Eskom	Standard	Nuclear Operating Unit

Title: **Operational Radiation Protection Requirements**

Document Identifier:	**238-36**
Alternative Reference Number:	**NSN-036**
Area of Applicability:	**Generation Division**
Functional Area:	**Radiation Protection**
Revision:	**1**
Total Pages:	**18**
Next Review Date:	**April 2024**
Disclosure Classification:	**Controlled Disclosure**

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Date: 29.04.2022	Date: 23/05/2022	Date: 27-05-2022

Nuclear Additional Classification Information

Business Level:	**2**
Working Document:	**3 – For reference**
Importance Classification:	**Not Applicable**
NNR Approval:	**Yes, letter k28457N, NAR-2006**
Safety Committee Approval:	**Not Applicable**
ALARA Review:	**Yes**
Functional Control Area:	**Radiation protection**

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1. INTRODUCTION

This standard specifies the operational radiation protection requirements for the Eskom Generation Division in terms of the Eskom Radiation Protection Policy 32-227 and Standard 32-226. Eskom is committed to ensure that nuclear and radiation safety receives the highest priority to provide for the protection of persons and the environment against harmful ionising radiation in accordance with the safety principles and requirements addressed in the Eskom Radiation Protection Policy and Standard.

2. SCOPE

2.1 PURPOSE

This standard specifies the requirements for operational radiation protection in terms of Eskom Policy 32-227, Eskom standard 32-226 and the Generation Division Radiation Protection Manual, 238-19 relating to radiation protection and safety of radiation sources.

2.2 APPLICABILITY

This procedure is applicable to Group III hazardous substances (electronic products), Group IV hazardous substances (radioactive sources), radioactive material, restricted material, special nuclear material and radioactive waste defined in the Generation Division Radiation Protection Manual, 238-19.

3. NORMATIVE/INFORMATIVE REFERENCES

The following normative references contain provisions that, through reference in the text, constitute requirements listed in this document. Parties using this document shall apply the most recent edition of the documents listed below, unless otherwise specified in the applicable statutory and regulatory requirements:

3.1 NORMATIVE

[1] 238-19: Generation Division Radiation Protection Manual.

[2] 238-35: Radiation Protection Dose and Risk Limits.

[3] 238-43: Requirements for Radiation Workers.

[4] 238-50: Respiratory Protection Requirements for Radiation Protection.

[5] 32-226: Eskom Standard, Radiation Protection and safety of radiation sources.

[6] 32-227: Eskom Policy, Radiation Protection and safety of radiation sources.

[7] ICRP 68: Dose Coefficients for Intakes of Radionuclides by Workers

3.2 INFORMATIVE

The following informative references were used during the development of this document. Although listed, the informative references are not mandatory requirements.

[8] 238-1: Nuclear Division Integrated Management System

4. DEFINITIONS AND ABBREVIATIONS

4.1 DEFINITIONS

4.1.1 **Assessment:** The process and the result, of analysing systematically the hazards associated with sources and authorised actions, and associated protection and safety measures, aimed at quantifying performance measures for comparison with criteria.

4.1.2 **Authorisation(s):** See authority and licence(s).

4.1.3 **Authorised action:** An action authorised in terms of the Nuclear Regulator Act, 1999 (Act No. 47 of 1999).

4.1.4 **Authority:** Written authority issued by the relevant regulator.

4.1.5 **Becquerel:** The unit of radioactivity in nuclear transformations or disintegrations per second.

4.1.6 **Dose limit:** The value of the effective radiation dose or the equivalent dose of radiation to individuals, from controlled practices, that shall not be exceeded.

4.1.7 **Dose:** The amount of radiation received, where the use of a more specific term such as effective dose or equivalent dose is not necessary for defining the quantity of interest.

4.1.8 **Electronic product:** Any electronic product that emits ionising electro-magnetic, particulate radiation or any sonic, infrasonic or ultrasonic wave.

4.1.9 **Eskom:** is used for Eskom Holdings SOC Limited, its divisions and wholly owned subsidiaries.

4.1.10 **Exposure:** The act or condition of being subject to irradiation. Exposure can be either external exposure (irradiation by sources outside the body) or internal exposure (irradiation by sources inside the body). Exposure should be classified as normal exposure, potential exposure, occupational exposure, public exposure or emergency exposure.

4.1.11 **Group III hazardous substance:** Any electronic product that emits ionising and non-ionising radiation.

4.1.12 **Group IV hazardous substance:** Any fabricated radio-isotopes.

4.1.13 **Intake:** The process of taking radioactive nuclides into the body by inhalation or ingestion or through the skin.

4.1.14 **Ionising radiation:** Radiation capable of producing ion pairs in biological material(s).

4.1.15 **Licence(s):** An Authorisation granted by the relevant regulatory authority, accompanied by specific requirements and conditions to be complied with.

4.1.16 **Occupational exposure:** All exposures of radiation to workers incurred during work.

4.1.17 **Practice:** Any human activity that introduces sources of exposure or exposure pathways, in addition to those of natural background radiation levels; 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 to people or the number of people exposed.

4.1.18 **Protection and safety:** The protection of people against exposure to ionising radiation or radioactive substances and the safety of radiation sources, including the means for achieving such protection and safety, such as the various procedures and devices for keeping peoples' doses and risks as low as reasonably achievable.

4.1.19 **Public exposure:** Exposure incurred by members of the public from radiation sources.

4.1.20 **Radiation worker:** Any person who is potentially exposed to radiation through his occupation to more than 1 mSv per annum.

4.1.21 **Radiation:** See ionising radiation.

4.1.22 **Regulatory authority:** Authority designated by government for regulatory purposes in connection with radiological protection and occupational health and safety i.e. the National Nuclear Regulator and the Directorate: Radiation Control, Department of Health.

4.1.23 **Risk:** The probability of a specified health effect occurring in a person or group as a result of exposure to radiation or (quantitatively expressed) a quantity expressing hazard, danger or chance of harmful consequences associated with actual or potential exposures relating to quantities such as the probability that specific consequences may arise and the magnitude and character thereof.

4.1.24 **Source:** Anything that may cause radiation exposure, by emitting ionising radiation or releasing radioactive substances or materials.

4.1.25 **Special person:** A person who under exceptional circumstances and for reasons approved by the Eskom Power Station/Installation Manager or his deputy requires entry into a radiological controlled area as defined in Eskom standard, 238-43: Requirements for Radiation Workers.

4.1.26 **Surface contamination:** The presence of fixed or non-fixed radioactive substance on a surface in quantities in excess of the limits specified.

4.2 ABBREVIATIONS

Abbreviation	Description
ALARA	As Low As Reasonably Achievable
Bq/m²	Becquerel per square metre
Bq/cm²	Becquerel per square centimetre
ESKOM	Eskom Holdings SOC Limited, its divisions and wholly owned subsidiaries
ICRP	International Commission on Radiological Protection
HEPA	High Efficiency Particulate Air
mSv/h	millisievert per hour

5. REQUIREMENTS

5.1 LOCAL RULES, PROCEDURES AND SUPERVISION

5.1.1 Radiation protection rules and procedures shall be established in writing as necessary to ensure adequate levels of radiation protection for workers and other persons.

5.1.2 Radiation protection rules and procedures shall be based on the requirements contained in the Eskom radiation protection policy, directive, regulation and associated standards.

5.1.3 Radiation protection rules and procedures shall be reviewed routinely.

5.1.4 Radiation protection rules and procedures shall be made available and the requirements should be made known to those workers to whom they apply and to other persons who may be affected by them.

5.1.5 The radiation protection rules and procedures shall reflect the ALARA principles.

5.1.6 Risk significant work involving occupational exposure shall be adequately supervised according to work requirements and all reasonable steps shall be taken to ensure that the radiation protection rules, procedures, protective measures and safety provisions are being applied.

5.2 PERSONAL PROTECTIVE EQUIPMENT

5.2.1 Radiation workers shall be provided with suitable and adequate personal protective equipment which meets relevant standards or specifications, including, as appropriate, protective clothing and; protective respiratory equipment for which the protection characteristics are made known to the users.

5.2.2 When appropriate, workers shall receive adequate instruction in the proper use of respiratory protective equipment, including testing for good fit as defined in Eskom standard, 238-50: Respiratory Protection Requirements for Radiation Protection.

5.2.3 Tasks requiring the use of some specific personal protective equipment should be assigned only to workers who on the basis of medical advice are capable of safely sustaining the extra effort necessary.

5.2.4 All personal protective equipment shall be maintained in proper condition and, if appropriate, shall be tested at regular intervals.

5.2.5 Appropriate personal protective equipment shall be maintained for use in the event of intervention.

5.2.6 If the use of personal protective equipment is considered for any given task, account shall be taken of any additional exposure that could result owing to the additional time or inconvenience, and of any additional non-radiological risks that might be associated with performing the task while using protective equipment.

5.2.7 The need for relying on administrative controls and personal protective equipment for protection and safety during normal operations shall be minimized by providing appropriate protective measures and safety provisions, including well engineered controls and satisfactory working conditions.

5.3 CLASSIFICATION OF RADIOLOGICAL CONTROLLED AND SUPERVISED AREAS

5.3.1 Radiological controlled areas

5.3.1.1 Any area in which specific radiological protective measures are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions and preventing or limiting the extent of potential exposures shall be designated as a radiological controlled area.

5.3.1.2 Radiological controlled areas shall be designated as radiation zones and/or contamination zones. The necessary controls shall be put in place to adequately control the radiological hazard in a non-radiological controlled zone when identified.

5.3.2 Radiation zones

5.3.2.1 A radiological controlled area shall be classified as a radiation zone if the estimated or measured occupational exposure to an individual exceeds 1 mSv per year.

5.3.2.2 A radiation zone shall be classified as a green zone when the ambient dose rate is greater or equal to 5×10^{-4} mSv/h but less than 2.5×10^{-2} mSv/h.

5.3.2.3 A radiation zone shall be classified as a yellow zone when the ambient dose rate is greater than or equal to 2.5×10^{-2} mSv/h but less than 1 mSv/h.

5.3.2.4 A radiation zone shall be classified as an orange zone when the ambient dose rate is greater than, or equal to 1 mSv/h but less than 10 mSv/h.

5.3.2.5 A radiation zone shall be classified as a red zone when the ambient dose rate is greater than, or equal to 10 mSv/h.

5.3.3 Surface Contamination zones

5.3.3.1 A radiological controlled area shall be classified as a surface contamination zone when the alpha emitter surface contamination is greater than or equal to 3.7×10^{-1} Bq/cm^2 averaged over 100 cm^2 area; or

5.3.3.2 A radiological controlled area shall be classified as a surface contamination zone when the beta or gamma emitter surface contamination is greater than, or equal to 3.7 Bq/cm^2 averaged over 100 cm^2 area.

5.3.4 Airborne contamination zones

5.3.4.1 A radiological controlled area shall be classified as an airborne contamination zone when identified radionuclides are estimated to result in a rate of effective committed dose, equal to, or greater than, 2.5×10^{-3} mSv/h; based on dose coefficients for intakes of radionuclides by workers and recommended by the International Commission on Radiological Protection in ICRP publication 68; or

5.3.4.2 A radiological controlled area shall be classified as an airborne contamination zone, when unidentified radionuclides are greater than, or equal to, 37 Bq/m^3. (See Footnote 1)

5.3.5 Radiological supervised areas (low occupancy areas)

5.3.5.1 Any area not already designated as a radiological controlled area, but where occupational exposure conditions are greater, or equal to, 5×10^{-4} mSv/h, but less than 7.5×10^{-3} mSv/h, shall be kept under review; taking occupancy into account, even though specific protective measures and safety provisions are not normally needed. No radioactive contamination shall be located in radiological supervised areas.

5.4 DEMARCATION OF RADIOLOGICAL CONTROLLED AND SUPERVISED AREAS

5.4.1 In determining the boundaries of any radiological controlled or supervised area, account should be taken of the magnitudes of the expected normal exposures, the likelihood and magnitude of potential exposures, and the nature and extent of the required radiation protection procedures.

5.4.2 Radiological controlled areas shall be clearly delineated and supervised areas shall be identified by an appropriate means.

5.4.3 Account should be taken of the nature and extent of radiation hazards in radiological controlled or supervised areas.

5.4.4 A radiation warning notice and appropriate instructions shall be displayed at access points and/or other appropriate locations within radiological controlled or supervised areas.

5.4.5 Operational radiation protection measures, including local rules and procedures that are appropriate to safeguard individuals in radiological controlled or supervised areas, shall be established.

5.4.6 Protective clothing; monitoring equipment and suitable storage for personal clothing shall be provided as appropriate at entrances to radiological controlled areas.

5.4.7 Contamination monitoring equipment shall be provided as appropriate at exits from radiological controlled areas where contamination is present.

5.4.8 Radiological conditions shall be reviewed periodically to determine the possible need to revise the radiation protection measures or the boundaries of radiological controlled or supervised areas.

5.4.9 Within a zone localised areas, “Hot Spots”, may exist where radiation dose rate levels are in excess of those defined for the zone. A zone containing such localised areas need not be given a higher zone classification provided the radiation level approximately 0.5m from the source, does not exceed the levels specified for the zone. “Hot Spots” shall be clearly signposted and, if practicable, be cordoned off.

5.5 RADIATION WORKERS AND VISITORS

5.5.1 Radiation workers

5.5.1.1 The requirements for radiation workers in Eskom employment are defined in Eskom Standard, 238-43: Requirements for Radiation Workers.

5.5.2 Visitors

5.5.2.1 Visitors to radiological controlled areas shall be registered as a special person.

5.5.2.2 Visitors to a radiological controlled area, shall be accompanied by a person knowledgeable about the radiation protection measures for that area.

5.5.2.3 Visitors shall be informed of the applicable radiation protection requirements before they enter a radiological controlled area to ensure appropriate protection of the visitors and of other individuals who may be affected by their actions.

5.5.3 Non-radiation workers

Non-radiation workers shall receive training in basic radiation protection and emergency planning concepts.

5.6 WORK PLANNING AND CONTROL TO RADIOLOGICAL CONTROLLED AREAS

5.6.1 Work planning

5.6.1.1 Work in radiological controlled zones shall be planned and reviewed to ensure that adequate controls are in place to conduct work safely. Planning and reviews should be commensurate with the radiological risk associated with individual tasks.

5.6.1.2 Planning the radiological aspects of work should be integrated into the work-planning process.

5.6.1.3 Methods available for radiological control such as engineered controls, shielding, efficiency improvement, decontamination, containment devices, work rescheduling or mock-ups should be made part of the job, where applicable.

5.6.1.4 Sufficient management review should be given to work which involves radiological risk.

5.6.1.5 Operational experience should be applied, where applicable.

5.6.1.6 Worker dose assessments and dose tracking processes shall be established.

5.6.2 Access controls

5.6.2.1 Access to radiological controlled areas shall be restricted by means of administrative controls and/or physical barriers, which could include locks; the degree of restriction being commensurate with the magnitude and likelihood of the expected exposures.

5.6.2.2 Controls should be adequate to ensure that an individual is not able to gain inadvertent access to red radiation zones. When access to a red radiation zone is by means of a door, gate, etc., it shall be kept locked. If a lockable entrance to a red radiation zone is not available, satisfactory methods shall be provided to prevent unauthorised access.

5.6.3 Work control

5.6.3.1 Engineering and administrative controls should be applied to complement operational radiation protection, where applicable.

5.6.3.2 Internal deposition of radioactive material should be kept as low as reasonably achievable.

5.6.3.3 Shielding and other protective measures for the worker that are optimised in accordance with the requirements of this standard shall be implemented as appropriate for restricting exposure in accordance with the limits specified.

5.6.3.4 The radiation protection programme shall include requirements relating to stopping work activities, whenever radiological safety may be compromised.

5.7 CONTROL OF ACTIVITIES IN RADIOLOGICAL CONTROLLED ZONES

5.7.1 Responsibilities of workers

5.7.1.1 Workers shall be informed of radiological protection rules and requirements.

5.7.1.2 Workers shall be subjected to a system to verify compliance and address deficiencies.

5.7.1.3 Workers shall co-operate in all aspects pertaining to radiological safety.

5.7.2 Storage of radioactive material

5.7.2.1 Radioactive material shall be stored safely in appropriate designated areas.

5.7.2.2 Storage facilities shall be adequately shielded and demarcated.

5.8 RADIOLOGICAL MONITORING

5.8.1 Monitoring of the workplace

5.8.1.1 In Eskom workplaces where occupationally exposed workers are unlikely to receive doses exceeding 6 mSv per year averaged over five consecutive years, workplace monitoring shall be implemented to keep under review the workplace exposure conditions in order to maintain an awareness of any significant changes in conditions and to enable doses to be assigned to occupationally exposed workers on the basis of general workplace exposure conditions.

5.8.1.2 Radiological controlled areas shall be maintained and kept under review through a monitoring programme.

5.8.1.3 The nature and frequency of radiological monitoring shall be sufficient to enable:

a. evaluation of radiation and contamination conditions in radiological controlled areas;

b. evaluation of concentrations or quantities of radioactive material;

c. evaluation of potential radiological hazards;

d. assessment of exposures in radiological controlled and supervised areas; and

e. review of the classification of radiological controlled and supervised areas.

5.8.1.4 The nature and frequency of radiological monitoring shall be documented in local rules and procedures.

5.8.1.5 The programmes for radiological monitoring shall specify:

a. the quantities to be measured;

b. where and when the measurements are to be made and at what frequency;

c. the most appropriate measurement methods and procedures; and

d. the reference levels and the actions to be taken, if they are exceeded.

5.8.1.6 Radiological monitoring results shall be made available to workers, where appropriate.

5.8.1.7 Instruments and equipment used for quantitative radiological measurement shall be calibrated periodically for radiation measurement.

5.8.2 Monitoring sources of external irradiation

5.8.2.1 All radioactive sources on Eskom premises shall be surveyed routinely.

5.8.2.2 Dose constraints for individuals operating sources on Eskom premises shall be implemented in accordance with the requirements contained in Eskom Standard, 238-35: Radiation Protection Dose and Risk Limits.

5.8.3 Monitoring radioactive contamination

5.8.3.1 The public shall be protected against radioactive contamination generated by Eskom.

5.8.3.2 Where possible, all radioactive sources on Eskom premises shall be monitored routinely.

5.8.4 Monitoring protective clothing (excluding respiratory equipment):

5.8.4.1 Protective clothing used in radiological controlled areas shall be routinely monitored for radiation and/or contamination, as appropriate.

5.8.4.2 Contaminated protective clothing shall not be used:

a. if the direct dose rate on clothing is equal to or exceeds 10^{-1} mSv/h; or

b. if the fixed contamination is equal to or exceeds 37 Bq/cm^2 averaged over 300 cm^2.

5.8.5 Monitoring tools and equipment for transfer

5.8.5.1 Tools and equipment shall be monitored and may be transferred from a radiological controlled area for use within the boundaries of the power station if:

a. the alpha surface contamination is less than 3.7×10^{-1} Bq/cm^2 averaged over 300 cm^2 area; and

b. the beta or gamma surface contamination is less than 3.7 Bq/cm^2 averaged over 300 cm^2 area.

5.8.6 Monitoring of tools and equipment for unconditional release

5.8.6.1 Tools and equipment shall be monitored and may be released unconditionally from a radiological controlled area for use outside the boundaries of the power station if:

a. the alpha surface contamination is less than 3.7×10^{-2} Bq/cm^2 averaged over 300 cm^2 area; and

b. the beta or gamma surface contamination does not exceed 3.7×10^{-1} Bq/cm^2 averaged over 300 cm^2 area.

5.8.7 Monitoring respiratory equipment

5.8.7.1 Respiratory equipment used in radiological controlled areas shall be monitored prior to use.

5.8.7.2 Contaminated respiratory equipment shall not be used, when:

a. the direct dose rate is equal to or exceeds 10^{-1} mSv/h; or

b. if the fixed contamination is equal to, or exceeds 110 Bq/cm^2 averaged over 100 cm^2, except for as given in paragraph 5.8.7.2.c.

c. if the fixed contamination is equal to, or exceeds 250 Bq/cm^2 averaged over 1 cm^2 for the gloves and boots of air suits, provided such are only used in contaminated areas.

5.8.8 Monitoring of skin and personal clothing

5.8.8.1 The levels above which skin or personal clothing contamination shall be routinely reduced before leaving a controlled zone are:

a. the alpha surface contamination is less than 3.7×10^{-1} Bq/cm^2 averaged over 300 cm^2 area; and

b. the beta or gamma surface contamination does not exceed 3.7 Bq/cm^2 averaged over 300 cm^2 area.

5.8.9 Radiation shield testing at nuclear installations

5.8.9.1 A radiation shield-testing programme shall be implemented to verify that sufficient radiation shielding has been provided to protect plant personnel from neutron and gamma radiation, as per the design.

5.8.9.2 Shielding shall be tested during initial power escalation. Testing shall include both neutron and gamma measurements.

5.8.9.3 During the operating phase, testing of new radiation shields or components, which do not contain sufficient radioactivity during the start-up phase, shall be implemented.

5.8.9.4 Exposures to personnel performing the surveillance testing shall be maintained as low as reasonably achievable. Testing of radiation shields should be co-ordinated with routine radiological surveys.

5.8.9.5 Testing of shield modifications shall be performed.

5.8.9.6 Consideration shall be given to testing both horizontal and vertical shields.

5.8.9.7 Radiation shield testing locations shall be identified and recorded.

5.8.9.8 Suitable radiation monitoring instrumentation shall be used for radiation shield testing.

5.8.9.9 If dose rates are found to exceed design criteria limits, corrective action should be implemented.

5.8.9.10 Radiation shield testing surveys shall be recorded and records shall maintained for the life of the plant.

5.8.9.11 The efficiency of charcoal and particulate HEPA ventilation filters shall be tested on an established frequency. If found inoperable, the filters shall be replaced and retested within 30 days (Footnote 3).

5.9 SAFETY CULTURE

A safety culture should be fostered and maintained to encourage a questioning and learning attitude to radiation protection and to discourage complacency.

5.10 RECORDS AND REPORTS

5.10.1 Records and reports relating to operational radiation protection shall be established, implemented, retained, maintained and made available for reference.

5.10.2 Records and reports relating to operational radiation protection shall be submitted to the relevant regulator at predetermined periods as required.

5.10.3 A reporting mechanism shall be established, implemented and maintained for recording incident and accidents of any events that the relevant regulator should specify relating to operational radiation protection.

5.11 QUALITY MANAGEMENT

A quality management programme shall be established, implemented and maintained in order to ensure on-going compliance with this standard.

5.12 FOOTNOTES

5.12.1 Footnote 1

For unidentified radionuclides the value is 37 Bq/m^3 provided that it may be reasonably demonstrated that the following radionuclides are not present in significant quantities (Footnote 2).

Element	Mass number	Symbol
Strontium	90	Sr-90
Ruthenium	106	Ru-106
Protactinium	230	Pa-230
Californium	253	Cf-253
Cerium	144	Ce-144
Iodine	129	I-129
Lead	210	Pb-210
Plutonium	241	Pu-241

Element	Mass number	Symbol
Einsteinium	255	Es-255
Radium	228	Ra-228
Europium	154	Eu-154
Actinium	227	Ac-227
Americium	242	Am-242m
Fermium	256	Fm-256
Berkelium	249	Bk-249

5.12.2 Footnote 2

The term “not present in significant quantities” mean that the calculated rate of committed effective dose due to the concentration of activation and fission products in a mixture, should not exceed 2.5×10^3 mSv/h based on dose conversion factors recommended by the International Commission on Radiological Protection in ICRP publication 68.

5.12.3 Footnote 3

This requirement is applicable to all ventilation filters which perform radiation protection and/or nuclear emergency response functions.

6. ACCEPTANCE:

This following people were informed of the request submitted to the National Nuclear Regulator (NNR) via letter K-28414-E and the NNR response via letter k28414N relating to implementation of administrative changes to this document.

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7. REVISIONS

Date	Rev.	Compiler	Remarks
March 2022	1	M Maree	Administrative changes implemented in accordance with letter k28414N dated, 22 March 2022.
December 2019	0B	M Maree	NNR approval via letter k26060N dated 6 December 2019 for extension of review date from October 2019 to May 2020.
September 2018	0A	M Maree	NNR approval via letter k24608N dated, 4 September 2018 for implementation of administrative changes.
March 2012	0	M Maree	NNR approval via letter k20275N dated, 12 March 2012 for implementation of Radiation Protection Standards.

8. DEVELOPMENT TEAM

This document has been developed by Marc Maree.

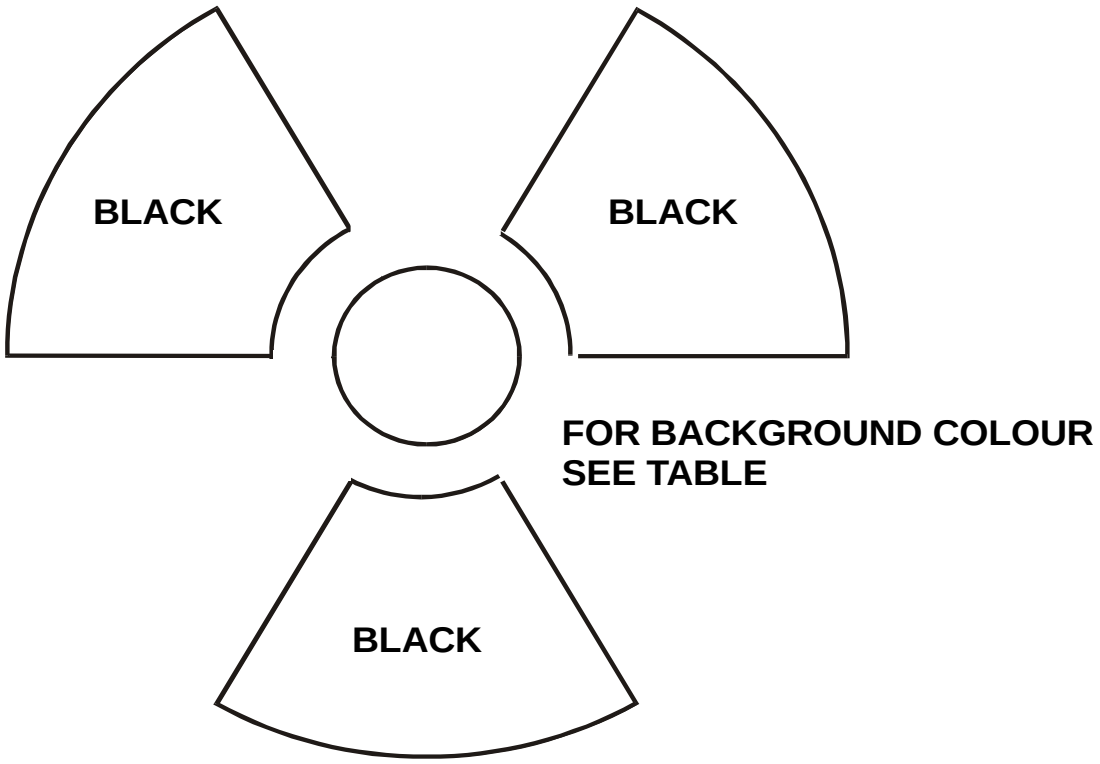
9. ACKNOWLEDGEMENTS

- E Flanagan
- K Featherstone
- MV Moduka

10. APPENDICES

A – Radiation Trefoil Sign

APPENDIX A: RADIATION TREFOIL SIGN



RADIATION ZONE	COLOUR OF		DOSE RATE LIMITS
	TREFOIL	BACKING	mSv/hr
GREEN	BLACK	GREEN	$\geq 5 \times 10^{-4} < 2.5 \times 10^{-2}$
YELLOW	BLACK	YELLOW	$\geq 2.5 \times 10^{-2}$ to < 1
ORANGE	BLACK	ORANGE	≥ 1 to < 10
RED	BLACK	RED	≥ 10