



- 50. Maintenance of ancillary equipment.
- 51. Maintenance of source changers.
- 52. Maintenance of X-Ray equipment and other radiation generator.

**PART VII – REQUIREMENTS FOR SHIELDED ENCLOSURES**

- 53. Shielded radiography enclosure.
- 54. Design of shielded enclosure.
- 55. Defence-in-depth.
- 56. Adequate shielding.
- 57. Safety and warning systems.
- 58. Warning system.
- 59. Designation of shielded enclosures.
- 60. Local rules.
- 61. Commissioning.
- 62. Decommissioning process.

**PART VIII – REQUIREMENTS FOR SITE RADIOGRAPHY**

- 63. Preparation for site Radiography.
- 64. Designation of a controlled Area.
- 65. Defence-in-depth during site radiography.
- 66. Shielding and restriction of dose rates.
- 67. Boundary of controlled area.
- 68. Warning notices.
- 69. Warning signals.
- 70. Patrolling and monitoring of controlled area.
- 71. Local rules at the radiography site.
- 72. De-designating the controlled area.

**PART IX – TRANSPORTATION OF RADIOACTIVE SOURCE**

- 73. General requirements.
- 74. Receipt of radioactive materials.
- 75. Dispatch of radioactive materials.
- 76. Empty packages.
- 77. Unused sources.
- 78. Dispatch of consignment.
- 79. Transportation routes.
- 80. Details of consignment.
- 81. Security for the consignment.

**PART X - EMERGENCY PLANNING AND PREPAREDNESS**

- 82. Programme for emergency planning and preparedness.
- 83. Consultation for emergency plan.
- 84. Implementation of emergency plan.
- 85. Initial safety assessment.
- 86. Sealed sources.
- 87. Radiation generators.
- 88. Development of emergency plans.
- 89. Features of emergency plan.
- 90. Emergency equipment.
- 91. Inspection and maintenance of emergency equipment.
- 92. Training.
- 93. Emergency exercises.
- 94. Periodic Reviews of emergency plans
- 95. Accident report.
- 96. Details of the accident report.

**PART XI - OFFENCES AND PENALTIES**

- 97. Offences and penalties.
- 98. Appeal.
- 99. Citation.

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**SCHEDULE**

**DOSE LIMITS**

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S. I. of 2006

NUCLEAR SAFETY AND RADIATION PROTECTION ACT  
(1995 No. 19)

Nigerian Radiation Safety in Industrial Radiography  
Regulations, 2006

*Commencement:*

In exercise of the powers conferred on it by Section 47 of the Nuclear Safety and Radiation Protection Act 1995 and of all other powers enabling it in that behalf, THE NIGERIAN NUCLEAR REGULATORY AUTHORITY, with the approval of the President, hereby makes the following Regulations –

PART I - GENERAL

1. Interpretation

For the purpose of these Regulations, unless the context otherwise requires -

“**absorbed dose**” means the quotient  $\frac{dE}{dm}$  (in Gy) where  $dE$  is the mean energy imparted by ionizing radiation to matter in a volume element and  $dm$  is the mass of matter in the volume element;

“**activity**” means the quotient  $\frac{dN}{dt}$  (in Bq or Ci) where  $dN$  is the expectation value of the number of spontaneous nuclear transformations from the given energy state in the time interval  $dt$ ;

“**applicant**” means any legal person who applies to the Nigerian Nuclear Regulatory Authority for authorization to undertake any of the actions covered by the scope of the regulations;

“**approved**” means approval by the Authority;

“**Authority**” means the Nigerian Nuclear Regulatory Authority established under Section 1 of Act 19 of 1995;

“**authorization**” means permission granted in a document by the Authority to a legal person who has submitted an application to carry out a practice within the scope of the regulations. The authorization can take the form of a registration or a licence;

“**collective dose**” means an expression for the total radiation dose incurred by a population, defined as the product of the number of individuals exposed to a source and their average radiation dose (man.Sv);

**“chronic exposure”** means exposure persisting in time;

**“disused source”** means a radioactive source no longer intended to be used for its original purpose;

**“decontamination”** means the removal or reduction of contamination by a physical or chemical process;

**“dose limit”** means the value of the effective dose or the equivalent dose to individuals from controlled practices that shall not be exceeded;

**“dosimeter”** means an instrument used for measuring the absorbed dose of radiation;

**“employer”** means a legal person with recognized responsibility, commitment and duties towards a worker in his or her employment by virtue of a mutually agreed relationship. A self-employed person is regarded as being both an employer and a worker;

**“effective dose”** means the quantity E, defined as a summation of the tissue equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_T w_T \cdot H_T$$

where  $H_T$  is the equivalent dose in tissue T and  $w_T$  is the tissue weighting factor for tissue T. From the definition of equivalent dose, it follows that:

$$E = \sum_T w_T \cdot \sum_R w_R \cdot D_{T,R}$$

where  $w_R$  is the radiation weighting factor for radiation R and  $D_{T,R}$  the average absorbed dose in the organ or tissue T. The unit of effective dose is  $J.kg^{-1}$ , termed the sievert (Sv).

**“health professional”** means an individual who has been accredited through appropriate national procedures to practice a profession related to health (e.g. medicine, dentistry, chiropractic, pediatrics, nursing, medical physics, radiation and nuclear medical technology, radio-pharmacy, occupational health);

**“Ionizing radiation”** means radiation capable of producing ion pairs in biological materials;

**“Licence”** means an authorization granted by the Authority on the basis of a safety assessment and accompanied by specific requirements and conditions to be complied with by the licensee;

**“Licensee”** means the holder of a current licence granted for a practice or source who has recognized rights and duties for the practice or source, particularly in relation to protection and safety;

**“limit”** means the value of a quantity used in certain specified activities or circumstances that must not be exceeded;

**“management”** means all activities, administrative or operational, that are involved in the manufacture, supply, receipt, storage, use, transfer, import, export, transport, maintenance or disposal of radioactive sources;

**“monitoring”** means the measurement of dose or contamination for reasons related to the assessment or control of exposure to radiation or radioactive substances, and the interpretation of the results;

**“notification”** means a document submitted to the Authority by a legal person to notify an intention to carry out a practice or any other action within the scope of the regulations;

**“occupational exposure”** means all exposures of workers incurred in the course of their work, with the exception of exposures from practices or sources exempted by the scope of the regulations;

**“operating organization”** means an operator of industrial radiography equipment and facilities in Nigeria

**“public exposure”** means exposure incurred by members of the public from radiation sources, excluding any occupational or medical exposure and the normal local natural background radiation but including exposure from authorized sources and practices and from intervention situations;

**“practice”** means any human activity that introduces additional sources of exposure or exposure pathways or extends exposure to additional people or modifies the network of exposure pathways from existing sources, so as to increase the exposure or the likelihood of exposure of people or the number of people exposed;

**“qualified expert”** means an individual who, by virtue of certification by appropriate boards, societies, professional licensees, academic qualifications and experience, duly recognized as having expertise in any specialized field e.g. medical physics, radiation protection, occupational health, fire safety, quality assurance or any relevant engineering or safety specialty;

**“radiation generator”** means a device capable of generating radiation, such as X rays, neutrons, electrons or other charged particles, which may be used for practices within the scope of the regulation;

**“radiation safety officer”** means an individual technically competent in radiation protection and safety matters relevant for a given type of practice who is designated by the registrant or licensee to oversee the application of the requirements of the Regulations;

**“radiation source”** means anything that may cause radiation exposure, such as by emitting ionizing radiation or releasing radioactive substances or materials. A complex or multiple installations situated at one location or site may, as appropriate, be considered a single source for the purposes of application of the regulations;

**“radioactive waste”** means a material, whatever its physical form, remaining from practices or interventions and for which no further use is foreseen (i) that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level from regulatory requirements, and (ii) exposure to which is not excluded from the regulations;

**“regulatory control”** means any form of control applied to facilities or activities by the Authority for reasons related to radiation protection, safety and security of radioactive sources;

**“risk”** means a multi-attribute quantity expressing hazard, danger or chance of harmful or injurious consequences associated with actual or potential exposures. It relates to quantities such as the probability that specific deleterious consequences may arise and the magnitude and character of such consequences;

**“safety”** means any measures intended to minimize the likelihood of accidents with radiation sources and, should such an accident occur, to mitigate its consequences;

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

**“supervised area”** means any area not designated as a controlled area but for which occupational exposure conditions are kept under review even though specific protective measures and safety provisions are not normally needed;

**“supplier”** means any legal person to whom a registrant or licensee delegates duties, totally or partially, in relation to the design, manufacture, production or construction of a source. An importer of a source is considered a supplier of the source;

**“unsealed source”** means a source that does not meet the definition of a sealed source;

**“worker”** means any person who works, whether full time, part time or temporarily, for an employer and who has recognized rights and duties in relation to occupational radiation protection. A self-employed person is regarded as having the duties of both an employer and a worker.

## 2. Objective

The regulations shall set up the basic technical and organizational requirements to be complied with by all operators of industrial radiography equipment and facilities in Nigeria,

in order to ensure the protection of human health and the environment from the hazards associated with ionizing radiation within and beyond the national borders of Nigeria.

### **3. Scope**

The regulations shall specify the minimum requirements for radiation protection and safety for all users of ionizing radiation in industrial radiography, these shall include; non-destructive testing, either with fixed assemblies x-rays generators or gamma emitting sealed sources where industrial radiography is carried out inside shielded facilities with engineering controls or with mobile assemblies for site radiography outside shielded facilities.

### **4. Application**

(1) The application of these Regulations shall be in addition to the Nigeria Basic Ionizing Radiation Regulations 2003 (NiBIRR) and any other existing ionizing radiation and nuclear regulations e.g. safety and security of radioactive sources regulations, transport of radioactive sources regulations in force.

(2) These Regulations shall apply to:

- (a) all sources of ionizing radiation used for industrial radiography purposes, with possible exemption prior to authorization by the authority;
- (b) facilities where sources of ionizing radiation are installed, used or stored;
- (c) the operation of sources of ionizing radiation;
- (d) the duties and responsibilities of the users, their internal safety organization and working procedures related to radiation protection;
- (e) the monitoring of persons occupationally exposed and of work places;
- (f) medical examinations of persons occupationally exposed;
- (g) radioactive sources or materials in storage or in transit;
- (h) handling of wastes from the above uses;
- (i) handling of radiological emergencies or accidents;
- (j) import or export requirements;
- (k) quality control of equipment and calibration of instruments, etc;
- (l) program for education, training and development;

- (m) handling of radiation injuries and medical preparedness.

## **PART II - GENERAL REQUIREMENTS**

### **5. Radiation safety requirements**

The principal radiation safety requirements related to justification of the practice, dose limitation, optimization of protection, and dose constraints, as specified in Nigeria Basic Ionizing Radiation Regulations shall be applied to industrial radiography.

### **6. Authorization of the practice**

(1) A legal person intending to carry out industrial radiography or any of the following associated activities shall notify the Authority of his intention and obtain an authorization for:

- (a) importation, purchase, sale, manufacture, repair of or modification to, radiation generators and sealed sources used for industrial radiography including ancillary equipment, which incorporates radioactive materials such as depleted uranium source containers etc;
- (b) transportation, storage, use of radiation generators and sealed sources for industrial radiography including ancillary equipment, which incorporates radioactive materials;
- (c) construction of facilities for industrial radiography and any temporary or permanent decommissioning of these facilities;
- (d) disposal of any sealed sources including ancillary equipment, which incorporate radioactive materials;
- (e) transfer of ownership of any radiation generator or sealed source including ancillary equipment which incorporates radioactive materials or any facility used for industrial radiography.

(2) When applying for a license, the legal person shall provide documentary evidence to the Authority which demonstrates an adequate level of radiation safety provided and maintained.

### **7. Requirement for authorizations**

(1) Legal persons shall provide all relevant information in their request for authorization to the Authority which shall include the following:

- (a) design and construction of facilities, equipment and radiation sources;
- (b) systems for managing radiation safety, radiation safety programme, results of safety assessments, quality assurance procedures;

- (c) procedures for the safe operation of radiation sources including local rules and record-keeping.

## **8. Duration of authorization**

(1) Authorization granted by the Authority shall be for a period as may be determined by the Authority and shall be renewable.

(2) The Authority may suspend or revoke the authorization where the licensee is in breach of the licence conditions, NiBIRR or these regulations.

(3) In order to be able to resume operation, the licensee shall reapply for authorization in case of revocation and reconsideration in case of suspension.

## **9. Responsibilities of the Licensee**

(1) The Licensee shall be responsible for setting up and implementing the technical and organizational measures that are needed for ensuring the protection and safety of sources for which they are authorized.

(2) The Licensee shall -

- (a) notify the Authority of all the activities stated in these regulations;
- (b) notify the Authority of any intentions to introduce modifications to any practice or source for which they are authorized;
- (c) prepare and implement an operational radiation protection and safety programme, which includes, the establishment of policies, procedures and standards for the safe keeping and use of radiation sources and the protection of workers and other persons;
- (d) appoint one or more Radiation Safety Officers to oversee the implementation of the radiation safety programme and provide such Radiation Safety Officers with appropriate authority and adequate resources;
- (e) consult and appoint Radiation Safety Adviser where necessary;
- (f) perform the required Safety Assessments as contained in these regulations;
- (g) ensure that workers are adequately trained in:
  - (i) radiation protection and safety,

- (ii) the operating procedures, local rules and emergency plans appropriate to the specific types of equipment used within the organization,
- (iii) provide workers with personal dosimeter and appropriate health surveillance;
- (h) ensure that all equipment used for the practice is suitable for its intended and actual uses and is properly maintained;
- (i) provide workers with appropriate survey meters that are maintained in good working order and tested regularly;
- (j) ensure that adequate radiation monitoring is carried out and that records are kept;
- (k) provide emergency plans (contingency plans) for all reasonably foreseeable radiation accidents and incidents;
- (l) make provisions for the safe disposal or return to the supplier of existing radioactive sources that are no longer required;
- (m) when applying for a new authorization for the importation, use or storage of any radioactive source including ancillary equipment that incorporates depleted uranium shielding, provide for a program for the safe disposal or return of radioactive sources to the supplier when they are no longer required;
- (n) ensure that any provider of radiation protection and safety related services (e.g. dosimeter laboratories) are authorized or approved by the Authority.

## **10. Management and organizational requirements**

(1) The Management of the operating organization shall provide the human and material resources necessary to ensure safe working conditions and compliance with License conditions.

(2) Every operating organization shall develop and promote a safety culture to encourage a questioning and learning attitude to protection, safety and to discourage complacency.

(3) This includes establishing and maintaining a radiation safety programme which objectives shall include the following elements:

- (a) taking all practicable steps to ensure that the exposure of all persons is kept as low as reasonably achievable and below the dose limits set in the Regulations as in Schedule 1;

- (b) taking all necessary steps to ensure the physical safety and security of radiation sources to minimize risk to persons not connected with the practice;
- (c) compliance with the Regulations and License requirements, ensuring that all necessary tests, inspections and records are maintained to enable the operating organization to demonstrate compliance with these requirements.

#### **11. Appointment of Radiation Safety Officer**

(1) The Licensee shall appoint at least one Radiation Safety Officer whose functions and duties are clearly defined and documented.

(2) The minimum requirements and qualities for a Radiation Safety Officer shall include:

- (a) theoretical knowledge and practical training in radiation protection and safety related to industrial radiography;
- (b) sufficient management authority within the operating organization to effectively supervise and control the radiography work to ensure that the license conditions are met;
- (c) the Radiation Safety Officers shall have the authority to stop work that is not being undertaken in a safe manner.

#### **12. Responsibilities of the Radiation Safety Officer**

(1) The Radiation Safety Officer's responsibility shall include:

- (a) supervising the work to the extent necessary to ensure that procedures including local rules and all License terms and conditions are complied with;
- (b) preparing and reviewing written administrative procedures that define the means of complying with regulatory or license requirements;
- (c) preparing and reviewing operational procedures including local rules to ensure that exposures to radiation are kept as low as reasonably achievable;
- (d) ensuring that operation manuals for the radiography equipment are provided and are understood by the radiographers;
- (e) ensuring that safety assessments and emergency plans are prepared;
- (f) ensuring that engineering controls and other equipment designed to protect persons against ionizing radiation are maintained;

- (g) identifying designated areas and establishing necessary safeguards for controlling access to such areas;
- (h) arranging for and supervising the use of personnel dosimeter and ensuring that that appropriate dose records are maintained;
- (i) ensuring that there is adequate monitoring of workplaces in order to prevent unnecessary exposure and to demonstrate compliance with the Regulations and Licence conditions;
- (j) investigation of accidents including abnormal high exposures in routine work and overexposures, proposing, implementing remedial actions and accident preventive measures;
- (k) to determine the additional requirements for protection of any female staff engaged in the work with ionizing radiation who may be pregnant;
- (l) carry out a prior examination from a radiation safety standpoint of any plans for new fixed radiography facilities or modifications to existing ones;
- (m) maintain inventories of radioactive sources;
- (n) perform regular safety inspections of all radiography work;
- (o) identify situations where a Radiation Safety Adviser should be consulted.

(2) In cases where more Radiation Safety Officers are appointed, i.e. multiple job sites, the reporting structure and individual duties of each shall be well defined, with one Radiation Safety Officer having general oversight and the Authority shall be notified of these appointments.

### **13. Responsibilities of the Radiographer**

(1) Daily responsibility for safe working with industrial radiography sources shall rest with the radiographer and in addition to protecting himself, the radiographer shall be vigilant to ensure the safety of his colleagues, other workers not directly connected with the work and the public.

(2) In this regard, the radiographer should -

- (a) appreciate the hazards associated with radiography and take all necessary steps to protect themselves and others;
- (b) adequately supervise assistant radiographers;

- (c) undertake only work they are trained and qualified for, and to seek assistance from the Radiation Safety Officers if unsure about the safety implications of any work;
- (d) use the radiographic and ancillary equipment including safety equipment and sources for the purposes for which they were designed;
- (e) follow the written procedures and local rules provided, without exception;
- (f) wear personal dosimeter(s) at all times when handling or using radiographic equipment;
- (g) never undertake work with radiation sources if the equipment is defective or has not been adequately maintained according to standard procedures;
- (h) promptly report all equipment defect to the Radiation Safety Officers;
- (i) respond promptly and correctly in the event of emergencies, according to the documented contingency plans.

#### **14. The responsibilities of the Assistant Radiographer**

Assistant Radiographers shall always be directly supervised by a qualified Radiographer and the duties and responsibilities of the assistant Radiographer shall:

- (a) work only under the personal supervision of a qualified radiographer;
- (b) respect the hazards associated with radiography and taking all necessary steps to protect themselves and others;
- (c) undertake only work they are trained and qualified for and to seek assistance from the qualified radiographer if he is unsure of the safety implications of any work;
- (d) understand radiographic and ancillary equipment including safety equipment;
- (e) follow the procedures and local rules provided by the radiation employer;
- (f) wear a personal dosimeter at all times when handling or using radiographic equipment;
- (g) never undertake work with radiation sources if equipment is defective;
- (h) report all defects with equipment to the qualified radiographer and Radiation Safety Officers;

- (i) inform the qualified radiographer immediately in the event of an emergency and to assist in dealing with such situations as directed.

## **15. Appointment of Radiation Safety Adviser**

(1) Licensee shall appoint an authorized Radiation Safety Adviser, to advise in many areas, such as design of new facilities, maintenance of safety systems etc. to ensure compliance with regulatory and license requirements.

(2) The scope of advice and the services provided by an authorized Radiation Safety Adviser shall be agreed with the Licensee and clearly documented.

(3) Licensee shall provide the Radiation Safety Adviser with appropriate information and access to facilities in order for the Adviser carry out the agreed services.

## **16. Training and education**

(1) Licensees shall ensure that radiography is carried out only by qualified radiographers.

(2) Formal training of industrial radiographers shall be carried out in a systematic manner and shall involve accreditation to a recognized local, national or international standard and periodical training is essential to maintain the required level of competence.

(3) Licensees shall only employ qualified radiographers who have received formal training which include:

- (a) sufficient educational background;
- (b) specialized formal training in the techniques required to obtain a radiograph, as appropriate to the duties;
- (c) specialized formal training in radiation protection and safety;
- (d) familiarity with the organization's local rules and License requirements;
- (e) practical training in techniques and radiation protection and safety requirements including emergency procedures specific to the equipment used within the organization.

## **17. Obligations of the Licensee**

The Licensee shall also ensure that Radiation Safety Officers and all workers know and understand the following -

- (a) the conditions and limitations of the License held by the operating organization;
- (b) the organization's radiation protection and safety programme;
- (c) the operation and maintenance of the equipment used by the licensee;
- (d) hazards identified by the Safety Assessment;
- (e) local rules and other operating procedures;
- (f) the detailed procedures to be followed in the event of emergencies, training for which shall include training exercises carried under realistic condition.

### **18. Record of training**

(1) The licensee shall prepare and maintain a record of training of all the personnel involved in industrial radiography and these records shall include the following information:

- (a) name of the person who received the instruction or training;
- (b) name of the institution or person who delivered the training;
- (c) dates and duration of the instruction or training;
- (d) a summary or list of the topics addressed;
- (e) copy of any training certificates;
- (f) the result of any professional examination taken.

(2) The licensee shall provide copies of the training records to individual workers especially if they change their employers.

### **19. Safety assessments**

(1) Licensees shall ensure that a safety assessment is carried out at the following stages:

- (a) when applying for a new licence or for modification to an existing license;
- (b) at the design stage, prior to the construction of a fixed industrial radiography facility;
- (c) upon commissioning of the facility and before any routine radiography begins in the facility;

- (d) when making significant changes to working practices or modifications to permanent radiography enclosures;
- (e) when operating experience, or other information about accidents, failures, errors or other events that could lead to potential exposures indicates that the current assessment might be invalid.

(2) Licensee shall ensure that the safety assessment is fully documented and is prepared in consultation with the Radiation Safety Officer and Radiation Safety Adviser.

(3) The safety assessment shall include a systematic and critical review of -

- (a) the nature and magnitude of potential exposures and the likelihood of their occurrence;
- (b) the limits and technical conditions for operation of radiation sources;
- (c) the ways in which structures, systems, components and procedures related to radiation protection or safety might fail, singly or in combination, or otherwise lead to potential exposures, and the consequences of such failures;
- (d) factors which could give rise to the unintended operation of any radiation source and the measures available to prevent, identify and control such occurrences.

(4) Where the safety assessment shows there is a risk of a radiation accident, Licensees shall take all practicable steps to:

- (a) prevent such accident;
- (b) limit the consequences of such accident, should the accident occur;
- (c) provide workers with training in emergency procedures.

## **20. Verification of safety**

Licensees shall carry out regular audits of normal radiography operations to ensure that a satisfactory standard of radiation safety is being maintained.

## **21. Policy statement**

(1) Licensees shall develop a policy statement that specifies the following:

- (a) person responsible for organizing and carrying out the safety audits;

- (b) the time interval between audits;
- (c) person responsible for preparing the audit report and making recommendations;
- (d) person to whom the audit report is to be sent;
- (e) person responsible for implementing any corrective measures that are identified during the audit.

(2) Each audit shall be done according to a structured plan and the time scale set for implementing corrective measures and shall ensure that any deficiencies which present a significant radiological hazard are dealt with promptly and the agreed corrective measures shall be followed-up to ensure that the audit process is completed.

### **PART III - INDIVIDUAL MONITORING OF WORKERS**

#### **22. Statutory (legal) dosimeters and dose records**

(1) Employers shall assess the occupational exposure of all workers, Radiographers, assistant radiographers and any other persons who may regularly work in controlled areas or may receive significant occupational exposure which shall be provided with appropriate individual dosimeters to assess their cumulative occupational radiation exposure.

(2) The dosimeters coverage is subject to the following:

- (a) the dosimeter shall be a film badge or a thermo-luminescent dosimeter;
- (b) the supplying laboratory shall be subject to the approval of the Authority;
- (c) the period for the use of a dosimeter shall be, for a maximum period of 3 month;
- (d) workers shall be required to wear additional dosimeters such as extremity thermo-luminescent dosimeter during source changes or additional dosimeters if neutron radiography is undertaken;
- (e) the statutory personal dosimeter shall only be used by the person to whom it is assigned;
- (f) the Licensee shall maintain a dose record for each individual in the manner specified in the regulations;
- (g) before a radiographer starts work, the licensee shall obtain a copy of the workers' dose record from previous occupational exposure;

- (h) the licensee shall also supply relevant information of their record of service to radiographers on termination of their employment;
- (i) licensee shall draw up a procedure to describe the way individual dosimeters are administered and this shall include persons who;
- (j) order and receive the dosimeters from the dosimeter laboratory;
- (k) distributes them to the radiographers and Radiation Safety Officer;
- (l) collects them and dispatches them to the dosimeter processing laboratory;
- (m) reviews and maintains the dose records.

**23. Protection of personnel dosimeters during use**

In order to ensure the protection of the personnel dosimeters, the Radiographers shall:

- (a) take good care of their dosimeter; protect them from loss, theft or damage;
- (b) return them at the end of every specified period of usage;
- (c) inform the Radiation Safety Officer without delay, if their dosimeter is missing, damaged or if it has been accidentally exposed to radiation when not in use.

**24. Storage of personnel dosimeters**

To ensure accurate reading of the dosimeters when not in use, the storage of individual dosimeters shall include the following elements:

- (a) dosimeters shall be stored in a suitable environmental condition, which will not damage or affect the properties of the dosimeter;
- (b) individual dosimeters shall not be stored in source stores, inside radiography enclosures, near exposure containers, near radioactive luminous items or in any other area where there are raised dose rates;
- (c) they shall not go through x-ray mail inspection systems.

**25. Loss of personnel dosimeters**

(1) For the loss of any dosimeter, the operating organization shall take all reasonable steps to recover it.

(2) If the dosimeter cannot be located, the operating organization shall carry out an investigation and prepare a report which includes an estimate of the dose received by the worker for the relevant period.

**26. Investigation of doses**

(1) Results of personal dosimeters shall be reported to the Radiation Safety Officer who shall inspect them to determine whether any unexpectedly high doses have been received and to determine whether individuals are keeping their doses within the dose limits.

(2) In addition, the Radiation Safety Officer shall set investigation levels of doses above which a formal investigation and written report shall be prepared.

**27. Reading of dosimeter**

(1) Direct reading dosimeters (e.g. quartz fibre electrosopes) shall be used to supplement the TLD or film badge, whenever it is important to have an immediate indication of exposure, for example during site radiography in a confined space or during emergency recovery of a source.

(2) Such uses shall be subject to the following conditions:

- (a) direct reading dosimeters shall be read or reset, at the start of each work shift and then read at regular intervals with accurate records kept;
- (b) if the direct reading dosimeter exceeds a level set by the Radiation Safety Officer, the radiographer shall stop work and discuss the situation with the Radiation Safety Officer to establish how procedures might be improved;
- (c) licensees shall ensure that direct reading dosimeters and personal alarm monitors are kept in good working condition and subject to regular operational checks.

**28. Personal alarm monitor**

All radiographers shall wear a personal alarm monitor that emits an audible and sometimes visible alarm when exposed to dose rates above a preset level as determined by the Radiation Safety Officer

**PART IV - WORKPLACE MONITORING**

**29. Maintenance of workplace monitoring**

Licensees shall develop and maintain a programme for workplace monitoring in order to:

- (a) evaluate radiological conditions;

- (b) assess exposures in controlled and supervised areas and;
- (c) review the classification of controlled and supervised areas.

### **30. Survey meters**

(1) The licensee shall ensure that a sufficient number of suitable radiation survey meters are available for the radiographers and Radiation Safety Officer.

(2) A survey meter shall be used before and after every exposure of a radioactive source to confirm that the source is in its fully shielded position. For it to be suitable for the work environment, radiation survey meters shall satisfy the following conditions:

- (a) survey meters shall be robust, waterproof if likely to be used in the rain and have an illuminated display if likely to be used in the dark;
- (b) batteries shall be readily available;
- (c) they shall be scaled in units of dose rate and shall be able to indicate radiation levels from about 1  $\mu\text{Svh-1}$  up to about 10mSvh-1;
- (d) licensees shall ensure that equipment obtained for this purpose is of a type approved by the Authority and that it comes with an operating manual and with an initial certificate of testing by the manufacturer or supplier.

### **31. Maintenance and calibration**

(1) The radiographer shall inspect the operation of the radiation survey meter at the start of each working shift.

(2) This inspection shall include:

- (a) battery condition;
- (b) any other instrument checks (e.g. high voltage setting);
- (c) background radiation level is as expected;
- (d) response against a gamma exposure container or other suitable check source.

(3) Every radiation survey meter used during radiography shall be checked regularly:

- (a) normal tests as in preceding paragraph;
- (b) any specific inspection of instrument specified by the manufacturer;

- (c) inspection of indicated gamma dose rate versus actual dose rate at a range of dose rates to establish linearity of response;
- (d) inspection of indicated dose rate versus actual dose rate at a range of dose rates to establish linearity of response;
- (e) over-load check to confirm that the survey meter indicator remains at maximum, under condition of a very high dose rate.

### **32. Use of radiation survey meters**

(1) Radiation survey meters shall be used to evaluate the radiological conditions in all workplaces, in particular at the following locations:

- (a) around controlled and supervised areas to review classification and assess exposures;
- (b) around a transport container when a new gamma source is received;
- (c) around a gamma source container when collecting it from a store;
- (d) around a gamma source container when returning it to a store to confirm the source is present and is fully shielded;
- (e) around a gamma source container when loading and offloading it into a vehicle used for transport.

(2) In the following situations:

- (a) after every exposure of a gamma source to confirm that it has fully returned to the shielded position in its exposure container;
- (b) to check the dose rates at the controlled area barriers during site radiography;
- (c) when transferring gamma sources between containers;
- (d) when dealing with emergencies involving gamma sources.

(3) The results of radiation surveys shall be recorded in the following instances:

- (a) when commissioning a new fixed radiography compound or one that has been significantly modified;
- (b) when commissioning a new radiation source store;

- (c) when checking the dose rate around a gamma radiography exposure container prior to transporting it so that the transportation index can be recorded on the consignment document;
- (d) routine surveys around fixed radiographic facilities at least once every year;
- (e) during site radiography with mobile sources to confirm that barrier distances are set correctly;
- (f) during emergencies and investigations so that dose estimates can be performed.

(4) Records of radiation surveys should include the following details:

- (a) location;
- (b) date;
- (c) name of person performing survey;
- (d) survey meter type and serial number;
- (e) radiation source details, e.g. type of source, activity, beam direction, x-ray tube settings, etc;
- (f) locations of measuring points;
- (g) dose rate in  $\mu\text{Sv h}^{-1}$ .

(5) The licensee shall ensure that records of radiation surveys are kept in a manner specified in any License conditions or the Regulations.

## **PART V - SECURITY OF RADIOACTIVE SOURCES**

### **33. Security and control of radiation sources**

(1) The licensee shall establish physical controls and administrative procedures to prevent damage to, theft, loss or unauthorized removal of radioactive sources.

(2) In order to ensure this, the licensee shall take into consideration the following:

- (a) controls and procedures to prevent entry by unauthorized persons into radioactive source stores, fixed radiography facilities and controlled areas during site radiography procedures;
- (b) control of source is not relinquished without prior notification of the Authority;

- (c) a radioactive source shall not be transferred, unless the receiver possesses a valid authorization;
- (d) that all workers shall be informed of the need and importance of radioactive source security;
- (e) permanent and purpose designed radioactive source stores are to be made available;
- (f) temporary stores are established where necessary at sites where radiography with mobile sources is undertaken;
- (g) identification of the potential ways in which sources can be lost or stolen, in particular the risks of theft during temporary storage and transporting radioactive sources;
- (h) an effective system for accounting radioactive sources shall be implemented and to be fully complied with by all workers and the system shall be capable of detecting losses quickly.

#### **34. Storage of industrial radiography sources**

Sealed sources used in industrial radiography shall be stored in secured exposure containers or source changers and these in turn shall be kept in suitable stores that will meet the following minimum requirements:

- (a) it shall be designated as a controlled area;
- (b) it shall be properly secured, to prevent removal or tampering with the radioactive sources;
- (c) the keys shall be made available to a qualified radiographer only and key holding shall be properly documented;
- (d) it shall protect the equipment from any mechanical damage and harsh environmental conditions;
- (e) it shall provide protection against fire and shall not contain or be located in proximity to flammable, corrosive or oxidizing materials, or explosives;
- (f) it shall provide adequate shielding against gamma radiation;
- (g) the entrance door to the store shall be labeled clearly and durably with a radiation trefoil symbol, the words: "Danger Radioactive Material" in an understandable language;

- (h) if the store is located at a place not on the operating organizations site, the name, address and telephone number of the licensee shall be displayed so that he can be contacted in an emergency situation.

**35. Accounting for radioactive sources**

(1) Licensee shall ensure that the location of their sources is known at all times and a formal accountability system shall be established that records the location of the following radioactive sources:

- (a) sealed sources used in gamma radiography;
- (b) pipeline crawler sources;
- (c) other sources such as those used to test radiation survey instruments;
- (d) exposure containers incorporating depleted uranium shielding, even when these containers do not contain a gamma radiography source.

(2) The accountancy procedures shall be documented and consist of a number of elements which together provide defence in depth to ensure that records are complete and accurate.

**36. Central records of radioactive sources**

(1) Licenses shall maintain a central and definitive record of all their radioactive sources.

(2) This shall be established for each source as soon as it is delivered to the organization and shall contain the following documents and details, which shall be updated when the sources are moved between storage locations or exposure containers, for each sealed source:

- (a) details of the source supplier;
- (b) date of receipt into the operating organization;
- (c) manufacturers' serial number;
- (d) radionuclide and activity on a stated date;
- (e) normal storage location;
- (f) type and serial number of the exposure container in which source is located;
- (g) local identifier;

- (h) original manufacturers' leak test certificate;
- (i) copy of any subsequent leak test certificate;
- (j) original suppliers' special form certificate if one is issued and any updated certificates;
- (k) date, method and destination for final disposal or transfer to another party as authorized by the Authority.

(3) For each exposure container or source changer incorporating depleted uranium -

- (a) details of the container supplier;
- (b) date of receipt into the operating organization;
- (c) manufacturers' serial number;
- (d) container type or model number or other descriptor;
- (e) transport code (e.g. Type A, Type B, etc);
- (f) maximum activity of source allowed to be used in the container;
- (g) the quantity of depleted uranium in kg (if used as shielding material);
- (h) date, method and destination for final disposal or transfer to another party as authorized by the Authority.

(4) These records shall be securely kept by the licensee and copies of the records shall be transported with each mobile source in a suitable file or other document holder so that they can be readily inspected by the Authority or internal auditor.

(5) When sources or exposure containers are finally disposed of, the central records for each source or container shall be stored in a secured place for such period as may be specified in the License conditions or Regulations.

### **37. Source movement records**

(1) Source movement records shall be maintained for every mobile radioactive sources, exposure container or source changer that incorporates depleted uranium of the sources and the records shall be recorded as follows:

- (a) an identifier that is sufficient to allow the exposure container to be related to the central records which also contain the records of the sealed source inside the container;
- (b) the radionuclide (e.g. cobalt-60, iridium-192);
- (c) date and time the exposure container or source is removed from the store;
- (d) name and signature of the radiographer removing the source;
- (e) the place where it will be taken;
- (f) date and time shall be returned to the source store;
- (g) name and signature of the radiographer returning the source.

(2) The source movement shall be recorded every time the source is moved and the Radiation Safety Officer shall regularly inspect them, to ensure that these records are accurately completed and the licensee shall retain the source movement records for a period specified by the Authority.

### **38. Radioactive source audits**

(1) Licensees shall ensure that monthly audits are made of the source accounts and movement records.

(2) The physical location of each source and any exposure containers incorporating depleted uranium shall be verified.

(3) The audit shall include the following:

- (a) identification from the central record of which sources are currently held by the licensee;
- (b) preparation of a checklist of these sources;
- (c) confirmation by physical inspection that every source and depleted uranium source container is accounted for using a radiation survey meter if there is any doubt whether the source is present;
- (d) confirmation that source movement records are accurately completed;
- (e) a written record that the audit results are satisfactory, this might take the form of the signature of the Radiation Safety Officer in the record or a separate record sheet retained by the Radiation Safety Officer.

**PART VI - REQUIREMENTS FOR INDUSTRIAL  
RADIOGRAPHY EQUIPMENT**

**39. General Requirements**

X-ray and gamma ray equipment shall be used for industrial radiography subject to the following general requirements:

- (a) any modification of an exposure container, sealed source, X-ray source, or any ancillary equipment used in industrial radiography shall be undertaken only by a qualified expert who is satisfied that the modification does not adversely effect the safety of the equipment. and significant modifications shall only be carried out following authorization from the Authority;
- (b) radiography equipment shall not be used in conditions or environments for which it was not designed and such equipment shall be stored in a suitable manner.

**40. Gamma radiography equipment**

To ensure adequate protection of persons during gamma radiography the sealed source shall be housed in a shielded container (the “exposure container”) and the source exposed only for the minimum time necessary to carry out the required radiographic inspections.

**41. Requirements for sealed sources**

(1) Sealed sources used for industrial radiography shall be designed, manufactured and tested to meet the requirements of the International Standard Organization or Standard Organization of Nigeria.

(2) In addition:

- (a) they shall be certified as meeting the requirements of ‘special form’ radioactive material according to the International Atomic Energy Agency transport regulations, TS-R-1;
- (b) each radioactive source shall have demonstrated its integrity by completion of a satisfactory leak test in accordance with the international standard organization;
- (c) any new source shall be supplied with a leak test certificate and to ensure the ongoing integrity of the source capsule.
- (d) leak tests shall be carried out at intervals prescribed by the Authority or license conditions or the regulations;

- (e) operating organizations shall require that source suppliers provide certification with all new sources;
- (f) source assemblies shall be designed, fabricated and tested to meet the requirements of the International Standard Organization (ISO);
- (g) source assemblies shall be compatible with the exposure container, ancillary equipment such as guide tubes and any source changer;
- (h) source assemblies shall be marked with the radiation trefoil sign and a legend **“radioactive”**;
- (i) they shall also be durably marked with the manufacturer’s serial number.

**42. Requirements for exposure container**

The radiographer shall have a good understanding of the type and safe use of the exposure containers, which includes the shutter type, projection container type or any other container authorized by the Authority shall be used and further requirements shall include:

- (a) containers that incorporate depleted uranium shall be treated as radioactive sources even when empty and they shall be properly stored, accounted for and disposed of only in a manner authorized by the Authority;
- (b) operating organizations shall ensure that they know which of their exposure containers incorporate depleted uranium and check that the containers are durably marked to identify this;
- (c) whichever type of exposure container is used, it shall meet the minimum requirements of the International Standard Organization or equivalent to the requirements of the Standard Organization of Nigeria;
- (d) any exposure container shall bear a durable and clear label with the following details:
  - (i) the ionizing radiation trefoil symbol,
  - (ii) a cautionary warning e.g. **“DANGER – RADIOACTIVE MATERIALS”**;
  - (iii) chemical and mass number of radionuclide (e.g. “Ir-192”, “Co-60”),
  - (iv) maximum source activity permitted for the container,
  - (v) model and serial number of the container,

(vi) licensee name and address;

the exposure container shall be supplied with an operational and maintenance manual;

licensee shall request that suppliers of exposure containers and ancillary equipment to provide these manuals in an appropriate language.

#### **43. Projection type containers**

The following are the requirements that shall be met in the case of projection type containers:

- (a) the coupling between the source assembly (the detachable element which is stored inside the exposure container when not in use) and the control (or “wind-out”) cable shall be designed in such a manner that the source assembly cannot become disconnected if cranked outside of the guide tube;
- (b) the container shall automatically secure the source in the shielded position, when it is cranked back into the fully shielded position, such that it is not possible to release the source again without the deliberate operation of a release mechanism;
- (c) all connecting fittings shall have protective covers or safety plugs installed during storage and transportation, to prevent the ingress of dirt or other foreign matter;
- (d) guide tubes shall be used at all times when cranking the source out of a projection type container and such guide tubes shall have source terminal point on them (i.e. a closed end) and drive (wind-out) cables shall be of sufficient length to allow the source to be projected all the way to the end of the guide tube;
- (e) when the source is in the shielded position, dose rates on the outside of an exposure container shall not exceed 2 mSv hr<sup>-1</sup> at the surface or 0.1 mSv hr<sup>-1</sup> one meter from the surface;
- (f) all ancillary equipment shall have its compatibility tested with the exposure container before use;
- (g) additional shielding, such as purposely made collimators or lead sheet, shall be used when practicable and compatible with the radiography technique.

#### **44. Requirements for ancillary equipment and source changers**

All ancillary equipment used for gamma radiography shall meet the requirements of the International Standard Organization or equivalent to Standard Organization of Nigeria's standard and also:

- (a) the equipment shall be tested by the licensee and must be genuine for its intended purpose before its first usage in industrial radiography;
- (b) the licensee shall carry out a pre-use test on equipment not covered under a recognized standard (e.g. collimators and positioning devices for pipeline radiography);
- (c) source changers used in industrial radiography shall have a system for ensuring that the source will not be accidentally withdrawn from the changer when connecting or disconnecting and the source changer shall meet all applicable transportation requirements;
- (d) depleted uranium shielding shall be taken into account in relation to storage, use, transport and disposal of source changers that incorporate such.

#### **45. Requirements for radiation generators**

Any radiation generating equipment, including X-ray tubes, Linear Accelerators, Betatrons or Neutron generators shall meet the following minimum criteria:

- (a) cable lengths shall not be less than 20 metres for x-ray generators and the capacity shall be the maximum of 300kV longer for higher energy equipment and cables, which shall be properly laid;
- (b) directional x-ray tube assemblies shall wherever practicable be fitted with suitable collimators (i.e. "cones" or "diaphragms");
- (c) x- ray equipment shall conform with the National and International Electrical requirements and also metallic items including casings, interconnecting cables, transformers, generators, X ray control equipment, tube assembly, warning signals, other safety devices, and the work-piece shall be electrically bonded together ("earth bonding") and grounded (connected to earth);
- (d) the x-ray tube assembly shall, wherever practicable, be supported in a suitable stand or clamped in position to prevent it from inadvertently moving during the operation;
- (e) the control panel shall be fitted with the following features:

- (i) a label incorporating the radiation (trefoil) symbol and a legend indicating that hazardous x-rays are emitted when the equipment is operating and a worded warning prohibiting unauthorized use,
- (ii) a key switch to prevent unauthorized use. The key should be removable only when the switch is in the 'off' or 'standby' position. the key positions shall be clearly marked,
- (iii) a labeled warning light (preferably fail-safe), which indicates when the x-ray equipment is enabled,
- (iv) a separate labeled warning light (preferable fail-safe), which indicates when the x-ray equipment is actually emitting x-rays,
- (v) a timer that controls the exposure duration, or an x-ray ON/OFF switch that requires continuous pressure by the radiographer to maintain x-ray production,
- (vi) indicators that show the x-ray tube potential in kilovolts (kV) and the current in milliamperes (mA) when the x-ray beam is ON,
- (vii) a clearly labeled way to terminate the generation of radiation.

#### **46. Requirements for underwater radiography equipment**

(1) The standards specified for conventional equipment, that is used for underwater radiography shall be designed, manufactured and tested to ensure that it is able to withstand pressures and conditions encountered in underwater environments.

(2) This shall include appropriate watertight seals, use of waterproof ancillary equipment and radiation survey meters or other radiation detectors (e.g. personal alarm devices).

(3) The equipment shall indicate the maximum depth rating at which it can be used safely and additional restrictions shall be described in an operation and maintenance manual.

(4) Licensees shall ensure that radiographers are aware of all such restrictions and that these are clearly stated in the local rules.

#### **47. Requirements for pipeline crawler equipment**

(1) Pipeline crawler equipment used for industrial radiography shall meet the applicable minimum standards for gamma sources or x-ray tubes as specified in these regulations.

(2) The sealed source used in the positioning device must meet the standard requirements for a sealed source as contained in these regulations.

#### **48. Maintenance programme**

(1) The licensee shall ensure that exposure devices, radiation generators, ancillary equipment, and safety systems are regularly inspected and maintained in good working order and this will require a formal programme of inspection and maintenance that shall take into account the recommendations of the equipment manufacturer and supplier.

(2) This program as a medium shall incorporate -

- (a) routine checks to be carried out at the beginning of each radiography session and which all radiographers are trained;
- (b) periodic inspection and servicing of equipment that can be done by the Licensee;
- (c) periodic inspection and servicing of equipment that shall only be done by a qualified expert either from the equipment supplier or agents approved by the equipment supplier;
- (d) any service arrangements made between the operating organization and the equipment supplier or approved agent shall be specified in writing and the operating organization shall monitor these arrangements to ensure that the agreed work is actually carried out;
- (e) any equipment found to be defective shall be marked unserviceable, and cannot be used until repaired. Any such defect shall be promptly notified to the Radiation Safety Officer.

#### **49. Maintenance of source exposure containers**

(1) The routine daily pre-operational safety checks done by radiographers or Radiation Safety Officer shall include:

- (a) verifying that the source locking mechanism functions properly;
- (b) verifying that accessible screws and nuts are tight and the threads are not damaged;
- (c) verifying that the source assembly connection to the drive cable is secured using a non interrupted gauge as supplied by the manufacturer to check for excessive wear;

- (d) inspecting the connections of the guide tubes and control mechanism to the exposure containers are properly secure;
- (e) monitor the radiation levels to be normal;
- (f) ensure that all labels are legible and securely fastened to the device.

(2) The periodic inspections and servicing of exposure containers shall be done by the supplier, their agents, or trained staff within the operating organization and shall include:

- (a) inspecting the security of source assembly connections;
- (b) monitoring free source movement;
- (c) inspecting the locking mechanisms; damaged or worn out parts replaced;
- (d) lubrication as described by the manufacturer;
- (e) operational check after re-assembly;
- (f) measurement of the exposure levels on the outside of the exposure containers;
- (g) checking the structural integrity of the device, e.g. no cracks in welds, other obvious damage, or missing parts;
- (h) ensuring that all fasteners are in good condition and are secured to the proper torque;
- (i) checking the condition and legibility of the identification and radiation labeling on the exposure device.

## **50. Maintenance of ancillary equipment**

(1) The routine pre-operational safety checks done by radiographers or Radiation Protection Officer shall include:

- (a) drive cable, checked for free movement;
- (b) check for excessive leakages or damages to the guide tubes;
- (c) collimators or specialized guide tubes shall be clear of obstructions and all fittings should be secured.

(2) The periodic inspections and servicing of ancillary equipment by the supplier, their agents, or trained staff within the operating organization shall include:

- (a) removal and cleaning of the drive cable, inspect for corrosion, fraying and bends or leakages;
- (b) application of proper lubrication to the drive cable as described by the manufacturer;
- (c) all source stops and fittings shall be securely fastened with no visible damage, cracking, or excessive wear;
- (d) all threaded fittings are not damaged.

**51. Maintenance of source changers**

(1) The routine pre-operational safety checks by radiographers or Radiation Safety Officer shall includes:

- (a) lock assemblies to function properly;
- (b) guide tube connections are properly secured;
- (c) there are no obstructions in the transfer tubes.

(2) If a source changer is to remain with the operating organization at the radiography facility, periodic inspection and servicing shall be retained and which shall include:

- (a) lock assemblies to function properly;
- (b) threaded fittings are not damaged;
- (c) any source guides are not bent or damaged;
- (d) all lids and protective covers are properly fixed and not damaged;
- (e) all labels are legible and securely fastened to the source changer.

**52. Maintenance of X-Ray equipment and other radiation generator**

(1) Licensees shall ensure that the following pre-operational safety checks are carried out:

- (a) no visible damages to the equipment;
- (b) cables have no cuts, links or broken fittings;
- (c) no leakages on the cooling system (water or oil);
- (d) all interlocks are operational;

- (e) required warning signs are legible;
- (f) all warning indicators are functioning with no light bulbs, etc. broken;
- (g) all fastenings are tight and no threaded connectors are undamaged.

(2) The periodic inspection and servicing done by the supplier, their agents, or specially trained staff within the operating organization shall include the items listed above and the following:

- (a) inspecting the electrical safety including earth bonding;
- (b) cleaning or replacing any filters in cooling systems;
- (c) other servicing as recommended by the supplier;
- (d) check for any X- ray leakage from the tube;
- (e) inspection to ensure that all cables are in good condition, with no fraying or exposed wires;
- (f) tests on electrical insulation of cables;
- (g) tests on all interlocks and emergency cut-out switches;
- (h) tests on all permanently installed radiation detectors in radiography enclosures;
- (i) tests on all warning signals installed inside radiography enclosures and this shall be done in a safe manner and on a regular basis without exposure of persons inside the enclosure.

## **PART VII - REQUIREMENTS FOR SHIELDED ENCLOSURES**

### **53. Shielded radiography enclosure**

Whenever practicable, industrial radiography shall be undertaken in a shielded radiography enclosure and where this is not practicable (e.g.: for large or in-situ objects), radiography shall be carried out under 'Site Radiography' conditions.

### **54. Design of shielded enclosure**

(1) The design of a shielded enclosure shall be based on 'Defence-In-Depth' as described in Regulation 55.

(2) The design shall be submitted by the licensee to the Authority for authorization and work shall not commence until authorization is granted.

(3) Any significant modification relevant to radiation safety to be proposed to the design that has been authorized, the licensee shall not implement that modification until it has been authorized by the Authority.

## **55. Defence-in-depth**

(1) Licensees shall ensure that defence in depth is achieved by providing multiple layers of safety and such safety features shall be independent of each other so that failure of one does not result in failure of any other, and they shall be appropriate to the probability and magnitude of potential exposures.

(2) The following shall be provided as a minimum requirement:

- (a) adequate shielding for all persons in the vicinity;
- (b) safety system interlock that is free from any failure;
- (c) radiation warning system, free from any failure;
- (d) administrative procedures;
- (e) clear and well enforced operating procedures;
- (f) a qualified expert shall be consulted at the design stage of an enclosure and at the commissioning stage.

## **56. Adequate shielding**

(1) Licensees shall ensure that enclosures used for fixed radiography are adequately shielded.

(2) In order to assess the adequacy of shielding therefore the licensees shall ensure that the following factors are taken into consideration:

- (a) the source of radiation output and energy;
- (b) direction of the main radiation beam (panoramic, collimated, restricted direction);
- (c) setting of primary and secondary barriers and the calculation of adequate barrier thickness, including walls, doors, roofs and floors as applicable;
- (d) personnel access to areas in the vicinity of the shielded enclosure;
- (e) occupancy of relevant adjacent areas and an assessment of potential doses;

- (f) access into the enclosure for personnel or work pieces;
  - (g) accessible instantaneous dose rates outside shall not be exceeded.
- (3) Design calculations shall take into account the following aspects:
- (a) possible use of different radiation sources at a later stage;
  - (b) all likely radiation beam directions;
  - (c) leakage of radiation through the roof of the enclosure and the proximity of persons above the roof or at raised heights around the enclosure;
  - (d) scattering of radiation over the walls of the enclosure;
  - (e) design of cable penetrations and door seals to prevent leakage paths for scattered or direct beam radiation;
  - (f) determination of dose rates in adjacent areas.

#### **57. Safety and warning systems**

(1) Licensees shall ensure that for enclosures in which radiation generators and high output sealed sources (i.e.  $>10\mu\text{Svh}^{-1}$  at 1 m) are used.

- (2) The following safety systems are required:
- (a) effective devices (interlocks) that prevent exposure unless the door(s) is closed and that terminate the exposure if the door is opened and such devices shall be installed so that the mere act of closing a door does not initiate an exposure;
  - (b) emergency stop switches or other means of terminating the exposure, in case a person is inadvertently inside the enclosure.

#### **58. Warning system**

(1) Licensees shall ensure that the following warning systems are installed and maintained:

- (a) warning shall be given before the commencement of an exposure normally an audible signal, such as a siren to warn persons both inside and outside the enclosure;
- (b) a separate and distinguishable warning throughout the duration of the exposure normally visual, such as rotating and flashing beacons both inside and outside the enclosure;

- (c) notices giving instructions at every access points as well as inside the enclosure and also, an explanation of the meaning of various warning systems and instructions on what to do in an emergency situation;
- (d) notices inside the enclosure shall clearly state any working restrictions that must be observed (e.g. limitations on beam directions);
- (e) the warning signals described above shall operate automatically.

(2) With very high dose rates, consideration shall be given to installing a fixed radiation monitor inside the enclosure to provide one of the following features:

- (a) a visible indication of whether radiation levels are normal or elevated above a pre-determined level (i.e. when a source may not be shielded or an x-ray generator may not have terminated correctly);
- (b) a signal to a door actuator to prevent the door being opened unless the dose rate is below a pre-determined level.

#### **59. Designation of shielded enclosures**

Licensees shall designate the shielded enclosures as controlled areas and there shall be warning signs at access points to clearly indicate the designation and a description and the basis for designating shall be included in the local rules.

#### **60. Local rules**

(1) The Licensee shall establish local rules which shall describe how the practical aspects of industrial radiography will be carried out in compliance with the Regulations and License conditions.

(2) The local rules shall include:

- (a) a description of controlled and supervised areas around fixed facilities;
- (b) designation of controlled and supervised areas during site radiography, including procedures for setting up barriers and erecting warning signs;
- (c) control of access to designated areas;
- (d) operating instructions for the radiographic equipment and safety systems;
- (e) requirements for individual and area monitoring;
- (f) name of the Radiation Safety Officer and the radiographers;

- (g) transportation and storage of radioactive sources;
- (h) co-operation with clients and other employees during site radiography;
- (i) emergency plans for dealing with foreseeable emergencies.

#### **61. Commissioning**

The Licensee shall carry out a detailed commissioning safety assessment and radiation survey before an industrial radiography facility is brought into routine operation and for the purpose of the commissioning, the following are to be considered:

- (a) the facility has been constructed in accordance with the design specification, as authorized;
- (b) the design specifications have resulted in accessible dose rates outside the facility being no greater than planned, under the most critical conditions of operation;
- (c) the safety and warning systems have been properly installed and confirmed to be operating in accordance with the design specifications;
- (d) administrative systems, local rules and operating procedures are in place.

#### **62. Decommissioning process**

(1) At the end of the useful life of a radioactive source, a radiation generator or a radiography facility, the decommissioning process shall pay due regard to safety.

(2) Licensees shall notify the Authority and ensure the following items are implemented as appropriate to the circumstances:

- (a) authorized disposal or transfer of sealed radioactive sources;
- (b) checks for any residual radioactive contamination and the authorized disposal of any contaminated material that is found or is created during decontamination;
- (c) authorized disposal of sealed source containers that incorporate depleted uranium;
- (d) exposure containers shall be labeled as “**empty**” if they do not contain a radioactive source;

- (e) safe disposal of radiation generators rendered inoperative;
- (f) removal of all warning notices that are no longer applicable;
- (g) documentary evidence that the decommissioning work is completed.;
- (h) on completion of decommissioning, no residual radiological hazard shall remain and there should be no indications that might create unnecessary concern in the future.

## **PART VIII - REQUIREMENTS FOR SITE RADIOGRAPHY**

### **63. Preparation for site radiography**

(1) Work pieces shall, where practicable be radiographed inside shielded facilities and where this is not practicable, such as radiography of in-situ plant or very large work pieces, radiography shall be undertaken under “site radiography” conditions.

(2) site radiography shall be confined to a controlled area where specific protective measures and safety provision are rigidly enforced before commencing radiography under site radiography conditions.

(3) The licensee shall -

- (a) obtain a licensee as required by the authority;
- (b) carry out a site-specific safety assessment;
- (c) provide a secure store for sealed sources and radiation generators;
- (d) ensure that a suitable, tested and functioning radiation monitor is available at the site;
- (e) exchange necessary information and co-operate with the site operator in so far as it is necessary to ensure the safety of all persons on the site in respect of the radiography;
- (f) evaluate the most appropriate radiation source to use, such that its output is not significantly greater than required to produce the required radiograph (i.e. lowest operating voltage and beam parameters for radiation generators and lowest activity for gamma sources) and this is particularly so for gamma sources, where there is a chance of a jammed or disconnected source that may need to be recovered.

**64. Designation of a controlled area**

(1) A controlled area shall be designated, without exception, during site radiography.

(2) In order to determine the extent of the controlled area, Licensees shall take account of the nature and frequency of site radiography at a specific site as well as occupancy.

(3) The boundary of the controlled area shall be physically demarcated at all positions where access is possible.

**65. Defence-in-depth during site radiography**

During site radiography, licensees shall ensure that defence in depth is achieved by providing multiple layers of safety that include:

- (a) carrying out a prior site-specific safety assessment;
- (b) establishment and demarcation of a controlled area;
- (c) restriction of access to the controlled area;
- (d) patrolling the controlled area by the radiographers;
- (e) use of survey meters before and after every exposure;
- (f) use of personal alarming dosimeters;
- (g) use of warning signals before and after the exposure;
- (h) properly and well implemented operating procedures.

**66. Shielding and restriction of dose rates**

Restriction of dose rates shall be achieved by the following measures -

- (a) use of a radiation source of output not significantly greater than required to produce the required radiograph;
- (b) use of natural boundaries around the work piece where necessary (e.g. walls and other structures in the area);
- (c) purpose designed shielding such as collimators;
- (d) additional local shielding such as “beam stops”, flexible lead sheet, bags of lead shot, etc;

- (e) control of beam direction to minimize spread (downward beam directions are usually preferable).

#### **67. Boundary of controlled area**

(1) A controlled area shall be designated, without exception, during all site radiography procedures and the contour demarcating the area of safe dose shall be set at a value ensuring that outside the controlled area the annual dose limits for the public is not exceeded.

(2) The controlled area shall include the complete periphery of the contour and where necessary demarcate areas above and below the working level.

#### **68. Warning notices**

(1) Warning notices shall be displayed around the controlled area boundary at suitable positions, and shall bear the international radiation trefoil symbol, warnings and appropriate instructions in English language and local language (e.g. Danger Radiation, Controlled Area And Keep Out) and the meaning of the warning signals shall be clearly stated.

(2) A notice should also include a phone number for use in case of emergencies.

#### **69. Warning signals**

Visible and audible signals shall be used when a radiographic source is exposed or an X-ray machine is energized and the warning signals shall be in the form of:

- (a) audible pre-warning that an exposure is about to take place;
- (b) visual warning throughout the duration of an exposure in the form of a rotating, flashing beacon;
- (c) these shall operate automatically and be designed to fail-to-safe in the case of radiation generators and in the case of sealed sources it is preferable that the warnings be arranged to operate automatically (e.g., actuated by a signal from a radiation monitor).

#### **70. Patrolling and monitoring of controlled area**

Before the commencement of any radiographic work:

- (a) the area shall be cleared of all people except for authorized personnel;
- (b) the boundary shall be clearly visible, well illuminated and continuously patrolled to ensure that unauthorized people do not enter the controlled area;

- (c) prior to carrying out the first exposure the radiographers shall perform a test exposure to ensure that dose rates at the boundary do not exceed authorized limits;
- (d) dose rates at representative points at the boundary shall be checked during operations to ensure that the barriers are correctly positioned, particularly if the position of the equipment or direction of the radiation beam is changed.

**71. Local Rules at the radiography site**

(1) The Licensee shall provide appropriate local rules that are followed by all persons involved in the site radiography.

(2) Some key elements of the rules shall include the following:

- (a) site radiography shall not be undertaken unless at least two trained radiography staff (one of who may be an assistant radiographer) is in attendance for each radiation source in use;
- (b) the boundary of the controlled area shall be determined in accordance and as contained in this regulations and it shall be effectively delineated with appropriate warning notices displayed;
- (c) warning notices and warning signals shall be clearly visible at the boundary of the controlled area;
- (d) a survey meter shall be used after every exposure to ensure that it is safe for persons to enter the controlled area;
- (e) any person who enters the controlled area shall wear a personal dosimeter and a functioning personal alarm monitor;
- (f) radiographic techniques shall be chosen with a view to minimizing doses received by radiography staff and other persons;
- (g) physical control shall be exercised over the radiation beam in so far as this will assist in restricting the size of the controlled area;
- (h) the wind-out crank or radiation generator control panel shall normally be set up outside the controlled area and where this is not possible it shall be positioned such that the authorized radiographer, who enters the controlled area in order to initiate or terminate an exposure, shall not be exposed to a dose rate in excess of  $2 \text{ msvh}^{-1}$ ;
- (i) only the Radiation Safety Officer, radiographers and trained radiography assistants shall be permitted into the controlled area;

- (j) dose rates at the boundary of the controlled area shall be checked during the first exposure and re-checked whenever exposure conditions are materially altered. The results shall be recorded;
- (k) the boundary of the controlled area shall be kept under continual surveillance throughout all exposures. This may require additional personnel if the area is large or complex;
- (l) when the controlled area is entered on the conclusion of an exposure, a survey meter shall be used to confirm that the exposure has ceased and, in the case of the use of sealed source, that the source is fully shielded;
- (m) on completion of an exposure using a sealed source, the operator shall ensure that the source is secured in the container or that the container is securely closed, as appropriate to the type of container in use;
- (n) on completion of an exposure using a radiation generator, the operator shall remove the key from the console and take it with him when entering the controlled area.

## **72. De-designating the controlled area**

On completion of site radiography work or at the end of a working period if the work is long-term the controlled area shall be de-designated and the following steps shall be taken:

- (a) confirmation that all radioactive sources are fully shielded and in their exposure container;
- (b) after all exposure containers have been removed, a final check shall be made with a survey meter to ensure that no radioactive sources have been inadvertently left behind;
- (c) check that all warning notices have been removed.

## **PART IX - TRANSPORTATION OF RADIOACTIVE SOURCES**

### **73. General requirements**

(1) The transportation of sealed sources shall comply with International Atomic Energy Agency for Safe Transport of Radioactive Materials, TS-R-1 and Nigeria Safe Transport of Radioactive Materials Regulations and proper packaging shall be used for all transportation, and the manufacturers instructions followed for proper preparation of exposure containers before transportation.

(2) The following steps shall be taken:

- (a) the package shall be suitable for its intended use and the modes of transport involved;
- (b) gamma radiography sources are transported only in Type B packages that must have a valid certificate. The licensee shall have a valid copy of the certification;
- (c) gamma radiography sources are locked in their shielded position and any key removed;
- (d) all shipping plugs or caps are fitted correctly and, where possible, locked in place;
- (e) the package is in good condition, is fit for transport and is labeled correctly;
- (f) radiation levels are measured at the surface of the package and at one meter from it to ensure that the levels are within allowed limits and to ensure that appropriate shipping labels are displayed;
- (g) applicable shipping labels shall be applied to the outer surface of the package based on the radiation levels obtained;
- (h) a radioactive source for transportation shall have a valid leak test certificate and if not, a leak or wipe test shall be performed on the outer surface of the source container and the shipping package before shipment;
- (i) the package shall be properly secured and braced in the transport vehicle;
- (j) the vehicle carrying the package shall be placarded on both sides of the vehicle and on the rear of the vehicle with radioactive placards as defined in the Nigerian Regulations for the Transportation of Radioactive Sources and in the International Atomic Energy Agency (TS-R-1);
- (k) appropriate transportation papers must accompany the shipment (e.g.: consignor's statement and information for the carrier, such as emergency contact details).

#### **74. Receipt of radioactive materials**

(1) Prior to each shipment of radioactive, the licensee shall make necessary arrangements with the source supplier, to receive all relevant information. This information shall include the following for each package or container:

- (a) the nuclide, number and activity of sources;
- (b) a description of the source construction and performance tests, including leakage tests;
- (c) special form approval certificate;
- (d) a description of the package;
- (e) approval certificate for Type B packages, or Statement of compliance with International Atomic Energy Agency (TS-R-1) for other packages;
- (f) details of any special arrangements required, including multilateral approvals, where necessary;
- (g) a copy of the transportation documents to be sent to the licensee by fax or e-mail before dispatch if possible.

(2) The licensee shall not agree to the dispatch of the consignment by the supplier, unless all the above items are complied with. The supplier and licensee shall agree on the transportation route and responsibility for each stage of the journey.

(3) Arrangements shall also be made for the following where necessary:

- (a) checking of radiation dose rates from the package or container;
- (b) checking that the correct transport labels are attached to the package or container, and replacing any that is damaged or illegible;
- (c) ensuring that the package or container is securely attached to the vehicle and that the vehicle is correctly labeled;
- (d) dealing with border controls;
- (e) security of the consignment during transport, particularly during delays or overnight stops.

## **75. Dispatch of radioactive materials**

The licensee shall return packages or containers to the source supplier after receipt of a consignment of radioactive material. All requirements in the Nigeria Safet Transport of Radioactive Materials and International Atomic Energy Agency (TS-R-1) concerning packaging, labeling, placarding where necessary, consignor responsibilities and all authorizations and approvals must be met before dispatching radioactive materials.

**76. Empty packages**

With regard to returning empty packages the licensee shall:

- (a) carry out dose rate and contamination monitoring of both the inside and outside of the package or container to ensure that there is no residual radioactive material present and it can therefore be treated as an empty package or container;
- (b) remove or cover all transport labels relating to the sources contained in the package or container when received;
- (c) examine the package or container to ensure that it is in good condition, and then close it securely, referring to any procedures provided by the source supplier;
- (d) attach a label to the outside of the package or container stating **“UN 2908 RADIOACTIVE MATERIAL EXCEPTED PACKAGE — EMPTY PACKAGING”**;
- (e) complete a transportation document;
- (f) contact the source supplier and agree on the transport route and responsibility for each stage of the journey. Inform the source supplier of the proposed date of dispatch.

**77. Unused sources**

With regard to returning unused sources, the licensee shall provide the following information to the consignee for each package or container:

- (a) the nuclide, number and activity of sources;
- (b) a description of the source construction including leakage tests;
- (c) special form approval certificate;
- (d) a description of the packaging in which the source is to be transported;
- (e) approval certificate for Type B package, or statement of compliance with International Atomic Energy Agency (TS-R-1) for other packages;
- (f) details of any special arrangements required, including multilateral approvals, where necessary;

- (g) a copy of the transportation documents to be sent to the consignee by fax or e-mail before dispatch if possible.

## **78. Dispatch of consignment**

The licensee shall not dispatch the consignment, unless they have received confirmation from the consignee that they are prepared to accept it.

## **79. Transportation routes**

(1) The licensee and consignee should agree on the transportation route and the responsibility for each stage of the journey.

(2) The Licensee shall be responsible from dispatch until the consignment reaches the consignee's premises and other arrangements are satisfactory provided they are agreed in advance by both parties and are also acceptable to the regulatory authorities.

## **80. Details of consignment**

In order to prepare the consignment for dispatch, the licensee shall:

- (a) load the sources into the package, verifying the details to be provided to the consignee e.g., serial numbers and comparable information to be entered on the transport document;
- (b) close it securely and then examine the package or container to ensure that it is in good condition, referring to any procedures provided by the source supplier;
- (c) carry out contamination monitoring of the outside of the package or container to ensure that there is no residual radioactive material present and it is therefore suitable for transport;
- (d) carry out dose rate monitoring of the package or container and attach appropriate transport labels;
- (e) refrain from using the transport labels relating to the sources contained in the package or container when received;
- (f) complete a transportation document.

## **81. Security for the consignment**

Arrangements shall also be made for the following:

- (a) ensure that the package is securely attached to the vehicle and that the vehicle is correctly labeled;
- (b) deal with border controls;
- (c) provide security for the consignment during transportation, particularly during delays or overnight stops.

## **PART X - EMERGENCY PLANNING AND PREPAREDNESS**

### **82. Programme for emergency planning and preparedness**

Where a safety assessment identifies that an accident is likely to affect workers or members of the public, the licensee shall prepare emergency plans which are designed to secure the protection and safety of anyone who may be affected by such accident.

### **83. Consultation for emergency plan**

(1) A Radiation Safety Adviser shall be consulted when drawing up emergency plans.

(2) Emergency planning and preparedness should be regarded as comprising the following stages:

- (a) identification of potential accidents and other unplanned events during industrial radiography and an evaluation of the risks associated with these;
- (b) development of emergency plans to deal with the identified hazards;
- (c) specification and acquisition of emergency equipment;
- (d) training to implement the emergency plan, including necessary training in the use of the emergency equipment;
- (e) exercises at appropriate intervals to test the implementation of the emergency plan;
- (f) periodic reviews and necessary updates of the emergency plans.

### **84. Implementation of emergency plan**

(1) The responsibility for adequately implementing each of the six stages contained under Regulation 83(2) lies with the licensee of the industrial radiography organization and the resulting emergency plans and associated arrangements shall form a part of the license application to the Authority.

(2) Implementation of the emergency plan may involve participation by external organizations and specialized consultants and the plan shall clearly address such external

participation, ensuring that the participators are fully aware of and accept their various responsibilities.

#### **85. Initial Safety assessment**

At this stage, reasonable foreseeable accident and incident situations shall be identified, likely consequences evaluated and potential doses estimated for all persons who may be involved including members of the public if applicable and local circumstances shall be taken into account.

#### **86. Sealed sources**

Each of the following events involving sealed sources shall be recognized as constituting a potential event necessitating implementation of an emergency plan:

- (a) failure to fully retract a source;
- (b) a source struck outside the shielded container, whether within the collimator, the guide tube or close to entrance to the container;
- (c) disconnection of the source from the wind-out cable;
- (d) a theft or loss of a source, container or exposure;
- (e) damage to a source or a container, e.g. mechanical or fire damage, including during transport;
- (f) radioactive contamination resulting from a damaged or faulty source;
- (g) malfunction or deliberate defeat of the safety and warning system.

#### **87. Radiation generators**

The identifiable potential events involving radiation generators shall be recognized to include the following:

- (a) an automatic exposure timer fails to terminate an exposure;
- (b) unintentional energizing of an X-ray tube;
- (c) an operator fails to terminate a manually controlled exposure;
- (d) a malfunction of any critical safety or warning system, including deliberate action to override;
- (e) physical damage causing an equipment malfunction or damage to shielding;

- (f) a failure of the associated safety and warning system, or the operator fails to heed a warning that is being given.

## **88. Development of emergency plans**

Emergency plans shall address each of the reasonably foreseeable accident situations identified during safety assessment and shall aim to restrict, so far as is reasonably possible, any exposures that may result from them.

## **89. Features of emergency plan**

The emergency plans should develop the following components:

- (a) identification of persons authorized to implement the various stages of the plans;
- (b) identification of persons or organizations that may need be notified at the various stages of the plans, including all necessary telephone, fax, e-mail numbers and addresses;
- (c) advice on when to implement the emergency plans;
- (d) procedures specific to each identified emergency situation, to be followed at various stages, as applicable -
  - (i) initial stage, to contain the situation;
  - (ii) planning stage, to plan and practice the recovery stage;
  - (iii) recovery stage;
  - (iv) post accident stage, to return working situation to normal;
  - (v) preparation of accident report;
- (e) special procedures to follow in life threatening situations;
- (f) availability of emergency response equipment;
- (g) notification to the Authority

## **90. Emergency equipment**

Licensees shall ensure that all necessary equipment is available to deal with emergency situations. Emergency equipment shall include:

- (a) appropriate and functioning survey meters, personal alarming dosimeters and direct reading dosimeters (QFE or electronic);
- (b) additional personal dosimeters, thermo luminescent dosimeters or film badges;
- (c) barrier materials and warning notices;
- (d) bags of lead shot, spare lead sheet and lead tunnel;
- (e) suitable tool kit and source recovery equipment long handling tongs, pliers, screwdrivers, bolt cutters, adjustable spanner, hacksaw and torch light;
- (f) emergency shielded storage container, spare source container and communication equipment (e.g. mobile phones, walkie-talkies);
- (g) spare batteries for survey meters, personal alarms and torch;
- (h) stationery supplies and incident logbook;
- (i) equipment manuals.

**91. Inspection and maintenance of emergency equipment.**

Licensees shall carry out regular audits to ensure that all emergency equipment is available and is functioning correctly.

**92. Training**

(1) All persons nominated to participate in the emergency plans shall be adequately trained to ensure efficient and effective implementation of their roles and this shall include familiarization and understanding of the plans together with training in the use of the emergency equipment.

(2) Training provisions shall be audited at intervals, not exceeding 12 months.

**93. Emergency exercises**

Emergency exercises shall be held to test critical components of the emergency plans at intervals and lessons learned shall form part of future reviews of emergency plans.

**94. Periodic reviews of emergency plans**

Formal reviews of emergency plans shall be undertaken annually to ensure:

- (a) names of persons, contact details, telephone and fax numbers shall be up to date; and
- (b) emergency equipment is available and is maintained.

**95. Accident report**

In order to learn from the accident situations that have occurred within the organization or elsewhere, and to report back the lessons learned so as to improve equipment, operating procedures and emergency plans, reports of any accidents shall be prepared by Radiation Safety Officer with the assistance of a Radiation Safety Adviser and the reports shall be submitted to the Authority.

**96. Details of the accident report**

**97.** The accident report shall include the following:

- (a) a description of the accident, giving as much details as possible concerning the specific equipment involved including model and serial numbers;
- (b) names and designations of all persons affected by the accident;
- (c) environmental conditions at the time of the accident;
- (d) the specific cause of the accident, where known;
- (e) details of actions taken to stabilize the accident situation and restore conditions back to normal;
- (f) evaluation of doses received by all persons affected by the accident;
- (g) recommendations made with the aim of preventing a similar accident occurring in the future.

**PART XI - OFFENCES AND PENALTIES**

**97. Offences and penalties**

(1) Any person who contravenes any of the provisions of these regulations commits an offence.

(2) Any person who commits an offence under these regulations shall be liable to the penalties as established in the enforcement policy issued by the Authority.

(3) The Authority shall impose penalties such as suspension, revocation of authorization, imposing administrative fine, closure of facility or any combination of these.

(4) Any person or body corporate who, being a holder of authorization under these regulations, who commits an offence shall be liable to prosecution in the court of law and upon conviction be liable to pay fines not exceeding ₦1,000,000 for an individual and not exceeding N10,000,000 for a corporate body or be given a jail term not exceeding ten years or both.

**98. Appeal**

Any person may appeal to the Board of the Authority if he is not satisfied with the decision made against him pursuant to these Regulations.

**99. Citation**

These Regulations may be cited as the Nigerian Radiation Safety in Industrial Radiography Regulations, 2006.

