

Radiation Protection Authority



Zambia

SAFETY GUIDE

RPA SG 23

Baggage Scanners

2025

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ABBREVIATIONS AND ACRONYMS

RPA:	Radiation Protection Authority
RPAB:	Radiation Protection Authority Board
IAEA:	International Atomic Energy Agency
ALARA:	As Low As Reasonably Achievable
TLD:	Thermoluminescent Dosimeter
EPD:	Electronic Personal Dosimeter
SOP:	Standard Operating Procedure
ICRP:	International Commission on Radiological Protection
IEC:	International Electrotechnical Commission
PPE:	Personal Protective Equipment
RPO:	Radiation Protection Officer
QA/QC:	Quality Assurance/Quality Control
DRL:	Diagnostic Reference Levels
CPD:	Continuing Professional Development
TSA:	Transportation Security Administration
ZACL:	Zambia Airport Corporation Limited
ZRA:	Zambia Revenue Authority

FOREWORD



Over the past decades, Zambia has experienced a growing utilisation of ionising radiation in various sectors, including an expansion in security screening applications. The widespread adoption of X-ray technology for inspecting luggage, cargo, and personal belongings at airports, border crossings, and high-security facilities has become essential for national security. These systems provide critical capabilities for detecting weapons, explosives, contraband, and other threats without physically opening containers or luggage.

This Baggage Scanner Safety Guide serves as a comprehensive resource for organisations, operators, and radiation safety personnel involved in X-ray screening operations. It provides essential requirements for the safe installation, operation, maintenance, and decommissioning of baggage scanning equipment. The guide aligns with the Ionising Radiation Protection Act No. 16 of 2005 as amended by Act No. 19 of 2011 and incorporates international best practices promoted by the International Atomic Energy Agency (IAEA) and other recognised bodies.

By adhering to this guide, facilities will ensure compliance with national regulations while fostering a culture of safety that protects workers, the public, and the environment from the harmful effects of ionising radiation. The implementation of these guidelines will enable effective security screening while maintaining radiation exposures As Low As Reasonably Achievable (ALARA).

A handwritten signature in black ink, reading 'C. Jinja', written over a horizontal line.

Christabel Jinja Ngongola-Reinke
RPA Board Chairperson

ACKNOWLEDGEMENT



The Radiation Protection Authority (RPA) of Zambia acknowledges the expertise and collaboration of security professionals, radiation safety experts, airport authorities, customs officials, and international bodies including the IAEA, International Commission on Radiological Protection (ICRP), and Transport Security Administration (TSA) in developing this guide. Special gratitude is extended to the Zambia Airport Corporation Limited, Zambia Revenue Authority, high security facilities utilising these screening systems and the RPA Board, Management and staff whose dedication to advancing radiation safety standards in security screening has been instrumental. Their commitment to protecting workers and the public while enabling effective security operations is deeply appreciated.

A handwritten signature in black ink, appearing to read 'B. Siwila', with a stylized flourish extending from the end.

Dr. Boster Dearson Siwila, PhD
Executive Director

1.0 INTRODUCTION

The Baggage Scanner Safety Guide provides comprehensive requirements to ensure safe and compliant use of X-ray screening equipment in Zambia. It aligns with the Ionising Radiation Protection Act No.16 of 2005 as amended by Act No. 19 of 2011 and international standards. The guide covers all types of baggage scanners including carry-on baggage units, checked luggage systems, cargo scanners, and vehicle inspection systems. It emphasises justification, optimisation, dose limitation, facility design, occupational protection, security measures, and emergency preparedness to maintain high safety standards in security screening operations.

1.1 Purpose

The purpose of this guide is to ensure that all facilities using baggage scanning technology maintain the highest standards of radiation safety throughout the equipment lifecycle from acquisition to decommissioning while enabling effective security screening.

1.2 Scope

This safety guide applies to all X-ray baggage scanning operations in Zambia under the purview of the Radiation Protection Authority. It covers cabinet X-ray systems for hand luggage, conveyor systems for checked baggage, cargo inspection units, and vehicle scanning systems used at airports, borders, government buildings, hotels, and other security checkpoints.

2.0 JUSTIFICATION AND OPTIMISATION

2.1 The Licensee should ensure that:

2.1.1 The benefits of security screening outweigh radiation risks.

2.1.2 Written justification for baggage scanning operations is documented and maintained.

2.1.3 Alternative security methods are considered where appropriate

- 2.1.4 Radiation exposure is kept "As Low As Reasonably Achievable" (ALARA) through:
 - 2.1.4.1 Use of lowest possible kVp and mA settings consistent with image quality
 - 2.1.4.2 Minimisation of beam-on time
 - 2.1.4.3 Appropriate collimation and beam limitation
 - 2.1.4.4 Maximum use of distance and shielding principles
- 2.1.5 Quality Assurance programs are implemented including:
 - 2.1.5.1 Daily operational checks
 - 2.1.5.2 Monthly performance verification
 - 2.1.5.3 Annual comprehensive assessments
 - 2.1.5.4 Post-maintenance testing
- 2.1.6 Dose constraints are established:
 - 2.1.6.1 Workers: ≤ 2 mSv/year as planning target
 - 2.1.6.2 Public: ≤ 0.25 mSv/year from the practice
- 2.1.7 Regular review of operating procedures for optimisation opportunities
- 2.1.8 Scanning of humans or animals is strictly prohibited

3.0 FACILITY DESIGN, EQUIPMENT AND SHIELDING

- 3.1 The Licensee/facility should ensure that:
 - 3.1.1 Equipment specifications meet requirements:
 - 3.1.1.1 Cabinet design completely encloses X-ray source
 - 3.1.1.2 Leakage radiation ≤ 5 μ Sv/hr at 5 cm from external surface
 - 3.1.1.3 Compliance with IEC 62523 or equivalent standards
 - 3.1.1.4 RPA type approval obtained before procurement
 - 3.1.2 Shielding design incorporates:

- 3.1.2.1 Lead-lined cabinet walls appropriate for X-ray energy
 - 3.1.2.2 Lead curtains (≥ 0.5 mm Pb equivalent) at tunnel openings
 - 3.1.2.3 Overlapping curtain design to prevent gaps
 - 3.1.2.4 Additional shielding for high-energy cargo scanners
 - 3.1.3 Safety features include:
 - 3.1.3.1 Fail-safe interlocks on all access panels
 - 3.1.3.2 Emergency stop buttons at operator position and machine
 - 3.1.3.3 Key-operated or password-protected controls
 - 3.1.3.4 Dead-man switch for X-ray generation where applicable
 - 3.1.4 Warning systems comprise:
 - 3.1.4.1 "X-RAY ON" indicator lights visible from all approaches
 - 3.1.4.2 Audible signals during X-ray generation for large units
 - 3.1.4.3 Radiation trefoil symbol and warning labels
 - 3.1.4.4 Status indicators on control panel
 - 3.1.5 Installation requirements include:
 - 3.1.5.1 Stable, level surface for equipment placement
 - 3.1.5.2 Adequate space for loading and unloading
 - 3.1.5.3 Proper electrical supply and grounding
 - 3.1.5.4 Environmental controls (temperature, humidity)
 - 3.1.6 Commissioning involves:
 - 3.1.6.1 Radiation survey by qualified expert
 - 3.1.6.2 Verification of all safety systems
 - 3.1.6.3 Documentation of baseline measurements
 - 3.1.6.4 RPA inspection before routine use
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4.0 OCCUPATIONAL PROTECTION

4.1 The licensee/facility should ensure that:

4.1.1 Safe work practices include:

4.1.1.1 Designated control position for Operators

4.1.1.2 No body parts enter tunnel during operation

4.1.1.3 Use of mechanical aids for stuck items

4.1.1.4 Written Local Rules are established and adhered to.

4.1.2 Area classification establishes:

4.1.2.1 Controlled areas inside tunnel and immediate openings

4.1.2.2 Supervised areas in screening zones

4.1.2.3 Clear demarcation with barriers or floor markings

4.1.2.4 Appropriate warning signage at boundaries

4.1.3 Personal protection measures require:

4.1.3.1 Thermoluminescent Dosimeters (TLD) badges for all occupationally exposed workers

4.1.3.2 Dosimeter serving/reading every 2 months of use

4.1.3.3 Establishment of investigation levels

4.1.3.4 Annual dose assessment and optimisation

4.1.4 Administrative controls include:

4.1.4.1 Operation of equipment by trained and authorised personnel only

4.1.4.2 Initial radiation safety training for all the operators

4.1.4.3 Annual refresher training for all the operators

4.1.4.4 Maintenance of current operator authorisation list

4.1.5 Pregnant worker protection involves:

4.1.5.1 Establishment of declaration procedures

4.1.5.2 Assessment of dose for work position

- 4.1.5.3 Work modification if necessary
 - 4.1.5.4 Fetal dose limit <1 mSv for pregnancy duration
 - 4.1.6 Health surveillance comprises:
 - 4.1.6.1 Pre-employment medical examination
 - 4.1.6.2 Periodic review based on exposure levels
 - 4.1.6.3 Exit examination upon termination
 - 4.1.6.4 Medical records retained per the Regulations
-

5.0 SECURITY AND TRANSPORT

- 5.1 The Licensee/facility should ensure that:
 - 5.1.1 Physical security of fixed installations is established:
 - 5.1.1.1 Screening areas have controlled access
 - 5.1.1.2 Equipment is secured against unauthorised use when unattended
 - 5.1.1.3 Keys are removed and secured at end of operations
 - 5.1.1.4 CCTV coverage where appropriate
 - 5.1.2 Operational security measures should include:
 - 5.1.2.1 Two-person rule for opening equipment panels
 - 5.1.2.2 Visitor escort requirements in screening areas
 - 5.1.2.3 Background checks for screening personnel
 - 5.1.2.4 Regular security awareness training
 - 5.1.3 Mobile scanner requirements should include:
 - 5.1.3.1 Secured storage when not in use
 - 5.1.3.2 Transportation by authorised personnel only
 - 5.1.3.3 Equipment inventory taking before and after deployment
 - 5.1.4 Cybersecurity considerations should include:

- 5.1.4.1 Password protection for system access
- 5.1.4.2 Regular software updates from manufacturer
- 5.1.4.3 Protection against unauthorised parameter changes
- 5.1.4.4 Secure image storage and transmission
- 5.1.5 Integration with security protocols includes:
 - 5.1.5.1 Coordination with overall facility security plan
 - 5.1.5.2 Clear procedures for threat detection response
 - 5.1.5.3 Preservation of radiation safety during security emergencies
 - 5.1.5.4 Regular joint drills with security teams

6.0 PUBLIC AND ENVIRONMENTAL PROTECTION

6.1 The Licensee/Facility should ensure that:

- 6.1.1 Public dose limits are maintained:
 - 6.1.1.1 Dose rate $<2.5 \mu\text{Sv/hr}$ in publicly accessible areas
 - 6.1.1.2 Assessment of realistic occupancy factors
 - 6.1.1.3 Consideration of multiple sources if present
- 6.1.2 Access control measures include:
 - 6.1.2.1 Physical barriers preventing public access during operation
 - 6.1.2.2 Queue management keeping public at safe distances
 - 6.1.2.3 Clear signage in appropriate languages
 - 6.1.2.4 Staff supervision of public areas
- 6.1.3 Layout considerations should incorporate:
 - 6.1.3.1 Minimum 1-meter distance from tunnel exits for public
 - 6.1.3.2 Operator position away from direct beam path
 - 6.1.3.3 Adequate shielding toward occupied areas
 - 6.1.3.4 Regular review of facility changes

6.1.4 Special considerations are in place for the following:

6.1.4.1 Children: maintain greater distances from equipment

6.1.4.2 Vendors/workers in adjacent areas: assessment of cumulative exposure

6.1.4.3 Multi-level buildings: assessment of floor/ceiling transmission

6.1.5 The following environmental aspects:

6.1.5.1 No radioactive waste generation from X-ray units

6.1.5.2 Proper disposal of equipment at end-of-life

6.1.5.3 Electrical/electronic waste regulations compliance

6.1.5.4 Documentation of disposal methods

7.0 INCIDENT/ACCIDENT REPORTING

7.1 The Licensee/facility should ensure that:

7.1.1 Incidents are documented and reported which include:

7.1.1.1 Equipment malfunction affecting safety systems

7.1.1.2 Suspected overexposure of any person

7.1.1.3 person accidentally scanned

7.1.1.4 Interlock or shielding failures

7.1.1.5 Continuous X-ray emission faults

7.1.1.6 Security breaches affecting equipment

7.1.2 Systems for detection and immediate notification are established

7.1.3 Records of incidents/accidents are maintained.

8.0 TRAINING

8.1 The Licensee/Facility should ensure that:

8.1.1 All the occupationally exposed workers are trained and the initial training covers:

- 8.1.1.1 Basic radiation physics and health effects
 - 8.1.1.2 Equipment-specific operation
 - 8.1.1.3 Emergency procedures
 - 8.1.1.4 Practical assessment
- 8.1.2 RPO training requirements:
 - 8.1.2.1 Comprehensive radiation protection course (40 hours)
 - 8.1.2.2 Regulatory requirements and compliance
 - 8.1.2.3 Incident investigation techniques
 - 8.1.2.4 Training delivery skills
- 8.1.3 Continuing education includes:
 - 8.1.3.1 Annual refresher training (4 hours minimum)
 - 8.1.3.2 Updates on regulatory changes
 - 8.1.3.3 New equipment or procedure training
 - 8.1.3.4 Emergency drill participation
- 8.1.4 Training documentation comprises:
 - 8.1.4.1 Individual training records with signatures
 - 8.1.4.2 Course content and duration
 - 8.1.4.3 Assessment results and certificates
 - 8.1.4.4 Training effectiveness evaluation
- 8.1.5 Auxiliary staff awareness covers:
 - 8.1.5.1 Basic radiation hazards (1 hour)
 - 8.1.5.2 Warning signs and signals meaning
 - 8.1.5.3 Emergency response roles
 - 8.1.5.4 Access restrictions understanding

9.0 RESPONSIBILITIES

9.1 The Licensee should ensure:

9.1.1 Management commitment to radiation protection through:

9.1.1.1 Appointment of qualified RPO with authority to stop any unsafe operations at the facility

9.1.1.2 Provision of adequate resources for radiation protection enhancement activities

9.1.1.3 Regular safety performance review

9.1.1.4 Promotion of safety culture

9.1.2 That compliance is maintained by:

9.1.2.1 operating under a valid Ionising Radiation Licence at all times

9.1.2.2 Adhering to all the Licence conditions

9.1.2.3 Implementation of regulatory requirements

9.1.2.4 Timely renewals of the Ionising Radiation Licence

9.1.3 Establishment and documentation of:

9.1.3.1 Current radiation protection and safety program

9.1.3.2 Equipment inventory and specifications

9.1.3.4 Training and monitoring programs

9.1.3.5 Maintenance and QA programs

9.2 The RPO should ensure:

9.2.1 Daily oversight through:

9.2.1.1 Supervision of operations

9.2.1.2 Enforcement of procedures

9.2.1.3 Resolution of safety concerns

- 9.2.1.4 Exercising “stop unsafe operations authority” exercise when needed
- 9.2.2 Radiation Protection and Safety Program management through:
 - 9.2.2.1 Local Rules development and posting
 - 9.2.2.2 Dosimetry program coordination
 - 9.2.2.3 Area monitoring schedule implementation
 - 9.2.2.4 QA program supervision
- 9.2.3 Regulatory interface by:
 - 9.2.3.1 RPA inspection coordination
 - 9.2.3.2 Required report submission
 - 9.2.3.3 License amendment requests
 - 9.2.3.4 Incident notification management
- 9.3 Operators should ensure:
 - 9.3.1 Safe operation through of the equipment through:
 - 9.3.1.1 Pre-operational checks completion
 - 9.3.1.2 Adherence to operating procedures
 - 9.3.1.3 Proper use of safety features
 - 9.3.1.4 Immediate fault/incident reporting
 - 9.3.2 Personal protection by:
 - 9.3.2.1 Wearing assigned dosimeter
 - 9.3.2.2 Following ALARA practices
 - 9.3.2.3 Using provided Personal Protective Equipment
 - 9.3.2.4 Maintaining safe distances
 - 9.3.3 Professional conduct via:
 - 9.3.3.1 Maintaining Current training

9.3.3.2 Cooperation with RPO

9.3.3.3 Participation in drills

9.3.3.4 Upholding safety culture

REFERENCES

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APPENDIX I: QUALITY ASSURANCE PROGRAM ELEMENTS

Daily QA Requirements:

1.1 Pre-operational checks:

- a. Visual inspection of equipment integrity
- b. Lead curtain condition verification
- c. Warning light functionality test
- d. Emergency stop accessibility confirmation

1.2 Operational verification:

- a. Test object image quality check
- b. Conveyor operation smoothness
- c. X-ray on/off indicator function
- d. Control panel status review

Monthly QA Requirements:

1.3 Safety system tests:

- a. Interlock functionality verification
- b. Emergency stop operation from all positions
- c. Warning system comprehensive check
- d. Key control security verification

1.4 Performance assessments:

- a. Image quality evaluation using standard test kit
- b. Radiation survey at reference points
- c. Conveyor speed verification
- d. Documentation review and trending

Annual QA Requirements:

1.5 Comprehensive evaluation:

- a. Full radiation survey by qualified expert
- b. Electrical safety inspection
- c. Mechanical system assessment
- d. Software/firmware update review

1.6 Program effectiveness:

- a. Procedure review and update
 - b. Training effectiveness evaluation
 - c. Incident trending analysis
 - d. Regulatory compliance audit
-

APPENDIX II: EMERGENCY RESPONSE PROCEDURES

1.0 Equipment Malfunction - Continuous X-Ray Production:

1.1 Immediate actions:

- a. Press emergency stop button
- b. Turn key switch to OFF position
- c. Disconnect main power if necessary
- d. Evacuate immediate area

1.2 Follow-up actions:

- a. Post warning signs "DEFECTIVE - DO NOT USE"
- b. Notify RPO immediately
- c. Conduct dose assessment
- d. Arrange qualified repair service

2.0 Person accidentally Scanned:

2.1 Immediate response:

- a. Stop X-ray and conveyor immediately
- b. Assist person from equipment
- c. Document exposure parameters
- d. Provide reassurance and information

2.2 Reporting actions:

- a. Notify RPO within 1 hour
- b. Estimate dose received
- d. Report to RPA within 24 hours

3.0 Shielding or Interlock Failure:

3.1 Discovery actions:

- a. Cease operations immediately
- b. Secure affected area
- c. Perform radiation survey
- d. Identify extent of failure

3.2 Corrective measures:

- a. Implement temporary controls if needed
- b. Arrange immediate repair
- c. Re-verify safety before restart
- d. Document and analyse root cause

3.3 Immediate response procedures require:

- a. Stop X-ray generation using emergency controls
- b. Evacuate affected area if necessary
- c. Notify RPO within 1 hour
- d. Preserve incident scene for investigation

APPENDIX III: INCIDENT REPORTING PROCEDURES

1.0 Incidents to be reported include but not limited to:

- a. Equipment malfunction affecting safety systems
- b. Suspected overexposure of any person
- c. person accidentally scanned
- d. Interlock or shielding failures
- e. Continuous X-ray emission faults
- f. Security breaches affecting equipment

2.0 Reporting timelines mandate:

- a. Verbal notification to RPA within 24 hours
- b. Written preliminary report within 7 days
- c. Complete investigation report within 30 days
- d. Corrective measures implementation verification within 60 days

3.0 Investigation elements include:

- a. Root cause analysis
- b. Dose assessment for involved persons
- c. Review of procedures and training
- d. Corrective and preventive actions
- e. Effectiveness verification
- f. Lessons learned documentation

4.0 Record requirements specify:

- a. Incident log maintained on-site
- c. Trending analysis performed annually
- d. Sharing of lessons learned across facilities