



# NATIONAL NUCLEAR REGULATOR

For the protection of persons, property and the environment against nuclear damage

## INTERIM REGULATORY GUIDE

# EMERGENCY PREPAREDNESS AND RESPONSE FOR NUCLEAR AND RADIOLOGICAL EMERGENCIES

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Rev 1

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excellence



integrity



openness &  
transparency



safety & security



teamwork



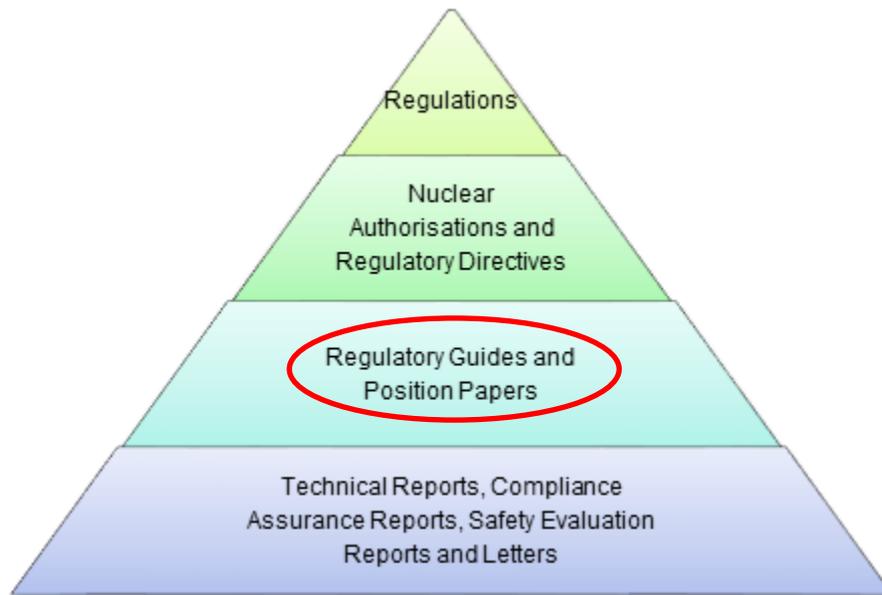
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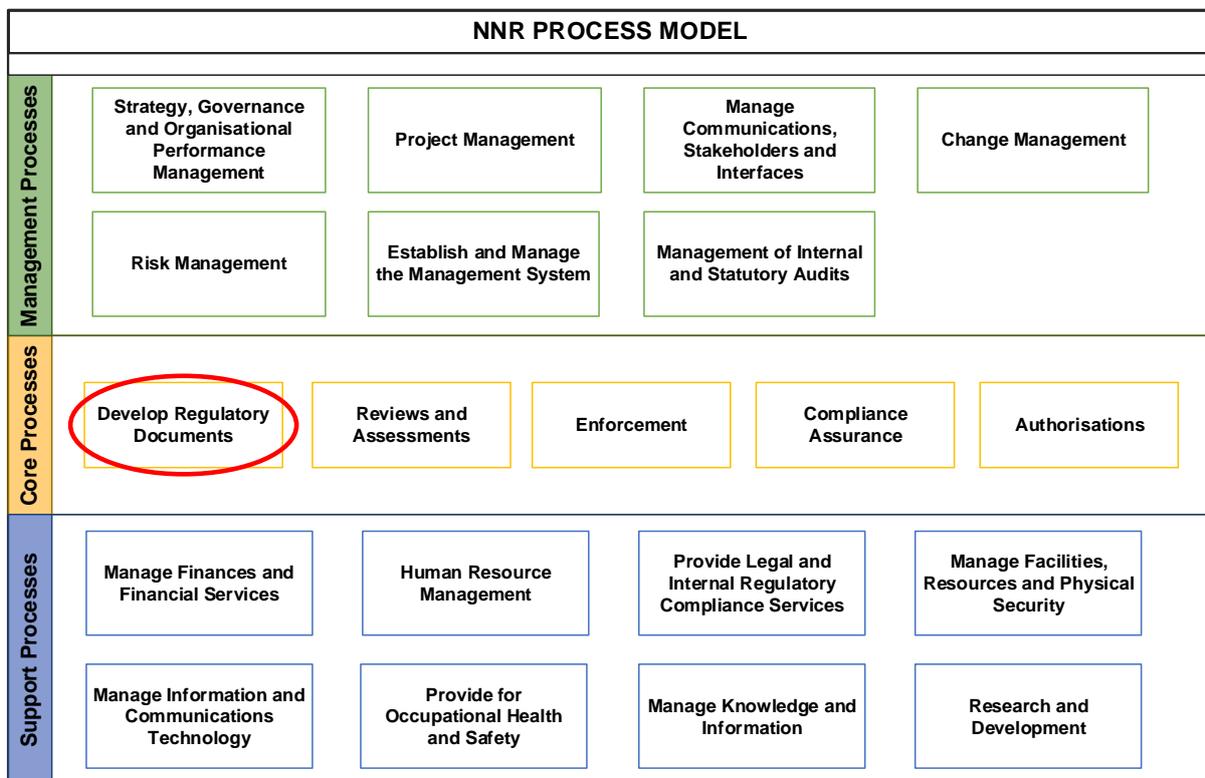
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**Figure 1: Location of the Regulatory Guide in the NNR Document Hierarchy**



**Figure 2: Location of the Regulatory Guide in the Process Model**

**FOREWORD**

The legal framework applicable to regulation of nuclear industry in South Africa is comprised of law and supporting regulatory documents. Law includes legally enforceable instruments such as Acts, Regulations and Conditions of licences. Regulatory documents comprise of policies, standards, guides, notices, procedures and information documents which support and provide further information on the legally enforceable instruments. Both law and regulatory documents form the framework for regulation of the nuclear industry in South Africa.

Regulatory Guidance documents provide guidance to the licensees and applicants on how to meet requirements of the legally enforceable instruments. This Regulatory Guidance document provides methodologies used by National Nuclear Regulator (NNR) for the emergency preparedness and response for nuclear and radiological emergencies at nuclear facilities and for activities involving radioactive material.

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## 1 BACKGROUND

The NNR exercises regulatory control on matters related to nuclear safety and security for all the activities and facilities as defined in the National Nuclear Regulator Act, 1999 (Act no. 47 of 1999) [1]. Section 5f and section 38 of the NNR Act, among other things, specifically require the Regulator to assure that provisions for emergency planning are in place ensuring the preparedness and response to deal with nuclear and radiological emergencies.

The NNR fulfils this obligation by setting safety standards, applying the principles derived from internationally accepted safety standards to establish requirements and guidance for common concepts and expectations, allocation of responsibilities among all response and intervening organisations, and arrangements for coordinating an integrated emergency response.

Regulations are mandatory and set specific requirements to be fulfilled by the authorisation holder or an applicant for a nuclear authorisation. The NNR has proposed new draft General Nuclear Safety Regulations (dGNSR) [2] and section 8 stipulates the requirements for emergency preparedness and response for nuclear and radiological emergencies. The regulations provide overarching requirements that must be complied with and may not be sufficiently detailed and comprehensive to enable authorisation holders and applicants to easily and fully meet the requirements. Therefore, Regulatory Guidance (RG) is necessary so that some level of consistency can be achieved and maintained amongst all holders and applicants in complying with the requirements.

The RG will also assist authorisation holders or applicants to achieve high levels of safety for purposes of emergency preparedness and response for nuclear and radiological emergencies, and will be updated in accordance with the regulatory plan to include additional aspects relating to emergency preparedness and response.

## 2 PURPOSE

This document has been developed to provide guidance on emergency preparedness and response for nuclear and radiological emergencies.

## 3 SCOPE

- 1) The document applies to all holders and prospective holders of NNR authorisations that carry out activities and operations requiring a nuclear emergency plan.
- 2) The document also applies to local authorities and provincial authorities (includes intervening organisations) when the emergency plan relies on these organisations for implementation in accordance with agreement entered between these organisations and authorisation holders as per Section 38 of the NNRA. The roles and responsibilities of the intervening organisation are outlined in respective emergency plans.
- 3) The following aspects are specifically covered and addressed in the scope of this document:
  - a) Protection strategies;
  - b) Hazard assessments;
  - c) Protection of emergency workers;
  - d) Radiation monitoring;
  - e) Agricultural countermeasures;
  - f) Notification following declaration of emergency; and
  - g) Termination and post-accident measures of nuclear or radiological emergencies.

## 4 TERMS, DEFINITIONS AND ABBREVIATIONS

In this RG, any word or expression to which a meaning has been assigned in the NNR Act or the Regulations promulgated in terms of the NNR Act [1], shall have the meaning so assigned. Only additional terms, definitions and abbreviations are provided.

### 4.1 Terms and Definitions

**Emergency:** a non-routine situation or event that necessitates prompt action, primarily to mitigate a hazard or adverse consequences for human health and safety, quality of life, property or the environment. This includes nuclear and radiological emergencies and conventional emergencies such as fires, release of hazardous chemicals, storms or

earthquakes. It includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard.

**Emergency Action Level (EAL):** a specific, predetermined criterion for observable conditions used to detect, recognise and determine the emergency class.

**Emergency worker:** a person having specified duties as a worker in response to an emergency.

**Helper:** a member of the public who willingly and voluntarily helps in the response to a nuclear or radiological emergency.

**Operational Intervention Level (OIL):** a set level of a measurable quantity that corresponds to a generic criterion. Operational intervention levels are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air activity concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples. An operational intervention level is used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of an environmental measurement.

## 4.2 Abbreviations

DMC	Disaster Management Centre
ECC	Emergency Control Centre
EPC	Emergency Preparedness Category
EPR	Emergency Preparedness and Response
FAO	Food and Agriculture Organisation
GAL	Generic Action Level
GIL	Generic Intervention Level
IAEA	International Atomic Energy Agency
NNR	National Nuclear Regulator
NNRA	National Nuclear Regulator Act, 1999 (Act No. 47 of 1999)
PAZ	Precautionary Action Zone
RBE	Relative Biological Effectiveness
RG	Regulatory Guidance Document
RTO	Response Time Objectives
UPZ	Urgent Protective Action Planning Zone
WHO	World Health Organisation

## 5 REGULATORY FRAMEWORK

### 5.1 Applicable Legislation

- 1) National Nuclear Regulator Act, 1999 (Act no. 47 of 1999);
- 2) Disaster Management Act, 2002 (Act 57 of 2002);
- 3) Disaster Management Amendment Act, 2015 (Act 16 of 2015);
- 4) Hazardous Substances Act, 1973 (Act No. 15 of 1973).

### 5.2 Regulations

The proposed draft General Nuclear Safety Regulations [2] require the authorisation holders to have in place for emergency preparedness and response, a protection strategy, hazard assessment, and arrangements for emergency workers, as well as radiation monitoring, notification following declaration of emergency, termination and post-accident management, and agricultural countermeasures. This document provides guidance and NNR's position which can be used by the authorisation holders to improve their EPR arrangements and for future compliance with the Regulations once promulgated.

## 6 GUIDANCE

This section provides guidance for authorisation holders and applicable stakeholders on how to meet the requirements mentioned above.

### 6.1 PROTECTION STRATEGY

- 1) A protection strategy should be established that indicates the goals of emergency response, objectives, activities and time frames to be achieved in response to a nuclear or radiological emergency.
- 2) The implementation of effective and efficient emergency response actions and adequate arrangements at the preparedness stage should be defined.
- 3) The protection strategy should cover the time span from the emergency's declaration until its termination.
- 4) For a large-scale emergency, the strategy should extend to the longer term within the framework of an existing exposure situation.
- 5) The strategy should describe the implementation of a justified and optimised set of protective actions and other response actions.

- 6) The development of the protection strategy should involve all relevant response organisations and other interested parties.
- 7) The protection strategy should include a reference level of residual dose between 20–100 mSv as well as generic criteria of levels for the projected dose at which protective actions and other response actions are to be taken.
- 8) Reference levels should be considered as follows [8]:
  - a) For each exposure situation and different categories of exposure, reference levels should be selected [17], noting that selection of such reference levels within the proposed range of 20–100 mSv acute or annual effective dose would depend on the phase of the emergency, the practicality of reducing or preventing exposures and other factors.
  - b) In the urgent phase of an emergency, an effective dose of 100 mSv, acute or annual, might be justified as one of the dosimetric bases for implementing and optimising a protection strategy.
  - c) In the later phases, such as during the transition, an effective dose of 20 mSv per year should be justified as one of the dosimetric bases for implementing and optimising a protection strategy to enable the transition to an existing exposure situation to be made.
- 9) At the preparedness stage, operational criteria should be derived from the generic criteria that can be used directly in the response.
- 10) The protection strategy should be based on the hazard assessment, and include the following:
  - a) Reference level of residual dose;
  - b) Generic criteria of projected dose and dose received;
  - c) Protective actions and other response actions;
  - d) Exposure scenario, pathways, periods of exposure;
  - e) Population and areas impacted;
  - f) Non-radiological consequences expected;
  - g) Dynamic and time frame for decision making;
  - h) Time for recovery expected; and
  - i) Available resources (human, technical, financial) and infrastructure.
- 11) The protection strategy should address the whole range of emergency response goals and time frames in which they are to be achieved from the onset of the emergency to its

termination and should feature detailed protective actions for those at risk of severe deterministic effects followed by a range of actions aimed at protecting those at risk of stochastic effects.

## 6.2 HAZARD ASSESSMENT

- 1) The identified hazards and potential consequences of an emergency should provide a basis for establishing arrangements for preparedness and response for a nuclear or radiological emergency. The results of the hazard analysis should be used to implement a graded approach to emergency preparedness arrangements commensurate with the potential magnitude and nature of the hazard.
- 2) Assessed hazards should be grouped in accordance with the emergency preparedness categories shown in Table 4 and Table 5 of Appendix A.
- 3) The hazard assessment should include consideration of:
  - a) Events that could affect the facility or activity, including events of very low probability and events not considered in the design;
  - b) Events involving a combination of a nuclear or radiological emergency with a conventional emergency such as an earthquake, volcanic eruption, tropical cyclone, severe weather, tsunami, aircraft crash or civil disturbances that may affect wide areas and/or impair capabilities to provide support in the emergency response;
  - c) Events that could affect several facilities and activities concurrently and the interactions among the facilities and activities affected;
  - d) Events at facilities in other States or events involving activities in other States;
  - e) Facilities and locations at which there is a significant likelihood of encountering a radioactive source that is not under control;
  - f) Results of threat assessments for nuclear security purposes;
  - g) Types of radioactive material shipments, the main routes and focal points; and
  - h) Uses of mobile radioactive sources (e.g. for medical or industrial uses).
- 4) Using the criteria in Appendix C, the hazard assessment should identify facilities, sources, practices, on-site areas, off-site areas or locations for which radiation emergencies could warrant:

- a) Precautionary urgent protective action to prevent severe deterministic health effects by keeping doses below those for which intervention is expected to be undertaken under any circumstances;
  - b) Urgent protective action to prevent stochastic health effects by averting doses, in accordance with international standards;
  - c) Agricultural countermeasures, countermeasures for ingestion and longer term protective measures, in accordance with international standards; or
  - d) Protection for the workers responding (undertaking an intervention), in accordance with NNR regulations.
- 5) For Emergency Preparedness Category (EPC) III and IV, a minimal hazard assessment should be accomplished by identifying the Emergency Preparedness Category (EPC) of facilities and activities in accordance with Table 5 in Appendix A and based on the results of generic accident studies.
- 6) For EPC I and II (as defined in Table 4 and 5 of Appendix A), a facility or activity specific hazard assessment should include, but not be limited to, a range of potential emergencies, the safety analysis, probabilistic safety analysis as well as industry and operational experience.
- 7) The methodology proposed for the facility or activity specific hazard assessment should entail:
- a) Identification of the applicable emergency scenarios;
  - b) Determination of the radiological release source terms for each emergency scenario and the time span from the start of the emergency to the start of the radiological release;
  - c) Determination of the timing of a significant radiological release;
  - d) Evaluation of off-site dose consequences for each emergency scenario and determination of the distance at which the dose limit criteria are met;
  - e) Evaluation of factors other than off-site dose consequences that would affect the establishment of the emergency arrangements; and
  - f) Evaluation of any security, geographic or travel route limitations.

## 6.3 EMERGENCY WORKERS

### 6.3.1 Responsibilities

- 1) The organisation(s) responsible for the protection of workers and helpers/volunteers in an emergency should be designated in the nuclear or radiological emergency plan.
- 2) The individual(s) that can authorise personnel to receive radiation doses in excess of the occupational annual dose limits should be identified by title/position and such arrangements should be documented.
- 3) Guidance values and default operational levels of dose for emergency workers for different types of response activities should be adopted/developed in accordance with the prescribed NNR regulations (Annexure 3 of the draft General Nuclear Safety Regulations [2]) and Appendix B.
- 4) Arrangements should be made for managing, controlling and recording the doses received by emergency workers.
- 5) The responsible organisations should:
  - a) Identify and determine the range of anticipated hazardous conditions in which emergency workers might have to perform response functions in accordance with the hazard assessment and the protection strategy.
  - b) Ensure the protection of emergency workers and helpers/volunteers in an emergency for the range of anticipated hazardous conditions.
  - c) Implement health surveillance for emergency workers in order to assess their initial fitness and continuing fitness in the execution of their intended duties.
  - d) Register and integrate emergency workers and helpers/volunteers who were not designated as such in advance into the emergency response operations.
  - e) Describe the process for allowing helpers/volunteers to receive radiation exposures in the course of carrying out life-saving and other emergency activities.
  - f) Establish a radiation protection programme for emergency workers to be implemented during emergencies that addresses:
    - i) Radiation exposure arrangements, including limits for internal and external radiation contamination;
    - ii) Capability to continuously monitor and assess the radiation doses received by emergency workers;

- iii) Capability to implement contamination control measures;
- iv) Capability to decontaminate emergency workers, equipment, vehicles and other material;
- v) Appropriate radiation protection briefings, consistent with the expected risk to the team; and
- vi) The process for site access, dosimetry issuance and recording doses received by emergency workers.

### **6.3.2 Information, Instructions and Training**

- 1) The organisations responsible for emergency workers should:
  - a) Designate all emergency workers as far as practicable;
  - b) Obtain informed consent from emergency workers, when appropriate, to perform specified duties;
  - c) Ensure that all emergency workers are fit for the intended duty;
  - d) Designate and train all emergency workers as far as practicable; and
  - e) Provide emergency workers and helpers not designated in advance with immediate instructions on how to perform duties under emergency conditions.
- 2) Where doses received might exceed 50 mSv emergency workers should be informed and trained in advance about the associated health risks and available protective measures.
- 3) Female workers who are aware that they are pregnant should be encouraged to notify the appropriate authority and would typically be excluded from emergency worker duties.
- 4) Emergency worker volunteers should understand and accept the risk of carrying out life-saving actions where doses approach or exceed the threshold for severe deterministic effects.

### **6.3.3 Radiation Dose Management and Control**

- 1) All practicable means should be used to minimise doses to emergency workers and helpers/volunteers due to exposure in the response to a nuclear or radiological emergency.
- 2) The relevant requirements for occupational exposure of emergency workers in planned exposure situations should be applied in accordance with a graded approach.

- 3) Arrangements should be established prior to and during the emergency for:
  - a) Managing, controlling and recording the doses received by emergency workers; and
  - b) Provision of appropriate specialised protective equipment and monitoring equipment for emergency workers.
- 4) The emergency organisation should have adequate personal protective equipment available, stored or placed in such a way that it is quickly available for different teams.
- 5) Provisions for the continuous capability to determine the doses received by emergency workers should be described.
- 6) Provisions of the number, types and distribution of dosimeters should be described.
- 7) Provisions to ensure that dosimeters are read at appropriate intervals and that dose records are maintained for emergency workers should be described.
- 8) No emergency worker should be subject to an effective dose in excess of 50 mSv other than for the purpose of:
  - a) Saving a life;
  - b) Preventing serious injury;
  - c) Taking actions to prevent severe deterministic effects;
  - d) Taking actions to prevent the development of catastrophic conditions that could significantly affect people and the environment; or
  - e) Taking actions to avert a large collective dose.
- 9) The responsible organisations should ensure that emergency workers who undertake emergency response actions in which the doses received might exceed an effective dose of 50 mSv do so voluntarily [8].
- 10) Emergency workers who received doses that might exceed an effective dose of 50 mSv should be trained as far as possible in the actions they may be required to take.
- 11) Emergency workers not designated as such in advance should not be chosen first for taking life-saving actions that could result in their doses exceeding the guidance values of dose.
- 12) Helpers/volunteers in an emergency should not be allowed to take actions that could result in them receiving doses in excess of an effective dose of 50 mSv.

- 13) Arrangements should be made to assess, as soon as practicable, the individual doses received by emergency workers and helpers in an emergency.
- 14) Information on the doses received and any consequent health risks should be communicated, as soon as practicable, to emergency workers and to helpers in an emergency.
- 15) The means and criteria for radiological decontamination for emergency workers should be described.
- 16) Facilities for the decontamination of emergency workers should be available in emergency situations.

#### **6.3.4 Medical Follow Up**

- 1) Emergency workers and helpers in an emergency should be given appropriate medical examination, longer term medical actions and psychological counseling for doses received or at their request.
- 2) An emergency worker who received an effective dose of 100 mSv in a month should be registered and subjected to health screening and should receive appropriate longer term medical follow up [8].
- 3) If an emergency worker received an effective dose exceeding 200 mSv, qualified medical advice should be obtained before incurring any further occupational exposure.

### **6.4 RADIATION MONITORING**

#### **6.4.1 General**

- 1) The monitoring in response to a nuclear or radiological emergency should be carried out on the basis of the protection strategy.
- 2) Arrangements should be made to adjust the monitoring in the emergency response on the basis of prevailing conditions.
- 3) Radiation monitoring and meteorological measurements should be carried out on and off-site, where necessary, in an emergency to assess the dispersion of radioactive substances.
- 4) The volume and nuclide composition of radioactive releases in all emergency situations and the prognosis thereof should be determined.

- 5) Radiation measurement programmes at the facility and in the vicinity, where necessary, should be planned in advance.
- 6) Emergency response facilities and locations should be designated to support the coordination of radiation monitoring, sampling and analysis.

#### **6.4.2 Fixed Monitoring**

- 1) Facilities in emergency preparedness category I and II should:
  - a) Install real-time fixed radiological detection and monitoring capabilities around the perimeter and vicinity of the facility;
  - b) Ensure that a sufficient number of continuous measurement stations are placed in the surroundings;
  - c) Ensure that the fixed continuous measurement stations have the capability to determine the composition of the radioactive plume; and
  - d) Compare the results of the fixed measurement stations with the field measurements in the surroundings.
- 2) Results from fixed radiological detection stations should be communicated to off-site authorities and the Regulator.
- 3) Facilities in emergency preparedness categories I and II should consider the following capability requirements for fixed monitoring instrumentation:
  - a) Redundancy;
  - b) Continuous operation on 24/7 basis;
  - c) Radionuclides identification;
  - d) Calibration of equipment;
  - e) Alarming capability;
  - f) Data for International Radiation Monitoring Information System (IRMIS);
  - g) Geographical coverage in large population areas;
  - h) Reliability under different weather conditions; and
  - i) Bench-marking with NNR monitors.

#### **6.4.3 Field Monitoring**

- 1) The following applies to facilities in emergency preparedness categories I and II:
  - a) The organisation with the primary responsibility for field monitoring activities, including the necessary resources, should be identified;

- b) The necessary equipment should be available so that prompt action can take place without delay;
- c) The responsible organisations should have sufficient capacity and capability for off-site radiological monitoring, including mobile survey teams;
- d) The capability to coordinate and implement in-field radiological assessments by field monitoring and/or sampling teams and assessment of the data obtained should be ensured;
- e) The highest external radiation dose rate should be measured and related airborne concentrations of the most important nuclides determined as far as possible;
- f) Measurement teams should have the capability of measuring the external dose rate and taking airborne samples.
- g) Measurement teams should use vehicles well suited to measurement activities and with channels for communicating;
- h) A reliable pre-planned method should be used for identification of the measurement locations;
- i) Transferring data from locations should be planned in such a way that the data is available promptly and reliably;
- j) Contingency arrangements should be made to conduct aerial monitoring to support ground monitoring positioning and deployment;
- k) Arrangements should include provision for extended monitoring and assessment beyond the extended planning distance if necessary;
- l) Arrangements should be made for monitoring the contamination levels of people, vehicles and goods for the purposes of decontamination;
- m) Monitoring and assessment of contamination of food, milk, drinking water and, as appropriate, commodities other than food should be conducted;
- n) A central point for the receipt and analysis of field monitoring data and coordination of sample media should be established;
- o) Adequate measurement equipment should be on continuous standby and a record should be kept on the quantity, location and operability of the equipment;
- p) Adequate records of dose measurements should be maintained.

#### 6.4.4 Radiological Assessments

- 1) The organisation(s) responsible for assessing radiological data should be identified.
- 2) Devices, systems and computer programmes that are needed for assessment purposes should be in place.
- 3) A radiological assessment model for airborne releases that provides realistic estimates of on-site and off-site radiation exposures and contamination levels should be in place.
- 4) A methodology for determining the magnitude and isotopic composition of potential or ongoing releases of radioactive material should be developed.
- 5) Facilities in EPC I and II should develop/adopt Emergency Action Levels (EALs) and Operational Intervention Levels (OILs) for ground deposition, food, skin and thyroid using guidance found in [11] and [15].
- 6) For facilities in EPC I and II, the dose to the public should be promptly and continuously estimated.
- 7) Facilities in EPC I and II should provide dose estimates and assessments to the off-site authorities and the Regulator.
- 8) Dose projections should be compared with projections of other organisations participating in the emergency response and with field data.
- 9) Adequate records of dose assessments should be maintained.

#### 6.4.5 Quality Assurance

- 1) The operability of facilities, systems and equipment for radiological monitoring as well as dose assessments should be regularly proven.
- 2) Communication and data transfer should be tested regularly, at least once a month.
- 3) Any defects, disturbances and deficiencies that are detected should be fixed without delay.
- 4) Facilities, systems and equipment should be tested in exercises at least once a year.
- 5) Provision should be made to inspect the inventory and operationally check emergency equipment/instruments at least once each calendar quarter.

## 6.5 NOTIFICATION FOLLOWING DECLARATION OF EMERGENCY

- 1) The plan should have the capability to timely notify the on-site and off-site emergency response organisations, and the specific timeframes for elements/tasks should be specified in procedure(s);
- 2) For facilities in EPC I and II, the plan should specify the following RTO for elements / tasks in Table 1 to be implemented by responsible organisations:

**Table 1: Response Time Objectives** [9]

No.	Element / Task	RTO
1.	Classification of emergencies	< 15 min
2.	Notification of facility emergency response organisations after classification	< 15 min
3.	Notification to the regulator after detection and identification of an emergency	< 15 min
4.	Notification of local emergency response organisations after classification	< 30 min
5.	Activation of facility and local emergency response organisations after notification	< 1 h
6.	Facility and Local emergency response organisations to be fully functional (after activation)	< 2 h
7.	Declaration of nuclear disaster	< 45
8.	Notification, warning and instructions to the public in different emergency planning zones after notification by the facility of a general emergency	< 1 h
9.	Decision making on protective actions after full functioning of ECC/DMC <sup>1</sup>	< 30 min
10.	Implementation of protective actions from decision making	< 15 min
11.	Conducting media briefing after notification by the facility of a general emergency	< 4 h
12.	Conducting environmental monitoring within/near facility after notification by the facility of a general emergency	< 1 h
13.	Conducting environmental monitoring within PAZ after notification by the facility of a general emergency	<4h
14.	Conducting environmental monitoring within UPZ after notification by the facility of a general emergency	< 12 h
15.	Activation of the environmental surveillance laboratories after notification by the facility of a general emergency	< 24 h

<sup>1</sup> In the case of fast evolving emergencies where there is limited time for activation of ECC and disaster management centre, the facility should establish the process for making decisions and implementation of protective actions for the public.

- 3) The plan should specify the responsible organisation's capability to alert and notify the public timely after being informed by the authorisation holder of an emergency situation;
- 4) When notifying the public within the emergency planning zones of an emergency situation, the plan should specify administrative and physical capabilities to provide such notifications with further instructions on implementation of protective actions;
- 5) The plan should make provision for the means of backup methods of communication;
- 6) Follow-up messages should be made to the local authorities and public as the emergency situation evolves, and should be in mostly spoken languages in the area.

## 6.6 TERMINATION/RECOVERY ACTIONS

### 6.6.1 General

- 1) For EPC I and II facilities a conceptual recovery plan should be prepared which should include:
  - a) Definitions, composition and timeframes associated with the emergency phase as well as the exit from the emergency phase;
  - b) Definitions and timeframes associated with the post- emergency phase which typically consists of a transition period and a long-term period;
  - c) Principles to determine the actions to be undertaken in preparing for post- emergency management and in real-life situations;
  - d) Resources such as personnel, facilities and emergency response equipment that are to be available for recovery purposes;
  - e) The roles and functions of all organisations;
  - f) Methods of transferring information;
  - g) Means for assessing radiological consequences and non-radiological consequences;
  - h) Personnel protection when assessing or implementing the recovery programme;
  - i) Conditions, criteria and objectives to be met for enabling the termination of the emergency phase;
  - j) Arrangements for consultation with interested parties;
  - k) Arrangements for continuing communication with the public;
  - l) Monitoring of public opinion and the response of the news media; and
  - m) Provision for post-emergency assessments of the causes, details, impacts and/or consequences of the events.

### 6.6.2 Termination and Exit from Emergency Phase

- 1) The decision to terminate the nuclear or radiological emergency and the transition to an existing exposure situation should be taken after:
  - a) Ensuring the facility has been brought into a safe state and the situation triggering release of radioactive material is under control;
  - b) Initiation of post-emergency measures;
  - c) Implementation of justified actions to meet existing exposure situation generic criteria;
  - d) A formal decision has been made public;
  - e) Both radiological and non-radiological consequences have been evaluated;
  - f) Transfer of responsibilities where necessary; and
  - g) Consulting and informing interested parties.
- 2) The following actions should be implemented or initiated at the exit from the emergency phase and establishment of prerequisites for terminating the emergency [18] should be considered:
  - a) Defining the emergency exposure and radiological situation;
  - b) Defining initial post-emergency areas with the technical basis, indicators and guidance values to be used;
  - c) Initiating early protective actions and management of the population such as relocation, prohibiting the consumption and placing on the market of foodstuffs, materials and products pending assessment of possible contamination;
  - d) Prohibiting access to areas with high concentration of radioactive substances;
  - e) Lifting the restrictions on supply of drinking water to the population;
  - f) Distributing emergency grants and financial assistance to affected population;
  - g) Improving radiological conditions in the environment, managing the amount of waste produced and taking the first actions related to the farming environment;
  - h) Determining and implementing an initial environmental radiological contamination measurement as necessary; and
  - i) Informing the public at the exit from the emergency phase.

### 6.6.3 Transition into Recovery

- 1) The following actions should be implemented or initiated for the transition period:
  - a) Reducing population exposure to deposited radioactivity by:
    - i) Identifying post-emergency areas;
    - ii) Ensuring that available foodstuffs are compliant with regulatory requirements on radioactive contamination;
    - iii) Ensuring the water supply is compliant with quality standards;
    - iv) Reviewing access restrictions to forests and green areas;
    - v) Investing resources in the development of a practical radiation protection culture;  
and
    - vi) Managing interventions.
  - b) Continuing medical care, consolidating and making use of epidemiological follow-up results to assess the health consequence of the emergency.
  - c) Sustaining and improving environmental contamination measurement programmes;
  - d) Continuing clean-up and decontamination of the environments.
  - e) Monitoring the quality of run-off waters and waste water as well as the state of the aquatic environments and biodiversity.
  - f) Identifying and implementing technical management solutions suited to the contaminated waste in line with the national waste management framework.
  - g) Implementing an information sharing and exchange system for the population and international authorities.
  - h) Implementing a management and support strategy for the agricultural production systems, marketing of foods, materials and products and facilitating the export of national products.
  - i) Providing, and continuing where necessary, emergency grants, setting up and making compensation payments and assessing the need for long-term compensation.

#### 6.6.4 Long-term Management

- 1) The following actions should be implemented or initiated for long-term management of the emergency:
  - a) Providing support to those who have chosen to remain and are residing in the contaminated territories with up-to-date information about the state of radiological contamination;
  - b) Establishing information points and a practical radiation protection culture in the population;
  - c) Monitoring radiological conditions and contamination of aquatic environments and biodiversity;
  - d) Providing the population with the means to measure the radiological quality of self-produced foodstuffs or products derived from gathering, fishing or hunting and facilitating the local population's access to contamination data;
  - e) Maintaining a system for monitoring the internal contamination of persons;
  - f) Setting up medical and epidemiological follow up involving local healthcare professionals;
  - g) Providing the production sectors with up-to-date information about the state of radiological contamination and using radioactivity measurement tools on products;
  - h) Supporting the sectors that have embarked on product quality improvement processes, redirection of production lines or focussing on specific production areas;
  - i) Studying the viability of the territory's activities and business sectors and providing the business community with up-to-date information about radiological contamination and a practical radiation protection culture;
  - j) Defining the supporting systems for business activities and the related implementation conditions; and
  - k) Re-assessing working conditions, in particular in sectors deemed vulnerable in terms of worker exposure.

## 6.7 AGRICULTURAL COUNTERMEASURES

### 6.7.1 General

- 1) To prevent inadvertent ingestion, restrictions on the consumption of food, milk and drinking water and on the use of commodities as well as the major exposure pathways, associated control and monitoring points and methods, should be identified.
- 2) For facilities in category I, II and V, a planning distance should be defined to deal with possible contamination following a significant release.
- 3) Generic criteria for taking protective actions and other response actions should be developed to reduce the risk of stochastic effects from the ingestion of food, milk and drinking water and from the use of other commodities in a nuclear or radiological emergency, or the values in the regulations could be adopted.
- 4) Generic criteria aimed at the effective implementation of response actions should be developed to reduce the non-radiological consequences of a nuclear or radiological emergency by providing a basis for the continuation or the resumption of international trade, or the values in the regulations could be adopted.
- 5) Arrangements to protect the food chain, water supply and other commodities from contamination should include:
  - a) Provision of instructions and advice;
  - b) Prompt monitoring, sampling and analysis;
  - c) Use of pre-established operational criteria in accordance with the protection strategy;
  - d) The means to enforce the restrictions;
  - e) Provision to expand the monitoring, assessment and restrictions beyond the food and commodities planning distance if necessary;
  - f) Mitigating the impacts on international trade; and
  - g) Initiating urgent, early protective actions and other response actions.
- 6) Information should be provided to the public and interested parties on controls put in place in relation to traded commodities, including food, vehicles and cargoes being shipped, and on any revision of national criteria.

- 7) A value of 1/10 of the generic criteria as listed in Table 9 of Annexure C for early protective actions and other response actions should be established as generic criteria for restrictions on food, milk, drinking water and other commodities.
- 8) Justified food, milk or drinking water exceeding the generic criteria should be consumed until replacements are available, otherwise, the people affected should be relocated.
- 9) The guidance from Joint FAO/WHO Codex Alimentarius Commission levels [13] for generic criteria for food traded internationally that could contain radionuclides should be used.
- 10) Justified food and other commodities that exceed the generic criteria should be traded until replacements are available, provided that:
  - a) Trade is approved with the receiving State;
  - b) Actions are taken to manage and control the dose during shipping; and
  - c) Actions are taken to control the consumption and use of food and other commodities and to reduce the dose to members of the public.
- 11) OILs for deposition, levels of individual contamination and contamination levels for food, milk and water should be adopted/developed.
- 12) A plain language explanation of the OILs and the means to revise them should be provided.

#### **6.7.2 OILs for Ground Contamination**

- 1) An OIL specifying a measured value of ground contamination for immediate restrictions on the consumption of leaf vegetables, milk from animals grazing in the area and rainwater collected for drinking should be developed/adopted.
- 2) Actions should be taken to stop consumption of locally produced vegetables and milk and rainwater collected for drinking until these are screened and analysed.
- 3) The consumption of non-essential local produce, rainwater and milk from grazing animals should be stopped in the area until these have been screened and contamination levels have been assessed.
- 4) Local produce, rainwater and milk from grazing animals in the area should be screened up to at least 10 times the distance at which the OIL is exceeded and samples should be assessed.

- 5) Iodine thyroid blocking should be considered if replacement for local produce or milk is not immediately available.
- 6) The dose of those who may have consumed food, milk or rainwater from the area where restrictions were implemented should be estimated to determine if medical screening is warranted.
- 7) Within a week food, milk and water should be screened and analysed and actions should be taken to restrict the consumption of food, milk and water with concentrations of radionuclides that exceed OILs.
- 8) However, if only limited amounts of food (e.g. fruit and vegetables from local gardens) and non-essential food could have been affected, this screening and analysis step may be omitted and instead restrictions should be placed on the consumption of all the food that could be contaminated until it can be screened and analysed.
- 9) For agricultural countermeasures, OILs for ground contamination [11], [15] and [16] are relevant and such OILs should be adopted/developed.

**Table 2: OILs for ground contamination [11]**

OILs for ground contamination	OIL3	<ul style="list-style-type: none"> <li>• Gamma (<math>\gamma</math>) 1 <math>\mu\text{Sv/h}</math> at 1 m from surface</li> <li>• 20 counts/s direct beta (<math>\beta</math>) surface contamination measurement</li> <li>• 2 counts/s direct alpha (<math>\alpha</math>) surface contamination measurement</li> </ul>
	OIL2	<ul style="list-style-type: none"> <li>• Gamma (<math>\gamma</math>) 100 <math>\mu\text{Sv/h}</math> at 1 m from surface or a source</li> <li>• 200 counts/s direct beta (<math>\beta</math>) surface contamination measurement</li> <li>• 10 counts/s direct alpha (<math>\alpha</math>) surface contamination measurement</li> </ul>
	OIL1	<ul style="list-style-type: none"> <li>• Gamma (<math>\gamma</math>) 1000 <math>\mu\text{Sv/h}</math> at 1 m from surface or a source</li> <li>• 2000 counts/s direct beta (<math>\beta</math>) surface contamination measurement</li> </ul>

		<ul style="list-style-type: none"> <li>• 50 counts/s direct alpha (<math>\alpha</math>) surface contamination measurement</li> </ul>
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### 6.7.3 OILs for Concentrations in Food, Milk or Water Consumption Restrictions

- 1) Default screening OILs for food, milk and water concentrations from laboratory analysis and default radionuclide specific OILs for food, milk and water concentrations from laboratory analysis should be adopted/derived.
- 2) In deriving OILs, conservative assumptions should be used such as:
  - a) All the food, milk and water initially contaminated are consumed throughout a full year;
  - b) The most restrictive age-dependent dose conversion factors and ingestion rates (i.e. those for infants) are used; and
  - c) The application of the generic criterion of 10 mSv per year applies to ensure that people who were not relocated will not receive a total dose (including the dose from ingestion) greater than 100 mSv per year.
- 3) A process should be established for assessing radionuclide concentrations in food, milk and water.
- 4) The potentially contaminated food should be screened over a wide area and analysed to determine the gross alpha and beta concentrations if this can be done more promptly than assessing the concentration of individual radionuclides.
- 5) Food, milk and water could be consumed during the emergency phase if the OILs screening levels are not exceeded.
- 6) If OILs are exceeded, the radionuclide specific concentrations in the food, milk or water should be determined. Consumption of food, milk or water should be stopped and essential food, milk and water should be replaced or the population should be relocated if replacements are not available
- 7) The OIL 5 and 6, as recommended in Tables 9 and 10 of GSG-02 [11], should be used for food, milk and water for screening or radionuclide specific laboratory analysis respectively.

**Table 3: OILs for Concentrations in Food, Milk and Water Consumption Restrictions** [11]

OIL5	• Gross beta ( $\beta$ ): 100 Bq/kg or Gross alpha ( $\alpha$ ): 5 Bq/kg
OIL6	• Table 10, GSG-2

## 7 REFERENCES

The following references were consulted during the compilation of this document:

- [1] National Nuclear Regulator Act, 1999 (Act No. 47 of 1999).
- [2] Draft NNR Regulations – General Nuclear Safety Regulations (pending).
- [3] Hazardous Substances Act, 1973 (Act No. 15 of 1973).
- [4] Disaster Management Act, 2002 (Act 57 of 2002).
- [5] Disaster Management Amendment Act, 2015 (Act 16 of 2015).
- [6] Radioactive Waste Management Policy and Strategy for The Republic of South Africa, 2005.
- [7] Regulations relating to Group IV Hazardous Substances: Government Notice R247 in Government Gazette 14596 of 26 February 1993.
- [8] IAEA, Safety Standard, GSR Part 7, Preparedness and Response for a Nuclear or Radiological Emergency, 2015.
- [9] IAEA, Safety Standard: GS-G-2.1, Arrangements for Preparedness for a Nuclear or Radiological Emergency, 2007.
- [10] IAEA, Technical Document Safety Report Series No. 27 – Monitoring and Surveillance of Residues from the Mining and Milling of Uranium and Thorium, 2002.
- [11] IAEA, Safety Standard, GSG-2, Criteria for Use in Preparedness and Response to Nuclear or Radiological Emergency, 2011, or as amended from time to time.
- [12] IAEA, TECDOC-953, Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency, EPR, 2003.
- [13] Joint FAO/WHO Food Standards Programme Codex Alimentarius Commission, Schedule 1 – Radionuclides, CODEX STAN 193-1995, General Standard for Contaminants and Toxins in Food and Feed, 2006.
- [14] World Health Organisation, Guidelines for Drinking-Water Quality, 2011.
- [15] IAEA, EPR-NPP OILs: Operational Intervention Levels for Reactor Emergencies and Methodology for Their Derivation, 2017.
- [16] IAEA, EPR-NPP Public Protective Actions, Actions to Protect the Public in an Emergency due to Severe Conditions at a Light Water Reactor, 2013.
- [17] IAEA, Safety Standard, GSG-8, Radiation Protection of the Public and the Environment, 2018.
- [18] IAEA, Safety Standard, GSG-11, Arrangements for the Termination of a Nuclear or Radiological Emergency, 2018.

**APPENDIX A: HAZARD ASSESSMENT**

Table 4: Emergency Preparedness Categories (EPC) [8]

EPC	Criteria
I	<p>Emergencies have been postulated that could result in severe deterministic health effects off-site, including:</p> <ul style="list-style-type: none"> <li>• Reactors with power levels greater than 100 MW(th) (power, nuclear ship and research reactors);</li> <li>• Spent fuel pools that may contain some recently discharged fuel and a total of more than 0.1 Bq of Cs-137 (equivalent to the inventory in a 3000 MW(th) reactor core);</li> <li>• Facilities with inventories of dispersible radioactive material sufficient to result in severe deterministic effects off-site in accordance to Appendix C, Table 7.</li> </ul>
II	<p>Emergencies have been postulated that could result in doses warranting taking urgent protective action off-site, including:</p> <ul style="list-style-type: none"> <li>• Reactors with power levels greater than 2 MW(th) and less than 100 MW(th) (power reactors, nuclear ship and research reactors);</li> <li>• Spent fuel pools containing fuel requiring active cooling;</li> <li>• Facilities with potential for an uncontrolled criticality within 0.5 km of the off-site boundary;</li> <li>• Facilities with inventories of dispersible radioactive sufficient to result in doses warranting taking urgent protective action off-site in accordance to Annexure C, Table 8.</li> </ul>
III	<p>Emergencies have been postulated that could result in doses warranting taking urgent protective action on-site, including:</p> <ul style="list-style-type: none"> <li>• Facilities with potential, if shielding is lost, of direct external (shine) dose rates of more than 100 mGy/h at 1 m;</li> <li>• Facilities with potential for an uncontrolled criticality more than 0.5 km from the off-site boundary;</li> <li>• Reactors with power levels of less than or equal to 2 MW(th);</li> <li>• Facilities with inventories of radioactive sufficient to result in doses warranting taking urgent protective action on the site in accordance to Appendix C, Table 8.</li> </ul>
IV	<p>Operators of mobile dangerous sources, including:</p> <ul style="list-style-type: none"> <li>• A mobile source with: i) potential, if shielding is lost, of direct external (shine) dose rates of more than 10 mGy/h at 1 m or ii) those with inventories in accordance with Appendix 8; of the IAEA EPR method, 2003;</li> <li>• Satellites with dangerous sources in accordance with Appendix 8 of the IAEA EPR method, 2003;</li> <li>• Transport of quantities of radioactive material that would be dangerous if not controlled;</li> <li>• Facilities/locations with a significant probability of encountering an uncontrolled dangerous source, such as: large scrap metal processing facilities; national border crossings and facilities with fixed gauges with dangerous sources in accordance with Appendix 8 of the IAEA EPR method, 2003;</li> </ul>
V	<p>Areas within emergency planning zones and distances for activities in EP category I or II not located in the State where the facility is located (i.e. across the border).</p>

Table 5: Typical Emergency Preparedness Categories of Actions

Practice	Hazard summary	Typical EP category
<b>Facilities manufacturing or using radioisotopes for industry, medical or scientific research</b>		
Radiopharmaceutical manufacturing	<p><i>Off-site:</i> No potential for deterministic health effects. A small potential for a release in excess of urgent Generic Intervention Levels (GILs) near the facility. Major facility and loading dock fires appear to represent the greatest potential for a release in excess of urgent GILs. The threat will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks.</p> <p><i>On-site:</i> Severe deterministic health effects very unlikely on site, but dose in excess of occupational limits possible.</p>	None or III
Radiopharmacies	<p><i>Off-site:</i> No potential for radiopharmacy releases in excess of urgent GILs.</p> <p><i>On-site:</i> No potential for exceeding urgent GILs on site. Very small potential for exposures above occupational limits.</p>	None
Hospitals	<p><i>Off-site:</i> No potential for releases in excess of urgent GILs unless dangerous sources are lost or stolen.</p> <p><i>On-site:</i> Severe deterministic health effects possible to staff or patients if sealed sources (e.g. brachytherapy or radiation beams) are misused or not controlled/secured. In addition, radioactive medication and diagnostic drugs can represent a hazard if not properly controlled or administered.</p>	III
Sealed source manufacturing	<p><i>On-site:</i> Severe deterministic health effects possible during manufacturing process due to loss of shielding or intake (inhalation/ingestion).</p> <p><i>Off-site:</i> No potential for deterministic health effects. A small potential for a release in excess of urgent GILs near the facility. A major facility fire appears to represent the greatest potential for a release in excess of urgent GILs. The release will be a function of inventory and volatility. Explosions, tornadoes, spills and leaks represent small risks.</p>	III
Research laboratories	<p><i>Off-site:</i> Unless large quantities of radioactive or fissile materials are stored or used in a single location, there is no potential for exposures in excess of urgent GILs.</p> <p><i>On-site:</i> Potential for severe deterministic health effects due to external exposure and intake. This will be site specific.</p>	None or III
Low-level waste warehousing and burial	<p><i>Off-site:</i> No potential for exceeding urgent GILs for low-level burial operations.</p> <p><i>On-site:</i> No potential for exceeding urgent GILs on site. Small potential, if the waste contains radioiodine. A major fire involving warehousing of waste may result in a release in excess of occupational exposure limits.</p>	None
Depleted uranium products	<p><i>Off-site:</i> No potential for exceeding urgent GILs. Potential for deaths from a UF<sub>6</sub> release due to chemical toxicity from HF (product of UF<sub>6</sub> release). The potential is a function of UF<sub>6</sub></p>	None

	inventory. Greatest risk appears to be ruptures of heated tanks of many tons. <i>On-site:</i> No potential for exceeding urgent GILs.	
<b>Source</b>		
<ul style="list-style-type: none"> <li>• Sterilisation</li> <li>• Irradiators</li> <li>• Industrial</li> <li>• Radiography</li> <li>• Teletherapy</li> <li>• High and medium dose brachytherapy</li> <li>• Category 1 and 2 radioactive sources</li> </ul>	<p><i>Off-site:</i> If controlled, no potential for exceeding urgent GILs. If uncontrolled (lost or stolen), potential for fatal exposure in minutes if unshielded and severe tissue damage if held.</p> <p><i>On-site:</i> Localised dose sufficient for fatal exposure in minutes if unshielded.</p>	III or IV
<ul style="list-style-type: none"> <li>• Gauges</li> <li>• Well logging</li> <li>• Category 3 radioactive sources</li> </ul>	<p><i>Off-site:</i> If uncontrolled (lost or stolen), potential for fatal exposure if unshielded and severe tissue damage if held.</p> <p><i>On-site:</i> Potential for fatal exposure if unshielded.</p>	IV
<ul style="list-style-type: none"> <li>• Moisture density</li> <li>• Static eliminator</li> <li>• Tritium exit signs</li> <li>• Pu pacemaker</li> <li>• Consumer products</li> <li>• Category 4 and 5 radioactive sources</li> </ul>	<p><i>Off-site:</i> No potential for exceeding urgent GILs.</p> <p><i>On-site:</i> No potential for exceeding urgent GILs.</p>	None
Dangerous source use or storage	<i>Off-site:</i> No potential for exceeding urgent GILs unless control over the sources is lost. If uncontrolled, potential for severe tissue damage or fatal exposure. The threat is dependent on the inventory of the source.	
	<i>On-site:</i> Potential for severe deterministic health effects due to external exposure and intake. This will be site specific.	
<b>Fuel cycle</b>		
Uranium milling and mining	<i>Off-site:</i> No potential for releases in excess of urgent GILs. Contamination warranting intervention (e.g. water contamination) could result from tailing pond failures.	None
	<i>On-site:</i> No potential for exceeding urgent GILs.	
Yellow cake processing	Same as uranium milling and mining.	None
UF6 conversion plants	<i>Off-site:</i> Potential for deaths from a UF6 release due to chemical toxicity from HF (product of UF6 release). The potential is a function of UF6 inventory. Greatest risk appears to be ruptures of heated tanks of many tons.	None
	<i>On site:</i> Same as off-site.	

Enrichment plants	<i>Off-site:</i> Same as UF6 conversion plants.	None
	<i>On-site:</i> Same as UF6 conversion plants.	
Fuel fabrication using uranium	<i>Off-site:</i> Risk for UF6 same as for UF6 conversion plants. Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary.	II or III
	<i>On-site:</i> Risk for UF6 same as for UF6 conversion plants. Potential for deterministic health effects and doses in excess of urgent GILs on-site from criticality accidents.	
Fuel fabrication using plutonium	<i>Off-site:</i> Potential for doses in excess of urgent GILs from criticality accidents if the fissile material is processed in an unshielded location within 200–500 m of the site boundary. Large fires or explosions could result in doses off-site in excess of urgent GILs near the facility. This will be a function of inventory.	II or III
	<i>On-site:</i> Potential for deterministic health effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in doses in excess of urgent GILs from inhalation.	
New fuel (not irradiated)	<i>Off-site:</i> No potential for doses in excess of urgent GILs.	None
	<i>On site:</i> No potential for doses in excess of urgent GILs.	
Spent fuel pool storage	<i>Off-site:</i> For damage to fuel in a pool (under water), no potential for doses in excess of urgent GILs. If the fuel in the pool is totally uncovered, doses exceeding urgent GILs may be possible. Distance of concern depends on inventory. If the pool drains and contains fuel discharged from the core within a few months, severe deterministic health effects are possible. The potential and distances of concern depend on quantities and pool design.	I, or II or III
	<i>On-site:</i> For damage to fuel in a pool (under water) doses from Kr-85 could exceed urgent GILs in the pool area. For a drained pool, the dose from the direct shine from the pool could be several Sv/h near the pool. If fuel is uncovered, the dose near the pool could result in severe deterministic health effects.	
Spent fuel – dry cask storage	<i>Off-site:</i> No potential for doses in excess of urgent GILs.	III
	<i>On-site:</i> No potential for doses in excess of urgent GILs from inhalation. If shielding is lost, direct shine dose could exceed urgent GILs.	
Reprocessing of spent fuel	<i>Off-site:</i> Small potential for doses in excess of urgent GILs from criticality accidents (depending on location of criticality). Large fires or explosions could result in doses in excess of urgent GILs several kilometres from the facility depending on the inventory and its volatility. Ruptures of large liquid storage tanks could result in expensive contamination	I, or II or III

	warranting intervention. This will be a function of inventory and volatility.	
	<i>On-site:</i> Potential for severe deterministic health effects and doses in excess of urgent GILs from criticality accidents. Fires and explosions could result in inhalation doses in excess of urgent GILs and that result in severe deterministic health effects. If shielding is lost, direct shine dose could exceed urgent GILs or result in severe deterministic health effects.	
<b>Reactors (power, ship, research)</b>		
> 100 MW(th)	<i>Off-site:</i> Emergencies involving severe core damage have the potential for causing severe deterministic health effects, including deaths. Doses in excess of the urgent GILs are possible more than 5 km from the facility. Deposition resulting in doses in excess of the relocation GILs and ingestion GALs is possible at great distances from the facility. An emergency not involving core damage has only a small potential for exceeding urgent GILs.	I or II
	<i>On-site:</i> For core damage emergencies, doses sufficient to result in severe deterministic health effects, including deaths, are possible.	
≥2≤100 MW(th)	<i>Off-site:</i> Doses due to inhalation of short-lived iodine in excess of urgent GILs are possible if cooling of the core is lost (core melt).	II or III
	<i>On-site:</i> Potential for doses in excess of urgent GILs if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or result in severe deterministic health effects.	
< 2 MW(th)	<i>Off-site:</i> No potential for doses in excess of urgent GILs.	III
	<i>On-site:</i> Potential for doses in excess of urgent GILs from inhalation (depending on design) if fuel cooling is lost. If shielding is lost, direct shine dose could exceed urgent GILs or result in severe deterministic health effects.	
<b>Transport</b>		
Excepted packages UN 2910 UN 2911 UN 2909 UN 2908	These shipments contain only minor amounts of radioactive materials. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	None
Industrial packages UN 2912 UN 3321 UN 3322 UN 2913	These packages contain only qualified “low specific activity” materials or qualified “surface contaminated objects”. Urgent GILs may be exceeded, however, in the vicinity of a damaged package, since industrial packages are not designed to survive accidents and the only external radiation limit on the unshielded but qualified contents is 10 mSv/h at a distance of 3 m. Ground contamination resulting from the emergency may require decontamination.	None

Type A packages UN 2915 UN 3332	The activity allowed for Type A packages limits the radiological hazard. Doses in excess of urgent GILs are possible beyond the immediate vicinity of the package. Ground contamination resulting from the emergency may require decontamination.	None or IV
Type B packages [B (U) and B (M)] UN 2916 UN 2917	Type B packages will normally contain large amounts of radioactive material. Type B packages have been designed to withstand all credible land and sea transport accidents. The radioactive content of a Type B package shipped by air is restricted. For materials that have been certified as "low dispersible radioactive material", the limit is as authorised by the competent authority for the package design. For other material, if it is special form, 3000 A1 or 100 000 A2 [24], whichever is the lower, or if it is other than special form, 3000 A2. Doses in excess of the urgent GILs are considered possible in an air accident, but not credible in land or surface mode transport. However, in the event of an emergency, this should be confirmed by monitoring.	None or IV
Type C packages UN 3323	Type C packages will normally contain large amounts of radioactive material. Therefore, Type C packages have been designed to withstand all credible land, sea and air transport accidents. Doses in excess of the urgent GILs are not considered credible. However, in the event of an emergency, this should be confirmed by monitoring.	None or IV
Special arrangements UN 2919	Shipments of non-fissile or fissile excepted radioactive material transported under special arrangement require seven days prior notification to the competent authorities of each State involved. In an accident, urgent GILs may be exceeded. Ground contamination resulting from the accident may require decontamination.	None or IV
Package containing fissile material UN 2977 UN 3324 UN 3325 UN 3326 UN 3327 UN 3328 UN 3329 UN 3330 UN 3331	Industrial, Type A, Type B and Type C packages may all contain fissile materials. Such packages containing fissile material are designed with the contents limited, so as to maintain subcriticality during both normal and accident conditions of transport. The risk summary is therefore the same as that for the relevant Industrial, Type A, Type B or Type C package. Type IF, Type AF, Type B(U)F or Type B(M)F packages that are involved in an air accident and contain only fissile UF6, may release UF6 with the associated chemical hazard. However, packages containing only UF6 have no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	None or IV
Packages containing UF6 UN 2978	Packages containing non-fissile or fissile excepted quantities of UF6 that are involved in an air accident may release UF6 with the associated chemical hazard. There is no risk of any radiological consequences requiring special protective actions. Ground contamination resulting from the emergency may require decontamination.	None
<b>Other</b>		

Nuclear weapon accident (Pu dispersal)	If there is a fire or explosion resulting in dispersal of Pu from a weapon, deterministic health effects are possible from inhalation of the plume or resuspension of deposited material within about 1 km. The area of significant contamination could be on the order of a square kilometre. It may not be possible to detect dangerous levels of airborne contamination with common radiation survey instruments.	IV
Lost/stolen dangerous source	Lethal doses are possible for persons handling an unshielded dangerous source (see Glossary and Appendix 8 of the IAEA EPR method, 2003). Lethal doses and considerable contamination resulting in doses above the urgent GILs are possible from a ruptured source. A considerable area can be contaminated due to dispersal by human activities.	IV
Contamination from transboundary release	Deposition resulting in doses in excess of the relocation GILs and ingestion GALs is possible at great distances from facilities in threat categories I or II.	V
Nuclear powered satellite re-entry	The risk is very small and it will be virtually impossible to limit the area of concern so that reasonable protective action can be taken. The handling of debris (external exposure or inadvertent ingestion) could result in deterministic health effects.	IV
Import of contaminated food or material	<i>Off-site:</i> Uncontrolled (unknowing) use of contaminated steel and other products could result in doses in excess of the occupational limits, but it is very unlikely that the urgent protective GILs can be exceeded. Food contamination could exceed the GAL for food restriction.	V

**APPENDIX B: EMERGENCY WORKERS GUIDANCE VALUES**

Table 6: Emergency Workers Guidance Values [8]

Dose level	Emergency worker tasks/actions/comments
> 500 mSv effective dose and personal dose equivalent	<ul style="list-style-type: none"> <li>• The expected benefits to others of actions to be taken clearly outweigh the emergency worker's own health risks.</li> <li>• Emergency worker volunteer understands and accepts this health risk.</li> <li>• Every effort is made to keep the dose below this level.</li> <li>• Training of workers in radiation protection.</li> <li>• Undertaking life-saving actions, include rescue from immediate threats to life and prevention or mitigation of conditions resulting in a general emergency in a threat category I facility.</li> </ul>
< 500 mSv effective dose and personal dose equivalent	<ul style="list-style-type: none"> <li>• Workers and volunteers are instructed in the potential consequences of exposure to allow them to make an informed decision.</li> <li>• Potential life-saving actions and actions undertaken to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment are undertaken, such as: <ul style="list-style-type: none"> <li>○ Implementation of urgent protective actions on-site for a threat category I, II or III facility;</li> <li>○ Prevention or mitigation of conditions (e.g. fires) that potentially endanger lives;</li> <li>○ Environmental monitoring of populated areas in the emergency zones to identify where urgent protective actions are needed; and</li> <li>○ Implementation of urgent protective actions off-site for a threat category I or II facility.</li> </ul> </li> </ul>
> 200 mSv effective dose	<ul style="list-style-type: none"> <li>• Qualified medical advice obtained to assess continuing fitness of workers for their intended tasks involving occupational exposure.</li> <li>• Qualified medical advice obtained at the request of the emergency worker.</li> </ul>
< 100 mSv effective dose and personal dose equivalent	<ul style="list-style-type: none"> <li>• Actions to avert a large collective dose.</li> </ul>
> 50 mSv effective dose	<ul style="list-style-type: none"> <li>• Workers clearly and comprehensively informed in advance of the associated health risks as well as of available protective measures.</li> <li>• Workers trained in the actions that they may be required to take.</li> </ul>
< 50 mSv effective dose	<ul style="list-style-type: none"> <li>• Helpers in an emergency taking actions.</li> <li>• Emergency workers undertaking recovery operations, such as: <ul style="list-style-type: none"> <li>○ Repairs to the facility not related to safety;</li> <li>○ Large-scale decontamination;</li> <li>○ Waste disposal; and</li> <li>○ Long-term medical management.</li> </ul> </li> </ul>

## APPENDIX C: GENERIC CRITERIA

- 1) This Appendix provides generic criteria for:
  - a) The protective actions and other response actions that are expected to be undertaken under any circumstances to avoid or to minimise severe deterministic effects;
  - b) The protective actions and other response actions that are taken, if they can be done so safely, to reasonably reduce the risk of stochastic effects;
  - c) The restriction of trade that is warranted in consideration of the non-radiological consequences of the emergency; and
  - d) The use as a target dose for the transition to an existing exposure situation.
- 2) These generic criteria are generically optimised for taking appropriate protective actions and other response actions in a nuclear or radiological emergency.
- 3) For each exposure scenario that could result in doses that exceed the generic criteria, operational criteria (e.g. operational intervention levels) should be predetermined for these generic criteria to be used immediately and directly (without further assessment) to determine the appropriate protective actions and other response actions.
- 4) The operational criteria should be established for the representative person.
- 5) The basis for the protective actions and other response actions (e.g. operational criteria and calculated doses) should be explained to the public and decision makers in terms of the associated health hazards, according to the following system:
  - a) 'Possibly dangerous to health' when the generic criteria in Table II.1 of the IAEA GSR part 7 are projected or received, since there is a possibility of severe deterministic effects (i.e. radiation induced health effects that are life threatening or can result in a permanent injury that reduces the quality of life);
  - b) 'Health concerns' when the generic criteria in Table II.2 of the IAEA GSR part 7 are projected or received, since the risk of radiation induced health effects warrant a medical screening;
  - c) 'Safe' when the generic criteria in Table II.1 and Table II.2 of the IAEA GSR part 7 are not projected or received, since no protective actions and other response actions are justified to reduce the risk of severe deterministic effects or stochastic effects.
- 6) Table II.1 of the IAEA GSR part 7 provides generic criteria for use in developing a protection strategy and operational criteria for effective implementation of protective actions and other response actions to avoid or minimise severe deterministic effects.

Table 7: Generic Criteria for Acute Doses for Which Protective Actions and Other Response Actions are Expected to be Taken Under Any Circumstances to Avoid or Minimise Severe Deterministic Effects [8]

<b>Acute external exposure (&lt; 10 hours)</b>		
AD <sub>Red marrow</sub>	1 Gy	If the dose is projected:
AD <sub>Fetus</sub>	0.1 Gy	Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria
AD <sub>Tissue</sub>	25 Gy at 0.5 cm	Provide public information and warnings
AD <sub>Skin</sub>	10 Gy to 100 cm <sup>2</sup>	Carry out urgent decontamination
<b>Internal exposure from acute intake (<math>\Delta = 30</math> d)</b>		
AD( $\Delta$ ) <sub>Red marrow</sub>	0.2 Gy for radionuclides with atomic number $\geq 90$  2 Gy for radionuclides with atomic number $Z \leq 89$	If the dose has been received:  Perform immediate medical examination, consultation and indicate medical treatment
AD( $\Delta$ ) <sub>Thyroid</sub>	2 Gy	Carry out contamination control
AD( $\Delta$ ) <sub>Lung</sub>	30 Gy	Carry out immediate decorporation <sup>f</sup> (if applicable)
AD( $\Delta$ ) <sub>Colon</sub>	20 Gy	Conduct registration for long-term health monitoring
AD( $\Delta'$ ) <sub>Fetus</sub>	0.1 Gy	Provide comprehensive psychological counselling

- AD( $\Delta$ )<sub>Red marrow</sub> represents the average RBE weighted absorbed dose to internal tissues or organs (e.g. red marrow, lung, small intestine, gonads, thyroid) and to the lens of the eye from exposure in a uniform field of strongly penetrating radiation.
- Dose delivered to 100 cm<sup>2</sup> at a depth of 0.5 cm under the body surface in tissue due to close contact with a radioactive source (e.g. source carried in the hand or pocket).
- The dose is to the 100 cm<sup>2</sup> dermis (skin structures at a depth of 40 mg/cm<sup>2</sup> (or 0.4 mm) below the body surface).
- AD( $\Delta$ ) is the RBE weighted absorbed dose delivered over the period of time  $\Delta$  by the intake (I05) that will result in a severe deterministic effect in 5% of exposed individuals.

- Different criteria are used to take account of the significant difference in the radionuclide specific intake threshold values for the radionuclides in these groups.
- Decorporation is the action of the biological processes, facilitated by chemical or biological agents, by means of which incorporated radionuclides are removed from the human body. The generic criterion for decorporation is based on the projected dose without decorporation.
- For the purposes of these generic criteria, “lung” means the alveolar-interstitial region of the respiratory tract.
- For this particular case,  $\Delta^1$  means the period of in utero development.

## GENERIC CRITERIA FOR PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS TO REDUCE THE RISK OF STOCHASTIC EFFECTS IN AN EMERGENCY

- 7) Table II.2 of the IAEA GSR part 7 provides generic criteria for use in developing a protection strategy and operational criteria for effective implementation of protective actions and other response actions to reduce the risk of stochastic effects in a nuclear or radiological emergency.
- 8) These actions should only be taken, if they can be done so safely, for those affected without endangering their lives (e.g. evacuation of patients requiring specialised medical treatment).
- 9) Arrangements should be made to revise the predetermined operational criteria based on these generic criteria, as appropriate, to be adapted to the prevailing conditions.

Table 8: Generic Criteria for Protective Actions and Other Response Actions in an Emergency to Reduce the Risk of Stochastic Effects [8]

Generic criteria	Examples of protective actions and other response actions
<b>Projected dose that exceeds the following generic criteria:</b>	
Take urgent protective actions and other response actions	
H <sub>Thyroid</sub> 50 mSv in the first 7 days	Iodine thyroid blocking <sup>a</sup>
E 100 mSv in the first 7 days	Sheltering; evacuation; decontamination; restriction of consumption of food, milk and water; contamination control; public reassurance
H <sub>Fetus</sub> 100 mSv in the first 7 days	
<b>Projected dose that exceeds the following generic criteria:</b>	
Take early protective actions and other response actions	
E 100 mSv per annum	Temporary relocation; decontamination; replacement of food, milk and water; public reassurance
H <sub>Fetus</sub> 100 mSv for the full period of in utero development	Water and restrictions on the food chain and water supply; restrictions on commodities other than food; contamination control; decontamination; registration; reassurance of the public
<b>Dose that has been received and that exceeds the following generic criteria:</b>	
Take longer term medical actions to detect and to effectively treat radiation induced health effects	

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E	100 mSv in a month	Screening based on equivalent doses to specific radiosensitive organs (as a basis for medical follow-up), counselling
H <sub>Fetus</sub>	100 mSv for the full period of in utero development	Counselling to allow informed decisions to be made in individual circumstances

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- For the thyroid, iodine thyroid blocking is an urgent protective action that is prescribed:
  - If exposure due to radioactive iodine is involved;
  - Before or shortly after a release of radioactive iodine; and
  - Only within a short period before or after the intake of radioactive iodine.

## GENERIC CRITERIA FOR FOOD, MILK AND DRINKING WATER TO REDUCE THE RISK OF STOCHASTIC EFFECTS IN AN EMERGENCY

- 10) Table II.3 of the IAEA GSR part 7 provides generic criteria for use in developing a protection strategy and operational criteria for effective implementation of protective actions and other response actions to reasonably reduce the risk of stochastic effects from ingestion of food, milk and drinking water in a nuclear or radiological emergency.
- 11) If the restriction of consumption of food, milk and drinking water will result in severe malnutrition or dehydration because replacements are not available, food, milk and drinking water with concentration levels projected to result in a dose above the generic criteria in Table II.3 of the IAEA GSR part 7 should be consumed until replacements are available, or the affected people can be relocated, provided this will not result in doses above the generic criteria in Table II.1 of the IAEA GSR part 7.
- 12) A value of 1/10 of the generic criteria for early protective actions and other response actions given in Table II.2 of the IAEA GSR part 7 is established for food, milk and drinking water restrictions to ensure that the dose from all exposure pathways, including ingestion, will not exceed the generic criteria for early protective actions and other response actions given in Table II.2 of the IAEA GSR part 7.
- 13) Arrangements should be made to revise the predetermined operational criteria (e.g. operational intervention levels) for food, milk and drinking water, as appropriate, to adapt to the conditions prevailing during the emergency to ensure that those people in the areas affected will not receive a dose from all exposure pathways greater than the generic criteria for early protective actions and other response actions given in Table 8.

Table 9: Generic Criteria for Food, Milk and Drinking Water to Reduce the Risk of Stochastic Effects in an Emergency [8]

Generic criteria	Examples of protective actions and other response actions
<b>Projected dose from ingestion of food, milk and drinking water that exceeds the following generic criteria:</b>	
Take protective actions and other response actions as justified	
<i>E</i> 10 mSv per annum	Stop consumption and distribution of non-essential food, milk and drinking water.

$H_{\text{Fetus}}$	10 mSv for the full period of in utero development	Replace essential food, milk and drinking water as soon as possible or relocate the people if replacements are not available. Estimate the dose of those who may have consumed food, milk and drinking water that may result in a dose exceeding the generic criteria to determine if medical counselling and follow-up is warranted in accordance with Table II.2.
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- Justified actions yield sufficient benefits to outweigh the detriments associated with taking them. This shall include consideration of those detriments not associated with the radiation exposure to include the detrimental impact on health (e.g. possible reduced life expectancy due to resettlement), economy, society and culture.
- Restricting essential food, milk or drinking water could result in dehydration, severe malnutrition or other health consequences, therefore, essential food, milk and drinking water should be restricted only if alternatives are available.

**GENERIC CRITERIA FOR VEHICLES, EQUIPMENT AND OTHER ITEMS TO REDUCE THE RISK OF STOCHASTIC EFFECTS IN AN EMERGENCY**

- 14) Table 10 provides generic criteria for use in determining a protection strategy and operational criteria for effective implementation of protective actions and other response actions to reduce the risk of stochastic effects from the use of vehicles, equipment and other items from an area affected by a nuclear or radiological emergency.
- 15) Restricting the use of vehicles, equipment and other items from an affected area could interfere with taking urgent protective actions and other response actions or with providing services essential for public health or well-being (e.g. transfer of patients requiring continuous specialised medical treatment, reaching a final destination only once the ship or aircraft has left the affected area). Such vehicles, equipment and other items whose use is projected to result in a dose above the generic criteria given in Table 10 should be used until replacements are available, provided that:
  - a) Their use will not result in doses that exceed the generic criteria given in Table 7 for a member of the public or the guidance values for restricting exposure of emergency workers and helpers in an emergency given in Appendix I of the IAEA GSR Part 7 and
  - b) Actions are taken to control the dose to the user and applies to an emergency worker, a helper in an emergency or a member of the public, as appropriate.
- 16) A value of 1/10 of the generic criteria for early protective actions and other response actions given in Table 8 is established for vehicles, equipment and other items from an affected area to ensure that the dose from all exposure pathways, including use of such vehicles, equipment and other items, will not exceed the generic criteria for early actions given in Table 8 for a member of the public.
- 17) Arrangements should be made to revise the predetermined operational criteria (e.g. operational intervention levels) for the use of vehicles, equipment and other items from an affected area, as appropriate, to adapt to the conditions prevailing during the emergency, to ensure that those people in the areas affected will not receive a dose from all exposure pathways greater than the generic criteria for early protective actions and other response actions given in Table 8.

Table 10: Generic Criteria for Vehicles, Equipment and Other Items to Reduce the Risk of Stochastic Effects in an Emergency [8]

Generic criteria		Examples of protective actions and other response actions
<p><b>Projected dose from the use of vehicles, equipment or other items from an affected area that exceed the following generic criteria:</b></p> <p>Take protective actions and other response actions as justified</p>		
$E$	10 mSv per annum	Stop non-essential use.
$H_{\text{Fetus}}$	10 mSv for the full period of in utero development	<p>Use essential vehicles, equipment and other items from an affected area until replacements are available if:</p> <p>(a) Use will not result in doses exceeding the generic criteria in Table II.2 for a member of the public or the guidance values in Annexure 7 for the emergency workers and helpers in an emergency; and (b) Actions are taken to reduce the dose to the user and applies to an emergency worker, helper in an emergency or a member of the public, as appropriate.</p> <p>Estimate the dose of those emergency workers, helpers in an emergency and members of the public who may have used a vehicle, equipment and other item from an affected area that may result in a dose exceeding the generic criteria for which medical counselling and follow-up is warranted in accordance with Table II.2</p>

- Justified actions yield sufficient benefits to outweigh the detriments associated with taking them. This shall include consideration of those detriments not associated with the radiation exposure to include the detrimental impact on health, economy, society and culture.
- Restricting the use of essential vehicles, equipment and other items from an affected area could interfere with taking urgent protective actions and other response actions or with providing services essential for public health or well-being (e.g. transfer of patients requiring continuous specialised medical treatment, reaching a final destination only once the ship or aircraft has left the affected area).

## GENERIC CRITERIA FOR RESPONSE ACTIONS FOR COMMODITIES AND FOOD TRADED INTERNATIONALLY

- 18) Table II.5 of the IAEA GSR Part 7 provides generic criteria for use in determining the strategy and operational criteria for effective implementation of response actions to reduce the non-radiological consequences of the emergency by providing a basis for the resumption of international trade.
- 19) Exceeding the generic criteria in Table 11 does not mean that the commodities and food are unsafe in terms of the radiation induced health effects. Commodities and food are to be considered unsafe in terms of the radiation induced health effects only if the generic criteria in Table 7 or Table 8 are projected to be exceeded.
- 20) The generic criteria for commodities and food traded internationally that could contain radioactive material as a result of a nuclear or radiological emergency are established at 1/100 of the generic criteria given in Table 8 for early protective actions and other response actions to ensure that the dose to the public will be a small fraction for which actions are warranted to reduce the risk of stochastic effects, since these commodities and food may not be controlled following export.
- 21) Arrangements should be made to revise the predetermined operational criteria based on these generic criteria, as appropriate, to adapt to the prevailing conditions.
- 22) If restricting trade in commodities and food could result in severe health effects or other detrimental effects in another State (country), then the commodities and food that are projected to result in a dose above the generic criteria should be traded if justified until replacements are available, provided that:
  - a) Trade is approved with the receiving State;
  - b) Trade will not result in doses that exceed the generic criteria in Table 8 for the public;
  - c) Actions are taken to control the dose during transport; and
  - d) Actions are taken to control the use and reduce the dose to members of the public.

Table 11: Generic Criteria for Response Actions for Commodities and Food Traded Internationally [8]

Generic criteria	Examples of other response actions
<p><b>Projected dose from commodities that exceed the generic criteria:</b> Take response actions to restrict international trade</p>	
<i>E</i> 1 mSv per annum	

$H_{\text{Fetus}}$  1 mSv for the full period of  
in utero development

Restrict non-essential international trade.

Trade essential commodities until replacements are  
available if: (a) Trade is approved with the receiving State;

(b) Trade will not result in doses that exceed the generic  
criteria given in Table II.2 for the public;

(c) Actions are taken to control the dose during transport;  
and

(d) Actions are taken to control the use and reduce the dose  
to members of the public.

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- Restricting the trade of essential commodities could result in severe health effects or other detrimental conditions in another State.

## GENERIC CRITERIA AS A TARGET DOSE FOR THE TRANSITION TO AN EXISTING EXPOSURE SITUATION

- 23) Generic criteria should be established for use as a target dose for the implementation of protective actions and other actions aimed at enabling the transition to an existing exposure situation with due consideration and verification of the fulfilment of conditions set below in para 24. These criteria should be established to 1/51 of the generic criteria for the early protective actions and other response actions given in Table 8 and are provided below:
- a) An effective dose of 20 mSv per annum; and
  - b) An equivalent dose to a fetus of 20 mSv for the full period of in utero development.
- 24) The decision to terminate the emergency phase and the concurrent transition to an existing exposure situation should be taken after:
- a) Justified actions have been taken to reach the target dose and it has been confirmed that further implementation of actions to reach the target dose will do more harm than good;
  - b) Confirmation that the source of exposure is fully characterised for all members of the public residing in the area;
  - c) The exposure situation is understood and remains stable;
  - d) Any restrictions on normal living conditions are limited and provisions are in place to confirm compliance with such restrictions; and
  - e) Ensuring that interested parties, including members of the public, are consulted and kept informed about the basis for the adjustment and transition placing the associated health hazards in perspective.
- 25) Any further reduction of the dose to a member of the public below the target dose used for deciding on the transition to an existing exposure situation should be carefully considered taking into account that actions to be taken to achieve such reduction should do more harm than good.
- 26) Arrangements should be made to revise the predetermined operational criteria (e.g. operational intervention levels) based on these generic criteria, as appropriate, to adapt to the prevailing conditions.