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GUIDELINE FOR CODE OF PRACTISE FOR INDUSTRIAL RADIOGRAPHY X-RAY

X-Ray equipment used in industrial radiography is subject to regulatory control in terms of Article 3(1) of the Hazardous Substances Act, 1973 (Act 15 of 1973), as amended. The body responsible for administering this legislation is SAHPRA: Radiation Control. This code of practice has been drawn up 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).

Document History

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1	First issue and published for implementation	October 2015
2	– Content structured on the new SAHPRA Guideline Template – A unique document number SAHPGL-RDN-XR-16 allocated to this Guideline – Form RC001 changed to **GLF-RDN-XR-02B,** Form RC005 changed to **GLF-RDN-XR-02C,** Form RC010 changed to **GLF-RDN-XR-10A,** Form RC013-1 also changed to **GLF-RDN-XR-16A**	September 2022

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Contents

Glossary

Abbreviation/ Term	Meaning
Approved	Approved by the SAHPRA: Radiation Control .
Directorate	The Directorate Radiation Control, SAHPRA
Enclosed exposure facility	A permanent, shielded installation or structure designed for industrial radiography, which incorporates a fixed exposure device and in which such work is regularly performed.
Industrial radiographer	means a person authorized by the Department to perform industrial radiography.
Industrial radiography	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
Operator	means a person who performs industrial radiography in an enclosed exposure facility.
Overexposure	any exposure of a person to ionising radiation to an extent that an annual dose limit is exceeded.
Radiography in open areas	Radiography not performed in an enclosed exposure facility.
Trainee	A person who has successfully completed an approved examination in industrial radiography, but who has not yet obtained the necessary practical training period of 480 effective working hours under the supervision of an approved and authorised industrial radiographer
X-Ray equipment	Electronic equipment producing ionising radiation (X-Rays) for the purposes of industrial radiography.

1. INTRODUCTION

X-Ray equipment used in industrial radiography is subject to regulatory control in terms of Article 3(1) of the Hazardous Substances Act, 1973 (Act 15 of 1973), as amended. The body responsible for administering this legislation is SAHPRA: Radiation Control

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 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 be used in this document, it implies that the requirement in question is compulsory. Where the word should be used, compliance is strongly recommended, but is not mandatory.

The holder of a licence must ensure that the requirements laid down in this code are always adhered to.

The latest version of this document as well as all forms and guidelines are available at:

https://www.sahpra.org.za/radiation-control-guidelines-and-codes-of-practice/

1.1 Purpose

The importance of radiation safety training was reiterated by the World Health Organization (WHO). It has been recognized since early studies on X-Rays that exposure to high levels of radiation may cause tissue damage, and that chronic exposure to lower levels of radiation may result in cancer. 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).

1.2 Scope

This Code of Practice sets out requirements and recommendations to license holders for radiation safety associated with the use of Industrial Radiography X-Ray equipment.

2. LEGAL PROVISION

The guideline is implemented in promulgating the Hazardous Substances Act 15, 1973 (Act15 of 1973) the related Regulations R.1332.

3. ADMINISTRATIVE AND MEDICAL REQUIREMENTS

3.1 An application for a licence to possess and use an X-Ray unit must be submitted to the Directorate SAHPRA: Radiation Control on form **GLF-RDN-XR-02B** (old Form RC001). 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.

3.2 The person nominated to act as Responsible Person must either be a full-time employee or the owner. The person nominated to act as Responsible Person must pass an approved examination before he/she can assume this position**. 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 responsible person in terms of Paragraph III.3 of the Regulations Concerning the Control of Electronic Products (Regulations No R1332 of 3 August 1973). Responsibilities for the transfer of duties when resigning or when the contract expires must be included in the service contract.

3.3 Should a Responsible Person change at any stage, SAHPRA Radiation Control must be informed of the change on form **GLF-RDN-XR-02C** (old Form RC005). A copy of the required service contract between the holder and the Responsible Person compiled in terms of Paragraph III.3 of the Regulations Concerning the Control of Electronic Products (Regulations No R1332 of 3 August 1973) must be attached.

3.4 An application for registration with SAHPRA: Radiation Control as an industrial radiographer must be made on form **GLF-RDN-XR-16A** (old Form RC013-1). 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.

3.5 The holder of the licence 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 SAHPRA: Radiation Control (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 licence must take steps to ensure that his employees adhere to the correct working procedures.

3.6 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.

3.7 When the South African Bureau of Standards (SABS)/ Dosimeter Services reports to the licence holder

that an employee's personal dosimeter (TLD) has registered more than the pro rata dose allocation for the wearing period, the holder must complete form **GLF-RDN-XR-10A** (old Form RC010) and forward it to SAHPRA: Radiation Control. The holder must furthermore ensure that a copy of this form is entered into the health register of the worker in question.

3.8 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.

3.9 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.

3.10 When the SABS/ Dosimeter services reports to the authority holder that an employee's personal dosimeter (TLD) has registered more than 50 mSv for the wearing period or if SAHPRA: Radiation Control 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 SAHPRA: Radiation Control.

3.11 When a radiation worker ceases to be employed by the licence 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.

3.12 The holder of the authority shall not transfer any industrial radiography X-Ray units unless this is done with the prior approval of SAHPRA: Radiation Control. This requirement refers to situations where X-Ray units are transferred between companies and when X-Ray units are permanently transferred between different sections of a company.

4. EQUIPMENT SPECIFICATIONS AND PERIODIC TESTING

4.1 An X-Ray tube must be enclosed in a tube housing in such a way that the dose equivalent rate from leakage radiation measured at a distance of one meter from the focus does not exceed the following values for the given applied voltages and the corresponding maximum tube currents:

- up to 150 kV: 1 000 μSv/h (100 mR/h)
- above 150 up to 200 kV: 2500 μSv/h (250 mR/h)
- above 200 kV: 5000 μSv/h (500 mR/h)

For discharge X-Ray equipment, the dose equivalent rate shall be defined as the dose equivalent in one hour at the highest pulse rate.

4.2 The tube head must provide a total filtration at least equal to the following values corresponding to the maximum voltage for which the tube head is designed (ref 2):

- up to 50 kV: no requirement
- above 50 up to 100 kV: 2 mm Al or the equivalent
- above 100 up to 200 kV: 3 mm Al or the equivalent
- above 200 up to 300 kV: 4 mm Al or the equivalent
- above 300 kV: 0.5 mm Cu or the equivalent

4.3 A lead cap to be used for covering the radiation window during testing and start up preparation of the tube must be supplied. The lead cap must attenuate the primary beam so that the leakage radiation limits are not exceeded.

4.4 The lead cap must be easy to mount correctly. For panoramic X-Ray equipment the lead cap (belt) must be mechanically strong.

4.5 Diaphragms giving different field sizes of the primary beam must be supplied.

4.6 The diaphragms must be easy to mount correctly. Panoramic X-Ray equipment must be supplied with diaphragms enabling directional beam exposure. This is not required for X-Ray crawlers.

4.7 X-Ray equipment must be equipped with an extension cable for remote exposure control. The length of this cable must be at least 20 m for X-Ray equipment exceeding 200 kV, and 10 m for kV's of 200 and lower (ref 14).

4.8 The control panel must be provided with a key activated control. Without this key the control panel

must be inoperable. Removal of the key after exposure must not result in any damage to the equipment, e.g. overheating.

4.9 Proper operation of the unit via the control panel must be the only way of controlling exposures. Accidental grounding of an electrical conductor must not result in generation of X-Rays.

4.10 Two independent means which indicate when X-Rays are being generated must be provided on the control panel. One of these indicators must be a red lamp of reliable design.

4.11 The control panel must be provided with door switch connectors for use on enclosed installations. This system must be designed in such a way that, when exposure has been interrupted by the opening of a door altering the switch circuit status, it shall be possible to resume generation of X-Rays only by activation from the control panel after all doors have been closed again.

4.12 The control panel must be provided with a connection to an external warning lamp.

4.13 The tube head must be distinctly marked with the following information:

- location of focus;
- primary beam angle; and
- for panoramic units the cylindrical window must be marked with a colour distinctly different from that of the rest of the housing.

4.14 A brief guidance, written in one of the official languages of the country, shall accompany the unit (if convenient, in the control panel cover). The guidance shall contain a warning concerning radiation hazards, and an indication that the installation must be operated by qualified personnel only.

4.15 The instruction manual for the use of X-Ray installations shall be written in one of the official languages of the country and shall only deal with the type of apparatus concern.

5. 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):

5.1 The remote control shall be placed outside the enclosure.

5.2 5.1.2 An enclosed exposure facility may not be located in an area zoned for domestic use.

5.3 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.

5.4 The facility must incorporate a means to indicate positively that an exposure is underway. The facility must incorporate warning lights linked to the on-off mechanism of the unit.

5.5 Facilities in which X-Ray equipment 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.

5.6 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.

5.7 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.

5.8 The radiation dose rate outside the exposure facility must comply with the requirements of paragraphs 9.1 to 9.3, and at a distance of 1 m from the outer surface of an enclosed installation should preferably not exceed 2.5 μSv/h (0.25 mR/h), but must not exceed 7.5 μSv/h (0.75 mR/h) when the properties of the radiation source correspond to the maximum ratings stated for that enclosed installation.

5.9 Enclosed installations must be provided with a sign stating the maximum rating and limitations on the primary beam directions established for that installation.

6. TRAINING REQUIREMENTS

6.1 Responsible Person

6.1.1 The Responsible Person 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 SAHPRA: Radiation Control on form **GLF-RDN-XR-16A** (old Form RC013-1).

6.2.2 Assistants to the industrial 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. industrial 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 3.5. 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 a licence must ensure that the Responsible Person 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 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 Responsible Person 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 industrial 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 Requirement

7.1.1 Industrial radiography may only be performed by:

7.1.1.1 a qualified industrial radiographer who has been granted a personal authority from SAHPRA: Radiation Control 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.

7.1.1.4 In the case of a trainee, the qualified industrial 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, an industrial radiographer must ensure that he/she, and the other members of the radiography team (i.e. industrial radiographers, trainee industrial radiographers and assistants), are wearing personal dosimeters (TLD's) and direct-reading dosimeters, and that he/she has in his/her possession a functioning radiation monitor. The industrial 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, direct-reading dosimeters, alarm dosimeters, etc) must be checked daily by the industrial radiographer before and after use. 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 μSv/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 9 (regarding dose limitations), the industrial radiographer must ensure, during the course of his/her work, that no individual is exposed to radiation in excess of the following levels:

- workers not wearing Personal Dosimeters: 20 μSv (2 mrem) in any one day; and
- 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 industrial 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 (ref 14).

7.2.9 During the exposure, the industrial 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 During start-up preparation or testing of X-Ray tubes, the radiation window must be closed by a lead cap designed for this purpose.

7.2.11 A warning lamp connected to the control panel must be prominently positioned near an X-Ray tube in order clearly to indicate exposure.

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.

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.

7.3.5 The operator must ensure compliance with all the limitations on use of the enclosed installation, e.g. the limitations with respect to beam direction and output 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 TLD's must be worn by persons performing radiography in an enclosed exposure facility.

8. RADIATION MONITORING REQUIREMENTS

8.1 All the members of an industrial radiography team (i.e. industrial radiographers, trainee industrial radiographers, student radiographers and assistants) as well as operators must be issued with a personal dosimeter (TLD). The worker's unique Bureau Identification Number (BIN) must be indicated on the personal dosimeter when returned to the SABS for processing. **No "blank" TLD's 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.**

8.2 All the members of industrial radiography teams performing radiography in open areas, as well as any other workers who are likely to receive more than 200 μSv (20 mR) during any one day, must in addition be issued with a direct-reading dosimeter (pocket dosimeter) or a digital audible-alarm dosimeter. The direct-reading dosimeter must have a full-scale deflection of at least 2 mSv (200 mR). Daily doses must be accurately recorded, and such records kept for a period of at least 5 years.

8.3 Direct-reading dosimeters and audible-alarm dosimeters must be checked for correct response to radiation at an approved facility, at periods not exceeding 26 months.

8.4 The dosimeters specified in paragraphs 9.1 to 9.2 above, must be **worn** by radiation workers (i.e. attached to their clothing) during the course of their work.

8.5 Each radiography team performing radiography in an open area must be provided with a radiation

monitor (dose-rate meter) with a range sufficient to measure 10 μSv/h (1 mR/h) through to at least 10 mSv/h (1 R/h). This monitor must be calibrated at an approved facility at periods not exceeding 7 months, and after servicing of the instrument.

8.6 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.**

9. DOSE LIMITATION

9.1 Radiation doses to individuals must at all times be kept as low as is reasonably achievable (ALARA).

9.2 In addition to the requirement of ALARA, the holder of the licence, as well as radiation workers, must ensure that radiation doses to individuals (including themselves) do not exceed the limits specified by SAHPRA: Radiation Control:

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	1 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.*

9.3 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 licence or the radiation workers, will, however, not be viewed as a statutory infringement.

10. EMERGENCY PROCEDURES

10.1 The document drawn up by the holder of the licence in terms of paragraph 3.5 must include a contingency plan describing procedures to be followed in the event of a radiation incident. The contingency plan must include the following:

10.1.1 Immediate action to be taken in order to prevent excessive radiation doses.

10.1.2 Internal and external notification procedures.

10.1.3 Procedures for dealing with the incident and returning the situation to normal.

10.1.4 Information regarding medical examinations and blood tests.

10.2 SAHPRA: Radiation Control must be notified immediately by telephone 012 501-0451 and the information must be reported to SAHPRA: Radiation Control in writing within 7 days in the following instances (See Regulation 16):

10.2.1 If any person is overexposed or suspected of being overexposed.

11. REFERENCES

The following related documents are referenced:

11.1 Nordic Recommendations on Radiation Protection in Industrial Radiography, 1987.

11.2 Standard Specification for Apparatus for Gamma Radiography, SABS 1980 (SABS 1317). (International Standard ISO 3999 - 1977)

11.3 Radiation Protection - Recommendations in the Nordic Countries, 1976.

11.4 Licenses for Radiography and Radiation Safety Requirements for Radiographic Operations, Part 34, US NRC Rules and Regulations, 1990.

11.5 Government Gazette no. R184, August 1973 concerning regulations governing the Hazardous Substances Act, 1973 (Act 15 of 1973) as amended. *

11.6 Proposed code of practice for the industrial use of ionising radiation, Part II: Radiation from listed electronic products, Document for committee draft stage SABS.

11.7 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).

11.8 The protection of persons against ionising radiation arising from any work activity, The Ionising Radiation Regulations 1985, Health and Safety Commission.

11.9 Ionising Radiation Dose Limits and Annual Limits on Intake of Radioactive Material, Directorate: Health Technology, Department of Health, Bellville, 1992.

11.10 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 (1990).

11.11 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).

11.12 ICRP ref 4825-3093-1464 (21 April 2011).

12. VALIDITY

This guideline is valid for a period of 5 years from the effective date of revision and replaces the old Code of Practice for Industrial Radiography X-Ray, revised October 2015. It will be reviewed on this timeframe or as and when required.