: 20 μ Sv/h (2 mR/h)
 - mobile containers: 50 μ Sv/h (5 mR/h)
 - fixed containers: 100 μ Sv/h (10 mR/h)
- Portable containers are those which weigh less than 50 kg, mobile containers are those which are not portable but which can be easily moved by suitable means, and fixed containers are those with mobility restricted to the confines of a particular working area.
- 3.6 There must be a provision to prevent the unauthorised operation of the remote control device when the operator is not in immediate attendance, for example, a removable winding cable handle.
- 3.7 Apparatus for gamma radiography should **preferably** be provided with a visual indicator to show whether the source assembly is in the secured, or working, position. Such an indicator may, however, at no time be used in place of prescribed monitoring procedures.
- 3.8 During storage or transport, apparatus for gamma radiography must be fitted, at each end, with suitable protective caps or plugs to protect the source assembly from water, sand or other foreign matter.
- 3.9 The length of the winding cables used for industrial radiography in open areas must comply with the requirements of paragraph 7.2.12 and the guide tube must be as short as practicable.
- 3.10 The sealed source itself must comply with ISO 2919, as well as the "special form" requirements laid down by the IAEA. The activity of the source must be as low as practicable - in general, activities requiring exposure times of less than one minute should **preferably** not be used.
- 3.11 The word "Radioactive" must be engraved in a durable and legible manner on the source encapsulation.
- 3.12 The coupling between the source assembly and the winding cable must be designed in such a manner that the source assembly will not become disconnected if cranked outside the guide tube. The coupling must be such that it cannot be unintentionally disconnected under normal and reasonably foreseeable abnormal conditions.
- 3.13 The source assembly should be automatically secured when it is cranked back into the fully retracted position within the source container. This securing system may only be released by means of a deliberate action on the apparatus.
- 3.14 The dimensions of the winding cable, winding cable sheath, guide tube, and associated connectors and couplings must be within the tolerances specified by the manufacturer of the source container.
- 3.15 An exposure head or similar device designed to prevent the source assembly from passing out of the end of the guide tube must be attached to the outermost end of the guide tube during radiographic operations.
- 3.16 Only lubricants specified by the manufacturer of the source container may be used on radiography equipment and associated accessories. (Usually graphite powder is recommended. Oils must not be used.)

4. SPECIFICATIONS FOR ENCLOSED EXPOSURE FACILITIES

Any facility that does not comply with the following requirements is considered to be an open area (for example an exposure bay with walls, maze and portable equipment).

- 4.1 The remote control shall be placed outside the enclosure.
- 4.2 An enclosed exposure facility may not be located in an area zoned for domestic use.

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- 4.3 The facility must be clearly marked with radiation warning signs, and the name and telephone number of a person to be contacted in the event of an emergency, must appear at the entrance to the facility.
 - 4.4 The facility must incorporate a means to indicate positively that an exposure is underway. In the case of a gamma radiography installation, the facility must incorporate warning lights activated by a radiation detector. In the case of an electrically activated unit, the facility must incorporate warning lights linked to the on-off mechanism of the unit.
 - 4.5 Facilities in which electrically activated gamma radiography apparatus are installed must have interlock systems which prevent exposure if one of the entrance doors is opened before exposure or opened during exposure. Resumption of exposure must be possible only after manual restart at the control panel, after the door has been closed.
 - 4.6 Facilities in which manually activated gamma radiography apparatus is used must have a safety system which either prevents access to the facility during exposure, or which gives an audible alarm if attempts are made to enter it.
 - 4.7 Radiographic apparatus which is not manually operated must be designed so that system failure automatically causes the apparatus to return to the secured mode. In addition, gamma radiography apparatus must be provided with a manual means of returning the source assembly to the shielded position.
 - 4.8 Enclosed exposure facilities must be provided with a device which makes it possible for a person accidentally left in the room, to open one of the doors easily and leave.
 - 4.9 In facilities having more than one entrance door, the doors that are not controlled by the operator must be lockable from the inside, and the door under his/her control, lockable from the outside. If the facility has only one door it must be lockable from the outside.
 - 4.10 The radiation dose rate outside the exposure facility must comply with the requirements of paragraphs 10.1 to 10.3, and at a distance of 1 m from the outer surface of an enclosed installation should preferably not exceed 2.5 $\mu\text{Sv/h}$ (0.25 mR/h), but must not exceed 7.5 $\mu\text{Sv/h}$ (0.75 mR/h) when the properties of the radiation source correspond to the maximum ratings stated for that enclosed installation.
 - 4.11 Enclosed installations must be provided with a sign stating the maximum rating and limitations on the primary beam directions established for that installation.

5. STORAGE REQUIREMENTS

- 5.1 No radioactive nuclides or radiography apparatus containing such material may be stored on any premises zoned for domestic purposes.
- 5.2 When in storage, radiography source containers containing radioactive nuclides must be locked in the "off" (fully shielded) position.
- 5.3 Warning signs, of a design approved by the Directorate, must be displayed at the entrance to radionuclide storage facilities, and at any other appropriate places, so as to clearly indicate the presence of radioactive material.
- 5.4 Dose rates outside radionuclide storage facilities must comply with the requirements of paragraphs 10.1 to 10.3 and must not exceed 2.5 $\mu\text{Sv/h}$ (0.25 mR/h).
- 5.5 A notice containing the names and telephone numbers of persons who can be contacted in the event of an emergency, must be displayed at radionuclide storage facilities.
- 5.6 Radionuclide storage facilities must be lockable and no unauthorised entry shall take place.
- 5.7 It is the responsibility of the radiographer to ensure personally that the radioactive source is safely returned after use to the storage facility. This important task may not be delegated to radiographic assistants or trainees.
- 5.8 A log of gamma radiography equipment must be kept on form RN 780. Source containers must be signed into and out of the storage facility and dose levels on the surface of the containers recorded. The serial number of monitors used and the condition of the equipment must also be noted.

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- 5.9 No radioactive nuclides may be stored with, or in close proximity to any corrosive, combustible or explosive materials.
- 5.10 Outside storage facilities (storage pit) must be weatherproof. The storage pit should have a raised floor where there is the possibility that water may enter the storage area.

SECURITY MEASURES AT STORAGE FACILITIES

- 5.11 Premises where storage areas are located must at least be linked to a 24 hour security reaction unit.
- 5.12 The storage area must have two layers of barriers to create a delay mechanism (e.g. devil's fork type security fence with locked gate and corrugated iron roof plus storage pit with locked lid **or** building with locked door plus locked safe inside building). Access to the storage area must be restricted to members of industrial radiography teams.
- 5.13 There must be an immediate electronic detection (alarm) of unauthorised access to the secured area/source location (e.g. movement detector at first barrier plus tamper switch at second barrier). This alarm must be able to be detected by appointed responsible personnel (e.g. 24 hour security reaction unit).
- 5.14 Assessment of the detection of a security breach must be available (investigation by responsible personnel e.g. 24 hour security reaction unit or assessment of 24 hour CCTV surveillance).
- 5.15 Rapid, dependable means of communication (cell phones) must be available. Responsible personnel must be able to immediately initiate a response to any detected adverse action (contact RPO, Police etc).
- 5.16 A weekly physical check of storage areas is required to detect the possible loss of any sources. The working condition of alarm/security systems must also be checked weekly.
- 5.17 Mobile/ portable sources must be under continuous surveillance by appointed responsible personnel during transportation. Rapid, dependable means of communication (cell phones) must be available.
- 5.18 In general, a vehicle may not be left unattended with a radioactive source in it. However, an exception may be made if a person is required to make an over-night stop during transportation of a radioactive source and a suitable storage facility is not available. In such a case the radioactive source container must be considered as being under transport during the night. The radioactive source container must be locked inside a vehicle with an alarm system such that access to the container will activate the alarm. The vehicle must be securely locked and parked in the safest possible area where it will be under constant surveillance of the overnight establishment security. Where practicable, the vehicle must be left on the premises of a police station during the night.
- 5.19 When sources are used in isolated **high risk** areas with no security nearby, special arrangements for the on-site availability of security (armed guards) must be made.

6. TRAINING REQUIREMENTS

6.1 Radiation Protection Officer

The Radiation Protection Officer must ensure that all persons performing industrial radiography or who act as radiographic operators and assistants have the necessary training and are familiar with the correct operating and safety procedures. In particular the training requirements specified below must be met.

6.2 Initial training requirements

- 6.2.1 Persons wishing to work as industrial radiographers must successfully complete a course in industrial radiography at an approved institution. The course must include both the technical and safety disciplines. Candidates must **subsequently** undergo a practical training period of 480 effective working hours under the supervision of an approved and authorised industrial radiographer. The practical training must be confirmed in a logbook signed by the supervisor. The logbook must give a description of the work performed. An application for a personal authority to act as a qualified industrial radiographer must be submitted to the Directorate on form RN 778.

- 6.2.2 Assistants to the radiographer and operators of enclosed exposure facilities must be given sufficient training to enable them to carry out their work satisfactorily. Such training must include information on the risks associated with ionising radiation, prescribed safety requirements and emergency procedures, as well as practical on-the-job training. After such training, the assistant's/operator's knowledge and understanding must be evaluated, in order to gauge the effectiveness of the training programme.

6.3 Periodic Training of all radiation workers

- 6.3.1 All radiation workers (e.g. radiographers, trainees, assistants and operators) must be given periodic training in radiation safety aspects relating to their work at least once a year. The training must ensure, in particular, that workers have a thorough knowledge of the procedural document referred to in paragraph 2.5. Such training must include an evaluation of the workers' knowledge and understanding of the training material.

6.4 Observations

- 6.4.1 The holder of an authority must ensure that the Radiation Protection Officer regularly observes the performance of all radiation workers during actual radiographic operations, in order to establish whether correct operating procedures and Departmental requirements are being adhered to. Each worker must be observed at least once every 3 months.
- 6.4.2 Where a radiation worker has not participated in a radiographic operation for more than 3 months, or where a worker has not used a particular type of radiographic apparatus for the above period, the Radiation Protection Officer must observe that individual's performance the next time he participates in radiographic operations.

6.5 Records of training and observations

- 6.5.1 Records must be kept of all training and observations conducted. These records must include details of the performance of radiographers during observations as well as information regarding attendance and content of training courses. As far as periodic training and training of radiographic assistants and operators are concerned, records must also be kept of tests or other methods which have been used to determine the individual's knowledge and understanding of safety requirements and operating procedures.

7. HANDLING PROCEDURES

7.1 General Requirements

- 7.1.1 Industrial radiography may only be performed by:
- 7.1.1.1 a qualified radiographer who has been granted a personal authority from the Directorate to perform such work; or
 - 7.1.1.2 a trainee industrial radiographer under the direct supervision of a fully qualified and authorised industrial radiographer; or
 - 7.1.1.3 an operator performing such work in an enclosed exposure facility.
- 7.1.2 In the case of a trainee, the qualified radiographer must be physically present at all times during radiography work, and assumes full responsibility for the actions of the trainee.

7.2 Radiography in Open Areas

- 7.2.1 Before commencing work, a radiographer must ensure that he/she, and the other members of the radiography team (i.e. radiographers, trainee radiographers and assistants), are wearing personal dosimeters (TLDs), and that he/she has in his/her possession a functioning radiation monitor. In addition to the afore-mentioned, every member of the radiography team must be wearing a functioning digital audible-alarm dosimeter with a history function (as specified in paragraph

- 9.2). The radiographer must also have the equipment necessary for the setting up of barriers (e.g. barrier rope, mechanical supports, etc.) as well as radiation warning signs and, in the case of night-work, warning lights.
- 7.2.2 Radiography equipment, accessories and auxiliary apparatus (i.e. radiation monitors, alarm dosimeters, etc.) must be checked daily by the radiographer before and after use, and the condition of such equipment noted in the logbook. If any equipment is not in a proper working order, radiography must NOT be carried out.
- 7.2.3 Appropriate collimators must be used for reduction of the field size of the primary beam to the minimum practicable size necessary for the performance of the work. Where it is not possible to use a collimator, other appropriate shielding material should be used.
- 7.2.4 Barriers must be erected at a distance calculated prior to commencing the exposure, so as to ensure that the instantaneous dose rate at the barrier is as low as is reasonably achievable and does not exceed 10 $\mu\text{Sv/h}$ (1 mR/h). Once the radiography unit has been activated, the radiation level at the barriers must be checked with a monitor and the barriers moved, if necessary, to ensure that levels are acceptably low.
- 7.2.5 In addition to the requirements of paragraph 7.2.4 and section 10 (regarding dose limitations), the radiographer must ensure, during the course of his/her work, that no individual is exposed to radiation in excess of the following levels -
- 7.2.5.1 Workers not wearing Personal Dosimeters: 20 μSv (2 mrem) in any one day.
- 7.2.5.2 Members of the Public: 4 μSv (0.4 mrem) in any one day.
- 7.2.6 Warning signs and, at night, warning lights must be prominently displayed at the barrier and must be visible from all directions.
- 7.2.7 Before commencing the exposure the radiographer must ensure that no people are within the demarcated area.
- 7.2.8 Boundaries of adjacent sites on which industrial radiography is done should not overlap. If overlap is unavoidable, close liaison shall be maintained between operators responsible for the overlapping sites to avoid accidental exposure.
- 7.2.9 During the exposure, the radiographer, or one of his/her assistants, must be in attendance near the demarcated area, in order to take immediate corrective measures should any unplanned entry into the area take place.
- 7.2.10 After rewinding a source assembly and before rolling up the guide tube, the radiographer must personally ensure by monitoring the entire circumference of the source container, as well as the length of the guide tube, that the radioactive source has indeed safely returned to the fully shielded position. Once this has been established, the radiographer must lock the source container.
- 7.2.11 Before a site is vacated, the operator shall ensure, by monitoring, that all radiation sources are locked in the fully shielded condition or switched off, as appropriate, and returned to the source container store or to the transport vehicle and that all boundary-defining equipment has been removed. The operator shall inform the person responsible for the area when this has been carried out.
- 7.2.12 Taking the ALARA principle into account and to ensure an average dose rate of ± 2 mSv/h (200 mR/h) at the position of the winding unit, the length of the winding gear must comply with the following:
- 7.2.12.1 When radioactive sources **not** exceeding 2,4 TBq (65 Ci) of Se-75 or 1,11 TBq (30 Ci) of Ir-192 or 370 GBq (10 Ci) of Co-60 are used, the winding gear must be long enough to ensure a distance of at least 7,5m between the winding unit and the source container.
- 7.2.12.2 When radioactive sources exceeding 2,4 TBq (65 Ci) of Se-75 or 1,11 TBq (30 Ci) of Ir-192 or 370 GBq (10 Ci) of Co-60 but not exceeding those mentioned in 7.2.12.3

are used, the winding gear must be long enough to ensure a distance of at least 10m between the winding unit and the source container.

- 7.2.12.3 When radioactive sources exceeding 4,07 TBq (110 Ci) of Se-75 or 1,85 TBq (50 Ci) of Ir-192 or 630 GBq (17 Ci) of Co-60 are used, the winding gear must be long enough to ensure a distance of at least 15m between the winding unit and the source container.

Emergency equipment (e.g. additional shielding material, long-handled tongs, emergency transport containers, etc.) should preferably be present at the site where the work is performed.

- 7.2.13 Radiography apparatus containing radioactive sources may not be left unattended unless it is locked in an approved storage facility, or is under transport and is temporarily stored in accordance with the provisions of paragraph 11.4
- 7.2.14 A radiography team operating one radiography unit must consist of one radiographer and at least one assistant. The assistant shall be capable of promptly taking charge in an emergency and shall be able to:
- 7.2.14.1 ensure that no person remains unnecessarily in an area where the dose rate exceeds or might exceed 25 $\mu\text{Sv/h}$ (2,5 mR/h);
 - 7.2.14.2 recognise a loose gamma radiography source by being familiar with the dummy source (or its photograph) supplied with the gamma radiography equipment; and
 - 7.2.14.3 inform the radiation protection officer and the authority holder of the emergency without delay.

7.3 Radiography in Enclosed Exposure Facilities

- 7.3.1 Before commencing the exposure, the operator must ensure that there is nobody inside the exposure facility.
- 7.3.2 The exposure must be terminated according to the correct termination procedures. Use of safety devices such as interlocks for exposure termination is not permitted.
- 7.3.3 Before entering the enclosed exposure facility after an exposure, the operator must make certain that the exposure has been terminated. If manually activated gamma radiography apparatus is used, the operator must use a functioning radiation monitor to monitor the source container, as well as the length of the guide tube to ensure that the radioactive source has indeed safely returned to the fully shielded position.
- 7.3.4 When the facility is not in use, the unit must be rendered inoperable by locking the control panel and removing the key, or by inactivating the winding gear (e.g. by locking or removing the handle) in the case of manually operated units.
- 7.3.5 The operator must ensure compliance with all the limitations established for the enclosed installation, e.g. the limitations with respect to beam direction and source activity of industrial radiography equipment. If these conditions are not satisfied, the installation is no longer considered to be an enclosed installation, and the work must be carried out in accordance with the requirements for open installations.
- 7.3.6 Persons performing radiography in an enclosed exposure facility must wear TLDs.

8. PERIODIC TESTING AND MAINTENANCE OF EQUIPMENT

- 8.1 The items of radiography equipment specified below must be submitted for periodic testing and maintenance to an institution which is authorised by the Director-General to perform such tests: -
- 8.1.1 Source assemblies ("pigtailed")
 - 8.1.2 Source containers
 - 8.1.3 Guide tubes, winding cables and winding cable sheaths.

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- 8.2 All items of equipment which fail the prescribed tests, or which do not meet the requirements specified below, must be replaced, or repaired and retested.

SOURCE ASSEMBLIES (“PIGTAILS”)

- 8.3 Disposable source assemblies must not be used for a period exceeding that specified by the manufacturer and must be replaced when found necessary (i.e. if they fail the tests specified in paragraph 8.5). Re-useable source assemblies, including those which contain nuclides imported directly by the holder of an authority, must be tested and maintained in accordance with paragraph 8.5.
- 8.4 Source assemblies containing nuclides with relatively long half-lives (such as Co-60), must be replaced whenever a new radioactive source is loaded. Such source assemblies must not be used for a period exceeding that specified by the manufacturer.
- 8.5 The following tests must be carried out by an approved testing facility with every radioactive source change, and at intervals not exceeding 6 months for assemblies containing nuclides with relatively long half-lives (e.g. Co-60):
- 8.5.1 The source assembly must be thoroughly cleaned and inspected for visible damage such as wear, stretching and source attachment thread damage.
 - 8.5.2 The socket on the end of the source assembly where the winding cable is attached must be examined for wear and damage using an approved template gauge.
 - 8.5.3 A tensile test must be performed on the source encapsulation attachment to the source assembly. This shall consist of a load of 495 N applied to the components for a period of 30 seconds.
 - 8.5.4 The markings on the source assembly must be checked to ensure that they comply with the requirements of paragraph 3.11.

SOURCE CONTAINERS

- 8.6 Periodic testing and certification of portable and mobile source containers must be carried out at intervals not exceeding 24 months at an approved testing facility. The testing programme must comprise of all the tests prescribed by the manufacturer and must include checks on the container for compliance with the following:
- 8.6.1 The container must be marked in accordance with paragraph 3.3 and 3.4, the marking plate and labels being firmly attached and legible.
 - 8.6.2 The container must not show any signs of external damage or deformation that could affect its safe operation or shielding function (as specified in paragraph 3.5) and must be complete.
 - 8.6.3 After first removing the radioactive source assembly to a shielded storage container, the container must be dismantled to such an extent that all internal parts, including the shutter and exposure channels, can be inspected. These parts must be clean and must not show signs of excessive wear or damage.
 - 8.6.4 No screws, bolts or nuts must be loose or missing.
 - 8.6.5 Mechanisms which connect the guide tube and winding gear to the container must not show any signs of unacceptable wear or damage.
 - 8.6.6 The shutter and/or locking mechanism, the locking device (e.g. key) and the securing system referred to in paragraph 3.13, must not show signs of excessive wear or damage and must function faultlessly.
 - 8.6.7 All safety plugs and protective caps (as specified in paragraph 3.8) must be present, undamaged and must function correctly.
 - 8.6.8 No radioactive source may be loaded into an uncertified (untested) container.

GUIDE TUBES, WINDING CABLES & WINDING CABLE SHEATHS

- 8.7 Periodic testing of winding cables, winding cable sheaths and guide tubes must be carried out at intervals not exceeding 24 months at an approved testing facility. The testing programme must comprise of all the tests prescribed by the manufacturer and must include checks on the above-mentioned items for compliance with the following:
- 8.7.1 The guide tube and winding cable sheath must not show signs of excessive wear or damage and must not be brittle, cracked or kinked in any way.
 - 8.7.2 The connecting device/s which attaches the winding gear to the source container must be undamaged and function correctly.
 - 8.7.3 The winding cable (especially near the ball attachment joint) must not contain any damaged strands and the cable must not be bent to such an extent that it is impossible to straighten it without the use of tools.
 - 8.7.4 The cable must be clean, free from corrosion and must comply with the requirements of paragraph 7.2.12 regarding length.
 - 8.7.5 The connection between the winding cable and the source assembly must withstand a tensile force of 495 N for 30 seconds, and must comply with the requirements of paragraph 3.12 regarding cranking outside of the guide tube.
 - 8.7.6 The winding control mechanism must be dismantled and inspected thoroughly. The mechanism must not show signs of serious wear or damage that might endanger its safe operation, and must comply with the requirements of paragraph 3.6.
 - 8.7.7 The guide tube, winding cable and sheath, and associated connectors and couplings must comply with the requirements of paragraph 3.14 regarding manufacturer's specifications.
 - 8.7.8 The complete remote control system must function faultlessly.

LEAK TESTS

- 8.8 Sources not exchanged within 6 months must be leak tested at intervals not exceeding 6 months.
- 8.8.1 Ensuring the source is in the fully shielded position, wipe the outer surface of the source container and source outlet port as well as the inside of the guide tube, with a piece of absorbent material (e.g. tissue or filter paper).
 - 8.8.2 Place the tissue or filter paper in a plastic bag and send by road, rail or air freight to your nearest leak testing facility (See website for Leak Test Code of Practice containing names and addresses of testing facilities). The smear sample must not be sent via the post office.
 - 8.8.3 Once the testing facility has notified you of the result of the test, it must be entered on form RN 608 or similar document which must be filed for inspection purposes.

OTHER TESTS

- 8.9 In addition to all of the above-mentioned tests, the testing facility must carry out any further tests which they deem are necessary to ensure that the radiography equipment functions correctly.
- 8.10 If used (second-hand) radiography equipment is acquired, such equipment must be subjected to all appropriate tests specified above, **before** being brought into use.
- 8.11 The holder of the authority must keep documentary evidence of all of the above-mentioned tests for a period of at least 3 years. Such documents must be available for inspection purposes.

9. RADIATION MONITORING REQUIREMENTS

- 9.1 Each member of an industrial radiography team (i.e. radiographers, trainee radiographers, student radiographers and assistants) as well as operators must be registered at the SABS as a radiation worker and be issued with a Thermo Luminescent Dosimeter (TLD) from the SABS. The worker's unique Bureau Identification Number (BIN) must be indicated on the personal dosimeter (TLD) when returned to the

SABS for processing. No “blank” TLDs may be issued to any member of a radiography team. No radiation worker may perform industrial radiography work without a TLD issued in his/her name.

- 9.2 In the case of work with radionuclides in open areas, all members of the radiography team, as well as any other workers who are likely to receive more than 200 μSv (20 mrem) during any one day must, in addition to the above, be issued with a digital audible-alarm dosimeter with a history function. The alarm dosimeter must be set to give an alarm signal at a dose rate of 5 mSv/h (500 mR/h) and must be able to give a clear audible response at dose rates in excess of 500 mSv/h without saturation. Daily doses must be accurately recorded, and such records kept for a period of at least 5 years. (Regulation 22(6) and (7))
- 9.3 Digital audible-alarm dosimeters must be checked for correct response to radiation at an approved facility, at periods not exceeding 26 months.
- 9.4 The dosimeters specified in paragraphs 9.1 and 9.2 above, must be **worn** by radiation workers (i.e. attached to their clothing) during the course of their work.
- 9.5 Each radiography team must be provided with a radiation monitor (dose-rate meter) with a range sufficient to measure 10 $\mu\text{Sv/h}$ (1 mR/h) through to at least 10 mSv/h (1 R/h). When radiation levels exceed the maximum readings in their measurement ranges, they shall continue to indicate that fact and should provide an audible warning. This monitor must be calibrated at an approved facility at periods not exceeding 7 months, and after servicing of the instrument.
- 9.6 Before starting work, the radiation workers must ensure that the above dosimeters and monitors are in place, and in proper working order. **If not, the radiography work must not be carried out.**

10. DOSE LIMITATION

- 10.1 Radiation doses to individuals must at all times be kept as low as is reasonably achievable (ALARA).
- 10.2 In addition to the requirement of ALARA, the holder of the authority, as well as radiation workers, must ensure that radiation doses to individuals (including themselves) do not exceed the limits specified by the Directorate:

SUMMARY OF DOSE LIMITS

APPLICATION	OCCUPATIONAL DOSE LIMIT	PUBLIC DOSE LIMIT
Effective Dose	* 20 mSv per year, averaged over 5 years, and not more than 50 mSv in any 1 year.	** 1 mSv per year
Annual Equivalent Dose to lens of the eye	20 mSv	15 mSv
skin	500 mSv	50 mSv
hands and feet	500 mSv	-

* *Additional restrictions apply to the exposure of pregnant women.*

** *In exceptional cases, this may be exceeded provided that the average over 5 years is less than 1mSv per year.*

- 10.3 Exposures in excess of the dose limits which occur as a result of circumstances which cannot reasonably be considered as being under the control of the holder of the authority or the radiation workers, will, however, not be viewed as a statutory infringement.

11. TRANSPORT

- 11.1 Radioactive sources used for industrial radiography must be transported in accordance with the requirements of the current edition of "Regulations for the Safe Transport of Radioactive Materials", published by the IAEA, as well as relevant Departmental regulations.
- 11.2 An enclosed and lockable vehicle should be used to transport radioactive sources. Radioactive source containers must be locked inside a transport container permanently fixed to the vehicle if an open vehicle is used.

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- 11.3 The vehicle referred to in 11.2 must be fitted with a satellite vehicle recovery system. The system must provide countrywide coverage, including border posts.
- 11.4 In general, a vehicle may not be left unattended with a radioactive source in it. However, an exception may be made if a person is required to make an over-night stop during transportation of a radioactive source and a suitable storage facility is not available. In such a case the radioactive source container must be considered as being under transport during the night. The radioactive source container must be locked inside a vehicle with an alarm system such that access to the container will activate the alarm. The vehicle must be securely locked and parked in the safest possible area where it will be under constant surveillance of the overnight establishment security. Where practicable, the vehicle must be left on the premises of a police station during the night.
- 11.5 Three removable transport labels (see figure 2 annexure 1) must be displayed on a vehicle during transportation of radioactive sources, one sign on each side and one on the rear of the vehicle. The name and telephone number of a person to be contacted in the event of an emergency must also appear adjacent to the transport labels. Transport labels must be removed when the radioactive material is no longer in the vehicle.
- 11.6 The source container must be locked in the shielded ("*off*") position during transport.
- 11.7 The source container must bear IAEA approved transport labels, in accordance with the radiation levels associated with the unit. (See figure 1 annexure 1). These labels may not cover any other required labels or information on the container. Transport over packs must be used where transport labels will obscure other required markings and labels on the source container.
- 11.8 The source container must not be transported in the passenger's compartment of the transport vehicle and must be positioned as far as possible from any persons in the vehicle. The maximum dose rate at the position of any person in the vehicle shall not exceed 20 $\mu\text{Sv/h}$ (2mR/h).
- 11.9 Industrial radiography source containers may be dispatched by public freight transport (i.e. by ship, air or road) provided that the above requirements are met and the gauge is accompanied by properly completed transport documents specifying the radioactive content.
- 11.10 If a source container is, or appears to be damaged in transport, the following actions shall be taken:
- 11.10.1 The person or persons responsible for the container at the time of the incident shall notify the holder of the authority and the Directorate.
- 11.10.2 The owner shall ensure that the source container is carefully examined to verify that it continues to comply with the Regulations by carrying out a radiation survey on the container.
- 11.11 The sender, conveyor and receiver of radioactive sources must each keep a log of sources dispatched and/or received. The log must include the date and time of delivery/dispatch, the names and identity numbers of persons that received/delivered the sources and the container and source serial numbers.
- 11.12 Any incident in which radioactive sources are misrouted or go missing during transportation (accidents, hijackings etc) must immediately be reported to the Directorate in accordance with paragraph 12.

12. EMERGENCY PROCEDURES

- 12.1 The document drawn up by the holder of the authority in terms of paragraph 2.5 must include a contingency plan describing procedures to be followed in the event of a radiation incident. The contingency plan must include the following:
- 12.1.1 Immediate action to be taken in order to prevent excessive radiation doses.
- 12.1.2 Internal and external notification procedures.
- 12.1.3 Procedures for dealing with the incident and returning the situation to normal.
- 12.1.4 Information regarding medical examinations and blood tests.

12.2 **THE DIRECTORATE MUST BE NOTIFIED IMMEDIATELY BY TELEPHONE AND THE INFORMATION MUST BE REPORTED IN WRITING TO THE DIRECTORATE WITHIN 7 DAYS IN THE FOLLOWING INSTANCES (SEE REGULATION 16):**

- 12.2.1 If the authority holder is not able to deal with an emergency situation in a safe and acceptable manner with the equipment at his/her disposal, or if he does not have personnel who are trained to handle such situations.
- 12.2.2 If there is the likelihood of radioactive contamination occurring, or having occurred as a result of an incident.
- 12.2.3 If a radioactive source is lost or missing, in which case form RN900 must be submitted to the Directorate.
- 12.2.4 If any person is overexposed, or suspected of being overexposed in which case form RC010 must be submitted to the Directorate.

(EMERGENCY TELEPHONE NUMBERS: During office hours, phone 021-948 6162; Fax: 021-946 1589. After hours, call the Necsca 24-hour National Emergency Centre on 012-305 3333.)

12.3 **ALL NON-ROUTINE OCCURRENCES RELATING TO RADIATION SAFETY MUST BE LOGGED AND REPORTED TO THE DIRECTORATE WITHIN 7 DAYS OF THE OCCURRENCE OF ANY OF THE FOLLOWING INCIDENTS:**

- 12.3.1 Unintentional disconnection of the source assembly from the control cable.
- 12.3.2 Inability to retract the source assembly to its fully shielded position and secure it in this position.
- 12.3.3 Failure of any component (critical to safe operation of the device) to properly perform its intended function.
- 12.3.4 The following information must be included in each report:
 - 12.3.4.1 A description of the equipment problem;
 - 12.3.4.2 Cause of each incident, if known;
 - 12.3.4.3 Manufacturer and model number of equipment involved in the incident;
 - 12.3.4.4 Isotope type, activity and serial number;
 - 12.3.4.5 Equipment maintenance reports/records;
 - 12.3.4.6 Place, time and date of the incident;
 - 12.3.4.7 Actions taken to establish normal operations;
 - 12.3.4.8 Corrective actions taken or planned to prevent recurrence;
 - 12.3.4.9 Qualifications of personnel involved in the incident.

12.4 Emergency equipment should be available. The recommended minimum requirements are:

- dummy source or photograph (incorporating an indication of the physical dimensions) of the dummy source;
- personal radiation monitoring device;
- two survey meters (one of them suitable for high dose rates);
- tongs (one metre and two metre lengths);
- pliers;
- screwdriver;
- adjustable spanner or wrench;
- other hand tools which are appropriate for the particular equipment;
- bags of lead shot (2 kg per bag), at least two of which are required for Ir-192 sources;
- a lead pot with wall thickness greater than 4 cm and/or lead sheet.

- 12.5 **Radiography personnel may not attempt to perform operations involving radioactive source retrieval or recovery of a source not in a shielded position unless they have had specific instruction and actual practice in retrieval operations with a dummy source.**
- 12.6 In the event of an overexposure or suspected overexposure, the personal dosimeter of the individual involved must immediately be forwarded to the SABS for processing.

13. DISPOSAL AND EXCHANGE

- 13.1 Authority holders must not dispose of radioactive sources without the approval of the Directorate. "Dispose" here includes sell, lend, donate, as well as the return of the radiation source to the supplier, but excludes an exchange as referred to in paragraph 13.3.
- 13.2 Should the holder wish to permanently discard a radioactive source at the Nuclear Liabilities Management (NLM) section of NECSA at Pelindaba, application must be made to the Directorate on form RN 525.
- 13.3 If the holder wishes to exchange a short half-life radioactive source (such as Iridium-192) at NTP Radioisotopes (Pty) Ltd, permission need not be obtained from the Directorate. The holder is, however, required to provide NTP Radioisotopes (Pty) Ltd with a Departmental "exchange form".
- 13.4 If the holder wishes to import a short half-life radioactive source (such as Selenium-75) directly, the prescribed procedure for the importation of radioactive sources must be followed as referred to in paragraph 2.1. The transfer of the imported source from the transport container to the source container must be performed in the presence of the RPO or ARPO. The document drawn up by the holder of the authority in terms of paragraph 2.5 must include a full description of the procedure to be followed for this transfer. The source container used must comply with the directives of paragraph 8.6. **No radioactive source may be loaded into an uncertified container.** The holder is also required to provide the Directorate with a Departmental "exchange form" as well as proof of the container certification.

REFERENCES

1. Government Gazette no. R247, February 1993 concerning regulations governing the Group IV Hazardous Substances Act, 1973 (Act 15 of 1973) as amended. *
2. Nordic Recommendations on Radiation Protection in Industrial Radiography, 1987.
3. Standard Specification for Apparatus for Gamma Radiography, SABS 1980 (SABS 1317). (International Standard ISO 3999 - 1977)
4. Radiation Protection - Recommendations in the Nordic Countries, 1976.
5. Regulations for the Safe Transport of Radioactive Material, IAEA Safety Series 6, 1985. **
6. Guide for the Preparation of Applications for the Use of Sealed Sources and Devices for Performing Industrial Radiography, U.S. Nuclear Regulatory Commission, 1984.
7. Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations, Part 34, US NRC Rules and Regulations, 1990.
8. Ionising Radiation Dose Limits and Annual Limits on Intake of Radioactive Material, Radiation Control, Department of Health, Bellville, 1992.
9. Proposed code of practice for the industrial use of ionising radiation, Part II: Radiation from listed electronic products, Document for committee draft stage SABS.
10. Suggested State regulations for control of Radiation, Volume I, ionising Radiation, U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration (1982).
11. The protection of persons against ionising radiation arising from any work activity, The Ionising Radiation Regulations 1985, Health and Safety Commission.
12. Suggested State Regulations for Control of Radiation Volume I, Ionising Radiation, U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration (1990).
13. Code of practice for the safe use of Industrial Radiography equipment (1989), Radiation Health Series no. 31, National Health and Medical Research Council, Australia (December 1989).

* *Copies obtainable from the State Library in Pretoria, the SA Library in Cape Town, Bloemfontein Public Library and the Natal Society Library in Pietermaritzburg.*

** *Can be ordered through most leading bookstores.*

ANNEXURE 1

Figure 1: Transport label for container

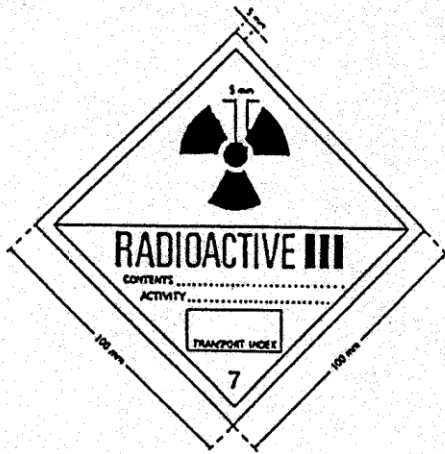


Fig 1: Category III -- Yellow label. The background colour of the upper half of the label shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black, and the colour of the category bars shall be red.

Figure 2: Transport label for vehicle

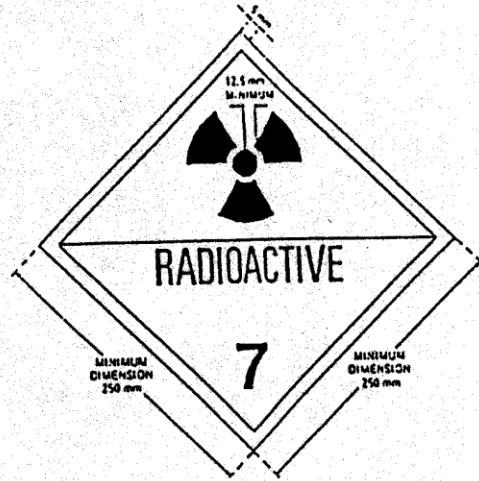


Fig 2: Placard. Minimum dimensions are given; when larger dimensions are used the relative proportions must be maintained. The figure '7' shall not be less than 25 mm high. The background colour of the upper half of the placard shall be yellow and of the lower half white, the colour of the trefoil and the printing shall be black.

Figure 3: NECSA label of source details

BRON	SOURCE
AKTIWITEIT	ACTIVITY
DATUM	DATE
BRON NO	SOURCE NO
HOUER NO	CONTAINER NO
RADIOAKTIEF	RADIOACTIVE