AERB SAFETY GUIDELINES NO. AERB/NRF/SG/EP-5 (Rev. 1)

CRITERIA FOR PLANNING, PREPAREDNESS AND RESPONSE FOR NUCLEAR OR RADIOLOGICAL EMERGENCY

Atomic Energy Regulatory Board
Mumbai – 400094
India

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Price

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FOREWORD

Activities concerning establishment and utilisation of nuclear facilities and use of radioactive sources are to be carried out in India in accordance with the provisions of the Atomic Energy Act 1962. In pursuance of the objective of ensuring safety of members of the public and occupational workers, as well as protection of environment, the Atomic Energy Regulatory Board (AERB) has been entrusted with the responsibility of laying down safety standards and enforcing rules and regulations for such activities. The Board, therefore, has undertaken a programme of developing safety codes, safety standards and related guides and manuals for the purpose. While some of these documents cover aspects such as siting, design, construction, operation, quality assurance and decommissioning of nuclear and radiation facilities, other documents cover regulatory aspects of these facilities.

Safety codes and safety standards are formulated on the basis of nationally and internationally accepted safety criteria for design, construction and operation of specific equipment, structures, systems and components of nuclear and radiation facilities. Safety codes establish the safety objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety guides elaborate various requirements and furnish approaches for their implementation. Safety manuals deal with specific topics and contain detailed scientific and technical information on the subject. These documents are prepared by experts in the relevant fields and are extensively reviewed by advisory committees of the Board before they are published. The documents are revised when necessary, in the light of experience and feedback from users as well as new developments in the field.

This 'Safety Guidelines' document provides criteria for establishing an emergency preparedness and response plan for nuclear and radiation facilities to deal with nuclear and radiological emergency and supersedes the Safety Guide AERB/SG /HS-1(1992). This document provides reference levels, generic criteria, emergency action levels, and operational intervention levels including numerical values for these criteria for protective actions and other response actions in the event of a nuclear or radiological emergency. This document also provides guidance dose value for protection of emergency workers and the public in the event of a nuclear or radiological emergency. The criteria provided in this document calls for protective actions and other response actions in precautionary action zone (PAZ), urgent protective action planning zone (UPZ), extended planning distance (EPD) and ingestion and commodities planning distance (ICPD) which replace existing space-time domain.

Consistent with the accepted practice, 'shall' and 'should' are used in the document to distinguish between a firm requirement and a desirable option respectively. Appendices are integral part of the document, whereas Annexures, bibliography and references are included to provide information that might be helpful to the user. Approaches for implementation different to those set out in the guidelines may be acceptable, if they provide comparable assurance against undue risk to the health and safety of the occupational workers and the general public, and protection of the environment.

For aspects not covered in this 'safety guidelines', applicable national and international standards, codes and guides, acceptable to AERB should be followed. Non-radiological aspects such as industrial safety and environmental protection are not explicitly considered in this 'guidelines'. Industrial safety is to be ensured through compliance with the applicable provisions of the Factories Act, 1948 and the Atomic Energy (Factories) Rules, 1996.

This 'Safety Guidelines' has been prepared by specialists in the field drawn from the Atomic Energy Regulatory Board, Bhabha Atomic Research Centre, Nuclear Power Corporation of India and other consultants. It has been reviewed by the Advisory Committee on Nuclear Safety.

AERB wishes to thank all individuals and organisations who have prepared and reviewed the draft and helped in its finalisation. The list of persons, who have participated in this task, along with their affiliations, is included for information.

(S. S. Bajaj)
Chairman, AERB

DEFINITIONS

Absorbed Dose

The fundamental dosimetric quantity D is defined as:

$$D = dE / dm$$

where, 'dE' is the mean energy imparted by ionising radiation to the matter in a volume element and 'dm' is the mass of matter in the volume element. The energy can be averaged over any defined volume, the average dose being equal to the total energy imparted in the volume divided by the mass in the volume. The SI unit of absorbed dose is joule/kg ($J.kg^{-1}$), termed the gray (Gy).

Activity

The quantity 'A' for an amount of radionuclide in a given energy state at a given time is defined as:

$$A = dN/dt$$

where 'dN' is the expectation value of the number of spontaneous nuclear transformations from the given energy state in a time interval 'dt'. The SI unit of activity is the reciprocal of second (s^{-1}), termed the Becquerel (Bq).

Anticipated Operational Occurrences

An operational process deviating from normal operation, which is expected to occur during the operating lifetime of a facility but which, in view of appropriate design provisions, does not cause any significant damage to items important to safety, nor lead to accident conditions.

Assessment

Systematic evaluation of the arrangements, processes, activities and related results for their adequacy and effectiveness in comparison with set criteria.

Atomic Energy Regulatory Board (AERB)

A national authority designated by the Government of India having the legal authority for issuing regulatory consent for various activities related to the nuclear and radiation facility and to perform safety and regulatory functions, including their enforcement for the protection of site personnel, the public and the environment against undue radiation hazards.

Authorisation

A type of regulatory consent issued by the regulatory body for all sources, practices and uses involving radioactive materials a nd radiation generating equipment (see also "Consent").

Averted Dose

The dose prevented or avoided by the application of a protective measure or set of protective measures.

Clearance Levels

A set of values established by the regulatory body and expressed in terms of activity concentrations and/or total activity, at or below which sources of radiation may be released from regulatory control.

Committed Effective Dose, E (τ)

The time integral of the whole body effective dose rate following an intake of a radionuclide. The quantity 'E (τ)' is defined as

$$E(\tau) = \sum w_T H_T(\tau)$$

where 'H_T (τ)' is the committed equivalent dose to tissue 'T' over the integration time 'τ'. When 'τ' is not specified, it will be taken to be 50 years for adults and age 70 years for intake by children.

Committed Equivalent Dose, H (τ)

The time integral of the equivalent dose rate in an organ or tissue following an intake of a radionuclide. The quantity 'H (τ)' is defined as

$$H_T(\tau) = \int_{t_0}^{t_0+\tau} \dot{H}_T(t)\, dt$$

where 't_0' is the time of intake, '$\dot{H}_T$ (τ)' is the equivalent dose rate at time 't' in an organ or tissue 'T' and 'τ' is the time elapsed after an intake of radioactive substances. When 'τ' is not specified it will be taken to be 50 years for adults and age 70 years for intake by children.

Competent Authority

Any official or authority appointed, approved or recognised by the Government of India for the purpose of the Rules promulgated under the Atomic Energy Act, 1962.

Consent

A written permission issued to the 'consentee' by the regulatory body to perform specified activities related to nuclear and radiation facilities. The types of consents are 'licence', 'authorisation', 'registration' and 'approval', and will apply according to the category of the facility, the particular activity and radiation source involved.

Consentee

A person to whom consent is granted by the competent authority under the relevant Rules.

Contamination

The presence of radioactive substances in or on a material/the human body or other places in excess of quantities specified by the competent authority.

Decommissioning

The process by which a nuclear or radiation facility is finally taken out of operation in a manner that provides adequate protection to the health and safety of the workers, the public and the environment.

Decontamination

The removal or reduction of contamination by physical or chemical means.

Design

The process and results of developing the concept, detailed plans, supporting calculations and specifications for a nuclear or radiation facility.

Design Basis Accidents (DBAs)

A set of postulated accidents which are analysed to arrive at conservative limits on pressure, temperature and other parameters which are then used to set specifications to be met by plant structures, systems and components, and fission product barriers.

Deterministic Effects

A radiation effect for which generally a threshold level of dose exists, above which the severity of the effect is greater for a higher dose.

Discharge (Radioactive)

Planned and controlled release of (gaseous or liquid) radioactive material into the environment.

Disposal (Radioactive Waste)

The emplacement of waste in a repository without the intention of retrieval or the approved direct discharge of waste into the environment with subsequent dispersion.

Documentation

Recorded or pictorial information describing, defining, specifying, reporting or certifying activities, requirements, procedures or results.

Dose

A measure of the radiation received or absorbed by a target. The quantities termed absorbed dose, organ dose, equivalent dose, effective dose, committed equivalent dose, or committed effective dose are used, depending on the context. The modifying terms are used when they are necessary for defining the quantity of interest.

Dose Limit

The value of the effective dose or the equivalent dose to individuals from controlled practices that shall not be exceeded.

Early Protective Action

See “Protective Action”

Effective Dose

The quantity ‘E’ defined as a summation of the tissue equivalent doses, each multiplied by the appropriate tissue weighting factor:

$$E = \sum_T W_T H_T$$

where ‘H_T’ is the equivalent dose in tissue ‘T’ and ‘W_T’ is the tissue weighting factor for tissue ‘T’.

Effluent

Any waste discharged into the environment from a facility, either in the form of liquid or gas.

Emergency

A situation, which endangers or is likely to endanger safety of the site personnel, the nuclear/radiation facility or the public and the environment.

Emergency Alert

Declared abnormal condition with the possibility of leading to plant/site/off-site emergency.

Emergency Exercise

A test of an emergency plan with particular emphasis on coordination of the many inter-phasing components of the emergency response, procedures and emergency personnel/ agencies. An exercise starts with a simulated/postulated event or series of events in the plant in which an unplanned release of radioactive material is postulated.

Emergency Plan

A set of procedures to be implemented in the event of an accident.

Emergency Planning Zone (EPZ)

Areas extending up to a specified distance around the plant, providing a basic geographic framework for decision making on implementing measures as part of a graded response in the event of an off-site emergency.

Precautionary Action Zone (PAZ)

An area around a facility for which arrangements have been made to take precautionary urgent protective actions in the event of a nuclear or radiological emergency to reduce the risk of severe deterministic effects in public domain. Protective actions within this area are to be taken before or shortly after a release of radioactive material or an exposure on the basis of the prevailing conditions at the facility.

Urgent Protective Action Planning Zone (UPZ)

An area around a facility for which arrangements have been made to take urgent protective actions in the event of a nuclear or radiological emergency to avert doses in public domain in accordance with international safety standards. Protective actions within this area are to be taken on the basis of environmental monitoring or, as appropriate, prevailing conditions at the facility.

Emergency Preparedness

The capability to take actions that will effectively mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

Emergency procedures

A set of instructions describing in detail the actions to be taken by response personnel in an emergency.

Emergency Response Arrangements

The integrated set of infrastructural elements necessary to provide the capability for performing a specified function or task required in response to a nuclear or radiation emergency. These elements may include authorities and responsibilities, organization, coordination, personnel, plans, procedures, facilities, equipment or training etc.

Emergency Worker

A person having specified duties as a worker in response to an emergency. Emergency workers may include workers employed both directly and indirectly by registrants and licensees as well as personnel of responding

organizations, such as police officers, firefighters, medical personnel, and drivers and crews of evacuation vehicles.

Environment

Everything outside the premises of a facility, including the air, terrain, surface and underground water, flora and fauna.

Equivalent Dose ($H_{T, R}$)

The quantity '$H_{T, R}$' is defined as

$$H_{T, R} = D_{TR} W_R$$

where 'D_{TR}' is the absorbed dose delivered by radiation type 'R' averaged over a tissue or organ 'T' and 'w_R' is the radiation weighing factor for radiation type 'R'. When the radiation field is composed of different radiation types with different values of 'W_R' the equivalent dose is

$$H_T = \sum_R W_R D_{T, R}$$

Evacuation

The rapid, temporary removal of people from an area to avoid or reduce short term radiation exposure in an emergency.

Exclusion Zone

An area extending upto a specified distance around the plant, where no public habitation is permitted. This zone is physically isolated from outside areas by plant fencing and is under the control of the plant management.

Existing Exposure Situation

An existing exposure situation is a situation of exposure that already exists when a decision on the need for control needs to be taken.

Existing exposure situations include exposure to natural background radiation that is amenable to control; exposure due to residual radioactive material that arose from past practices that were never subject to regulatory control or exposure due to residual radioactive material arising from a nuclear or radiation emergency after an emergency exposure situation has been declared to be ended.

Exposure

The act or condition of being subject to irradiation. Exposure may be either external (irradiation by sources outside the body) or internal (irradiation by sources inside the body). Exposure can be classified as either normal exposure or potential exposure; occupational, medical or public exposure; and in intervention situations, either emergency exposure or chronic exposure. The term 'exposure' is also used in radiation dosimetry to express the amount of ions produced in air by ionising radiation.

Exposure Pathway

A route by which radiation or radionuclides can reach humans and cause exposure.

Extended Planning Distance (EPD)

Distance around a nuclear power plant within which arrangements are made to conduct early monitoring of deposition to determine areas warranting (1) evacuation within a day following a release or (2) relocation within a week to a month following a release.

Generic Criteria

Dose levels (projected dose, the dose that has been received or the residual dose) at which protective actions and other response actions are to be taken.

Intake

The process of taking radionuclide into the body by inhalation or ingestion, or through the skin, and the amount of given radionuclide taken in during a given period.

Ingestion and Commodities Planning Distance (ICPD)

The distance around a nuclear power plant for the area within which arrangements are made, within hours of being notified by the nuclear power plant of the declaration of a General Emergency, to: (a) place grazing animals on covered feed and protect drinking water supplies that use rainwater (e.g. to disconnect rainwater collection pipes); and (b) restrict consumption of local produce and non-essential food, milk from grazing animals and rainwater until further assessments are performed.

Long Term Protective Action

See “Protective Action”.

Member of the Public

Any individual in the population except for one who is subject to occupational or medical exposure. For the purpose of verifying compliance with the annual dose limit for public exposure, the member of the public is the representative individual in the relevant critical group.

Mitigatory Action

Immediate action by the operator or other party:

(1) To reduce the potential for conditions to develop that would result in exposure or a release of radioactive material requiring emergency actions on or off the site; or
(2) To mitigate source conditions that may result in exposure or a release of radioactive material requiring emergency actions on or off the site.

Monitoring

The continuous or periodic measurement of parameters for reasons related to the determination, assessment in respect of structure, system or component in a facility or control of radiation.

Nuclear or Radiation Emergency

An emergency in which there is, or is perceived to be, a hazard due to:

(1) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or (2) Radiation exposure.

Nuclear Fuel Cycle

All operations associated with the production of nuclear energy, including mining, milling, processing and enrichment of uranium or processing of thorium, manufacture of nuclear fuel, operation of nuclear reactors, reprocessing of irradiated nuclear fuel, decommissioning, and any activity for radioactive waste management and research or development activity related to any of the foregoing.

Occupational Exposure

All exposures of personnel incurred in the course of their work.

Occupational Worker

Any person, working full time or part time in a nuclear or radiation facility, who may be employed directly by the "consentee" or through a contractor.

Off-site

Area in public domain beyond the site boundary.

Off-site Emergency

Accident condition/emergency situation involving excessive release of radioactive materials/hazardous chemicals from the plant to the public domain calling for intervention.

Operation

All activities following and prior to commissioning performed to achieve, in a safe manner, the purpose for which a nuclear/radiation facility is constructed, including maintenance.

Observables / indicators

Observables / indicators are instrument readings or other parameters which provide information on the conditions on the scene.

Plant Emergency

Declared emergency conditions in which the radiological/other consequences, confined to the plant or a section of the plant, requiring immediate operator action.

Precautionary Action Zone

See "Emergency Planning Zones"

Precautionary Urgent Protective Action (PUA)

See "Protective Action"

Prescribed Limits

Limits established or accepted by the regulatory body.

Projected dose

The dose to be expected if no protective or remedial action is taken.

Protective Action

An action for the purposes of avoiding or reducing doses that might otherwise be received in an emergency exposure situation or an existing exposure situation.

Precautionary Urgent Protective Action (PUA)

A protective action in the event of a nuclear or radiation emergency which must be taken before or shortly after a release of radioactive material, or before an exposure, on the basis of the prevailing conditions to prevent or to reduce the risk of severe deterministic effects.

Urgent Protective Action (UPA)

A protective action in the event of an emergency which must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed.

Early Protective Action

A protective action in the event of a nuclear or radiological emergency that can be implemented within days to weeks and still be effective. (Note: The most common early protective actions are relocation and longer term restrictions on consuming contaminated food).

Long Term Protective Action

A protective action that is not an urgent protective action. Such protective actions are likely to be prolonged over weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.

Quality Assurance (QA)

Planned and systematic actions necessary to provide the confidence that an item or service will satisfy given requirements for quality.

Radiation Worker

Any person who is occupationally exposed to radiation, and who in the opinion of the regulatory body, should be subjected to radiation surveillance.

Radioactive Waste

Material, whatever its physical form, left over from practices or interventions for which no further use is foreseen: (a) that contains or is contaminated with radioactive substances and has an activity or activity concentration higher than the level for clearance from regulatory requirements, and (b) exposure to which is not excluded from regulatory control.

Radiological Safety Officer (RSO)

Any person who is so designated by the employer and who, in the opinion of the competent authority is qualified to discharge the functions outlined in the Radiation Protection Rules, 2004.

Records

Documents, which furnish objective evidence of the quality of items and activities affecting quality. They include logging of events and other measurements.

Recording Level

A level of dose, exposure or intake specified by regulatory body at or above which values of dose, exposure or intake received by workers are to be entered in the individual exposure records.

Reference Level

Action level, intervention level, investigation level or recording level established for any of the quantities determined in the practice of radiation protection.

Relocation (Off-site Emergency)

The removal of members of the public from their homes, for an extended period or time, as a protective action in a chronic exposure situation.

Residual Dose

The dose expected to be incurred in the future after protective actions have been terminated (or a decision has been taken not to implement protective actions).

This applies in an existing exposure situation or an emergency exposure situation.

Safety Analysis Report (SAR)

A document, provided by the applicant/consentee to the regulatory body, containing information concerning the nuclear or radiation facility, its design, accident analysis and provisions to minimise the risk to the public, the site personnel and the environment.

Safety Assessment

A review of the aspects of design and operation of a source which are relevant to the protection of persons or the safety of the source, including the analysis of the provisions for safety and protection established in the design and operation of the source and the analysis of risks associated both with normal conditions and accident situations.

Safety Code

A document stating the basic requirements, which must be fulfilled for particular practices or applications. This is issued under the authority of the regulatory body and mandatory to be followed by the respective utilities.

Safety Guide

A document containing detailed guidance and various procedures/ methodologies to implement the specific parts of a safety code that are acceptable to the regulatory body, for regulatory review. This is issued under the authority of regulatory body and is of non-mandatory nature.

Safety Manual

A document detailing the various safety aspects/instructions and requirements relating to a particular practice or application, that are to be followed by a utility.

Site

The area containing the facility defined by a boundary and under effective control of the facility management.

Site Emergency

Accidental condition/emergency situation in the plant involving radioactivity transgressing the plant boundary but confined to the site, or involving release of hazardous chemicals or explosion, whose effects are confined to the site, with off-site consequences being negligible.

Siting

The process of selecting a suitable site for a facility including appropriate assessment and definition of the related design bases.

Source

Anything that causes radiation exposure, either by emitting ionising radiation or releasing radioactive substances or materials.

Stochastic Effects (Radiation)

Radiation effects generally occurring without a threshold level of dose whose probability is proportional to the dose and whose severity is independent of the dose.

Urgent Protective Action (UPA)

See ‘Protective Action’

Urgent Protective Action Planning Zone (UPZ)

See ‘Emergency Planning Zones’

SPECIAL DEFINITIONS
(Specific for the Present 'Guidelines')

Emergency Action Level (EAL)

A specific, predetermined, observable criterion used to detect, recognize and determine the emergency class.

Operational Criteria

Observables or values of measurable quantities to be used in the early phase of the response in a nuclear or radiological emergency in order to determine the need for appropriate protective actions and other response actions (Note: These include operational intervention levels (OILs), emergency action levels (EALs), specific observables and other indicators of conditions on the site).

Operational Interventional Level (OIL)

A set level of a measurable quantity that corresponds to a generic criterion. OILs are typically expressed in terms of dose rates or of activity of radioactive material released, time integrated air concentrations, ground or surface concentrations, or activity concentrations of radio-nuclides in environmental, food or water samples. An OIL is a type of action level that is used immediately and directly (without further assessment) to determine the appropriate protective actions on the basis of an environmental measurement.

General Emergency

An event resulting in an actual release, or substantial probability of a release, requiring implementation of urgent protective actions off-site.

- This includes: (1) actual or projected damage to the reactor core or large amounts of spent fuel; or (2) releases off-site resulting in doses exceeding intervention levels for urgent protective actions within hours.

- When a general emergency is declared, urgent protective actions are recommended immediately for the public near the facility.

CONTENTS

1. INTRODUCTION

1.1 General

Nuclear and radiation facilities are designed, constructed and operated with stringent regulatory and safety requirements. Adequate measures are in place to deal with occurrence of extremely low probability events that may lead to accidental release of radionuclides to the environment resulting in off-site radiological consequences. The radiological impact due to the nuclear and radiological emergencies can be mitigated (minimised) through timely implementation of emergency preparedness and response actions.

1.2 Objective

Objective of this Safety Guidelines is to provide criteria for establishing an emergency preparedness and response plans at nuclear and radiation facilities to mitigate the radiological consequences following nuclear accident or radiological emergency situation.

1.3 Scope

This Safety Guidelines can be used for preparing an emergency preparedness and response plans for facilities such as:

(a) nuclear power plants;
(b) research/experimental reactors;
(c) fuel enrichment/fabrication;
(d) fuel reprocessing;
(e) radioactive waste management plants;
(f) use of radionuclide in medicine, research and industries; and
(g) any other facility as determined by AERB.

Scope of this Safety Guidelines is to provide criteria for establishing an emergency preparedness and response plans to facilitate effective implementation of protective measures during a nuclear and radiological emergency situation. It provides basic consideration and goal for emergency response action, criteria for hazard categorisation and hazard assessment of nuclear and radiation facilities, system for protective actions, other response actions, guidance on dose levels for emergency workers and the reference dose levels for emergency and post emergency existing exposure situation.

This Safety Guidelines also provides guidance for establishing operational criteria that include operational intervention levels (OILs), emergency action levels (EALs), specific observables and other indicators on the scene to facilitate decision making process during an emergency situation.

This document may not be applicable to the emergency that may occur in public domain during transportation of radioactive materials. For such emergencies, the document cited under reference titled ‘Safety Code on Emergency Response Planning and Preparedness for Transport Accidents Involving Radioactive Material AERB/SC/TR-3’ [9] is applicable.

2. CLASSIFICATION OF EMERGENCY

2.1 General

The emergency situation of nuclear / radiation facilities (based on hazard category) is classified as (i) Emergency Alert, (ii) Plant Emergency, (iii) Site Emergency and (iv) Off site Emergency. Declaration of an emergency in any of these emergency classes should initiate a response that is considerably beyond normal operations. Each class initiates distinctly different level of response as indicated below.

<table>
<tr><td>Emergency Alert</td><td>Plant Emergency</td><td>Site Emergency</td><td>Off site emergency</td></tr>
<tr><td colspan="4">Immediate actions to analyze the plant condition and mitigate the consequences</td></tr>
<tr><td></td><td colspan="3">Immediate actions to protect those on-site</td></tr>
<tr><td colspan="2"></td><td colspan="2">Prepare to take off-site protective action</td></tr>
<tr><td colspan="3"></td><td>Immediate protective actions in public domain</td></tr>
</table>

Emergency classification is based on plant conditions called as EALs as detailed in section 5.3.1 & Appendix VI-A&B

2.2 Emergency Alert

The licensee should identify the events and develop appropriate emergency operating procedures to mitigate the consequences. The licensee should declare emergency alert in the facility on occurrence of such events. The emergency alert should be intimated to the regulatory body within 24 hours. In a multi-unit site, the emergency alert situation at one facility may have the potential of affecting other facilities. The emergency response plan of each unit should clearly indicate such events and response action to be followed at other facilities and adequate mechanism should exist for prompt communication among the co-located facilities.

2.3 Plant Emergency

An approved plant emergency preparedness and response plan commensurate with the hazard assessment of the facility should be in place prior to the commissioning. The plan should be tested by periodic exercises. The response plan should be reviewed and modified based on the experience with the approval of the regulatory body. If the site is having more than one facility, the plant emergency declared at one facility should call for an emergency alert or plant emergency for other facilities depending on the situation. The criteria and conditions of such emergency situation should be clearly brought out in the emergency preparedness and response plan of each facility. The plant emergency should be intimated to the regulatory body immediately. The facility should suspend operation during plant emergency and resume / re-start operation only after obtaining clearance from the regulatory body.

2.4 Site Emergency

An approved site emergency preparedness and response plan should be in place prior to the commissioning of the facility. The licensee should immediately report the site emergency to the regulatory body with relevant details. The important plant parameters and site radiological condition including radiation exposure status of the radiation/emergency workers should be intimated to the regulatory body in regular intervals or as directed by the regulatory body. If the site emergency is declared in a multi-unit/ multi-facility site, all the units/facilities in the site should be shutdown. The role and responsibilities of the site emergency response team should be clearly defined in the response plan and tested periodically. The licensee should be responsible for implementing the remedial measures for

mitigating the site consequences. The site emergency should be terminated under intimation to the regulatory body. The facility should resume / re-start operation only after obtaining clearance from the regulatory body. The site emergency response plan should be periodically tested and revised if required based on the experience.

2.5 Off-Site Emergency

An approved off-site emergency preparedness and response plan should be in place prior to the commissioning of the facility. The emergency response plan should delineate the role and responsibilities of all involved agencies. The emergency response plan should be periodically tested and revised if required based on the experience. The off-site emergency response plan should be inline with the national / state / district disaster management plan and should have approval of the state / district authorities.

3. BASIC CONSIDERATION FOR EMERGENCY RESPONSE

3.1 General

For successful implementation of emergency management programme the practical goals of emergency response plan are to be clearly brought out. To achieve these goals the inputs required should be specified and quantified. These goals and related inputs form the basis for emergency planning, preparedness and response. The objective of emergency response is to prevent the deterministic effects, limit the stochastic effects and reduce other consequences to the workers, public and environment.

3.2 Basic Consideration

The practical goals of emergency response plan in a nuclear and radiological emergency are

(a) regain control of the situation;

(b) prevent or mitigate consequences at the scene;

(c) prevent the occurrence of deterministic health effects in workers and the public;

(d) render first aid and to manage the treatment of radiation injuries;

(e) limit to the extent practicable, the occurrence of stochastic health effects in workers and the population;

(f) prevent to the extent practicable, the occurrence of non-radiological effects on individuals and among the population;

(g) protect to the extent practicable, property and the environment; and

(h) prepare to the extent practicable, for the resumption of normal social and economic activity.

To achieve the above goals following should be specified and quantified.

(i) hazard categorisation of the nuclear and radiation facility

(ii) system of protective actions and emergency planning zones (PAZ, UPZ &LPZ)

(iii) establishment of criteria for undertaking protective measures

The emergency response plan should take into account the deterministic effects, stochastic effects and socio economic consequences to the public and environment. This is ensured by keeping residual doses well below the reference levels.

3.2.1 Hazard Category of Nuclear and Radiation Facility and Response Actions Based On Hazard Category

The nuclear and radiation facilities should be categorized into five categories based on the nuclear and radiation related hazards for the purposes of establishing the emergency preparedness and response plan. Hazard categories I, II and III represent the decreasing levels of radiation related hazard. Hazard category IV involves transport of sources / orphan sources and category V involves contamination at distant places from the accident. The stringency of requirements for emergency preparedness and response decrease from category I to V. The licensee should carry out the hazard assessment of the facility by analysing the hazards associated with facilities, activities or sources within or beyond the site, on-site / off-site (refer Appendix-I)

Response actions based on Hazard category

(i) The licensee of a facility in hazard category I, II or III should make arrangements to ensure the safety of all persons on the site in the event of a nuclear or radiological emergency. This should include arrangements: to notify people on the site of an emergency; for all persons on the site to take appropriate actions immediately upon notification of an emergency; to account for those on the site; to locate and recover those unaccounted for; to take urgent protective action; and to provide immediate first aid. The facility should provide suitable assembly points for all persons

on the site and should be provided with a sufficient number of safe escape routes, clearly and durably marked, with reliable emergency lighting, ventilation and other building services essential to the safe use of these routes. The escape routes should meet the relevant requirements for radiation zoning and fire protection and the relevant national requirements for industrial safety and security. Suitable alarm systems and means of communication should be provided so that all persons present in the facility and on the site can be warned and instructed, even under emergency conditions.

(ii) The licensee of a facility in hazard category I, II or III should ensure the availability of means of communication necessary for protective actions to be taken within the facility and in the area controlled by the operator and to off-site agencies with responsibility for taking protective actions within the precautionary action zone and the urgent protective action planning zone at all times. The response plan should take into account the diversity of the methods of communication selected.

(iii) State Officials responsible for making recommendations / decisions on the protective actions in public domain within the precautionary action zone and/or the urgent protective action planning zone should do so promptly upon the notification of a nuclear or radiological emergency.

(iv) The authorities under whose jurisdiction the precautionary action zone and/or the urgent protective action planning zone fall should make arrangements to take appropriate urgent actions promptly upon the notification of a nuclear or radiological emergency. These arrangements should include arrangements for: taking appropriate actions for the protection of emergency workers; alerting permanent, transient and special population groups or those responsible for them; taking urgent protective actions; protecting supplies of food and water; imposing restrictions on the immediate consumption of produce from farms or gardens and of locally produced milk; monitoring and decontaminating evacuees; caring for evacuees; alerting special facilities; and the control of access to and the restriction of traffic by air, water, road and rail. Arrangements should be in place for co-ordinating with all the jurisdictions within any emergency zone.

3.2.2 System of Protective Actions and Establishment of Emergency Planning Zone (EPZ)

System of protective action should be based on the projected dose and other response action should be based on the actual dose received. This is further elaborated in Chapter-4. For effective implementation of protective actions the area around the site is divided into following zones based on quantum of release and atmospheric parameters:

(a) A precautionary action zone (PAZ), for facilities in hazard category I, for which arrangements should be made with the goal of taking precautionary urgent protective actions, before a release of radioactive material occurs or shortly after a release of radioactive material begins, on the basis of conditions at the facility (such as the emergency classification) in order to reduce substantially the risk of severe deterministic health effects. PAZ can extend up to 5 km.

(b) An urgent protective action planning zone (UPZ), for facilities in hazard category I or II, for which arrangements should be made for urgent protective action to be taken promptly, in order to avert doses in accordance with the prescribed level. UPZ can extend up to 16 km.

(c) Long-Term Protective Action Planning Zone (LPZ**)** is a pre-designated area around a facility which can extend up to 30 km and includes the urgent protective action zone. The LPZ is the zone where preparations for effective implementation of protective actions to reduce the risk of deterministic and stochastic health effects from ingestion of contaminated foodstuffs, either locally grown or sold in the affected area should be developed in advance.

3.3 Establishment of Criteria

Criteria discussed here take into account the projected dose, averted dose and residual dose during an emergency.

Reference Levels: In emergency exposure situations, the reference levels represent the levels of doses or risks, above which it is judged to be inappropriate to plan to allow exposures to occur, and for which therefore protective actions should be planned and optimised. A reference level for protection of public during emergency situation is set within an effective dose range of 20–100 mSv, expressed in terms of residual dose, which includes dose contributions via all exposure pathways. The protection strategy shall be optimized to reduce exposures below the reference level.

During emergency situation protective and other actions are undertaken to ensure that the reference levels are not exceeded. The type and scale of protective and other actions undertaken in turn are based on:

i. Generic Criteria: Generic criteria are set by considering two types of the health consequences (i) severe deterministic effect and (ii) increase in stochastic effect. Generic criteria start at levels of dose that are approaching the threshold for severe deterministic effects (could be as high as 1 Sv). Normally the generic criteria deal with estimated quantities such as projected dose and cannot be directly seen or easily measured.

ii. Operational Criteria: The generic criteria form the basis for developing the operational criteria. Operational criteria include (i) Emergency Action Levels (EAL) (ii) Operational Intervention Levels (OIL) and (iii) Observables (by operators or first responders); for decision making on emergency categorisation and initiating the protective actions. Operational criteria are established in advance (e.g control room indications, radiation and contamination levels in public domain etc.) by using the generic criteria and these are normally the observables.

Thus the system of protective actions and other response actions in an emergency includes numerical values of generic criteria as well as of the corresponding operational criteria that form the basis for decision making so as to ensure that the residual doses normally remain well below reference levels.

4. SYSTEM OF PROTECTIVE AND OTHER RESPONSE ACTION

4.1 General

The emergency preparedness and response plan needs to include the protective action and other response action commensurate with the hazard assessment of the facility. The protective action includes precautionary urgent protective actions (PUA), urgent protective actions (UPA) and other response actions to prevent severe deterministic effects and to reduce the risk of stochastic effects.

System of Protective and Response Actions

System of protective action should be based on the projected dose and other response action should be based on the actual dose received. Typical protective action and other response actions are provided in Table 1.

TABLE-1: SYSTEM OF PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN AN EMERGENCY [1]

Types of possible health consequences of exposure	**Basis for implementation of protective actions and other response actions**	
	Based on Projected dose	**Based on Dose received**
Severe deterministic effects (Generic criteria are established at levels of dose that are approaching the thresholds for severe deterministic effects)	Implementation of precautionary urgent protective actions (e.g evacuation), even under adverse conditions, to prevent severe deterministic effects	Other response actions for treatment and management of severe deterministic effects include immediate medical examination, consultation and treatment as indicated, contamination control, decorporation where applicable, registration for long term health monitoring, and comprehensive psychological counseling.
Increase in stochastic effects	Implementation of urgent protective actions and initiation of early protective actions (relocation and long term restriction of consumption of contaminated food) to reduce the risk of stochastic effects as far as reasonably possible	Other response actions for early detection and effective management of stochastic effects include screening based on individual doses to specific organs, considering the need for registration for medical follow-up and counseling to allow informed decisions to be made in individual circumstances.

4.3 Protection Strategy

The protection strategy should include, but not be limited to the following aspects:

i. On the basis of the optimization of protection strategy and the reference level, generic criteria for particular protective actions and other response actions should be developed and included in the emergency preparedness and response plan of each facility and site.

ii. The emergency preparedness and response plan should include the reference dose level for public.

iii. Suitable remedial measures should be implemented to limit dose of existing exposure situation to less than 1 mSv per year (excluding exposure due to natural radiation).

iv. Generic criteria for implementing precautionary urgent protective actions to prevent severe deterministic effects should be based on the values specified in Table 2.

4.4 Reference Dose Levels for Public

Reference dose levels for public are set typically between an effective dose 20 mSv and 100 mSv, expressed in terms of residual dose, which includes dose contributions via all exposure pathways. During the emergency phase, a reference level between 20 and 100 mSv per year should be used to implement protective actions driven by urgency, taking into account the prevailing conditions. The protection strategy should be optimized to reduce the exposures below the reference level. The regulatory body should be intimated for radiation dose level above 100 mSv during an emergency situation. Once the emergency is over, a reference level for the existing exposure situations should be used between 1 and 20 mSv per year depending upon the situation. Effort should be taken to reduce the radiation exposure.

4.5 Implementation of Protective Action and Other Response Action

The following possible impacts should be considered during the planning and implementation of protective actions and other response actions in an emergency:

(i) Development of severe deterministic effects.

(ii) Increase in stochastic effects.

(iii) Adverse effects on the environment and property.

(iv) Other adverse effects (e.g. psychological effects, social disorder, economic disruption).

The following types of exposure should be taken into account in the planning and implementation of protective actions and other response actions in an emergency:

(i) The projected dose that could be prevented or reduced by means of precautionary urgent protective actions and urgent protective actions.

(ii) The dose that has been received, the detriment due to which may be minimized by medical actions and may be addressed by public reassurance or counselling.

Precautionary urgent protective actions should be implemented on the basis of a substantial risk of a release or exposure under any circumstances, in order to prevent the development of severe deterministic effects for very high levels of dose (refer Table 2; generic criteria for deterministic effects). The authorities should assess the potential of incidents such as acute radioactive releases / exposure situation resulting events / accident considering single or combination of facilities at the site and the assessment should be taken into account in the emergency preparedness and response plan.

If the risk of stochastic effects is the main concern and the risk of the development of severe deterministic effects is negligible, urgent and early protective actions and other response actions, all of which are justified and optimized and response action should be implemented to reduce the risk of stochastic effects (Table 3; generic criteria for stochastic effects). The licensee should assess the events / accidents considering single or combination of facilities at the site and the assessment should be taken into account in the emergency preparedness and response plan.

If the dose exceeds a particular generic criterion identified in Table 2 or 3, individuals should be provided with appropriate medical attention, including medical treatment, long term health monitoring and psychological counselling.

Medical actions should be initiated and performed on the basis of medical symptoms and observations. However, dosimetric information (e.g. based on radiation survey data, dose measurements or dose calculations) can provide a valuable input for determining the medical treatment.

Other response actions for early detection and effective management of stochastic effects include screening based on individual doses to specific organs, considering the need for registration for medical follow-up and counselling to allow informed decisions to be made in individual circumstances.

For all levels of dose that may result in an emergency exposure situation, the identified responsible agency should inform the risk to the public and other involved agencies including first responders.

5. GENERIC AND OPERATIONAL CRITERIA

5.1 General

Generic criteria are used in terms of dose that can be projected or dose that has already been received. Use of generic criteria meets the need for a common term for the system of values that would be used as the basis for the implementation of protective actions (e.g. evacuation or food replacement) and other response actions (e.g. medical follow-up).

Projected dose and dose that has been received are not measurable quantities and cannot be used as a basis for quick actions in an emergency. There is a need to establish in advance operational criteria (values of measurable quantities or observables) as a surrogate for the generic criteria for undertaking different protective actions and other response actions.

The operational criteria are values of measurable quantities or observables that include operational intervention levels (OILs), emergency action levels (EALs), specific observables and other indicators of conditions on the scene that should be used in decision making during an emergency. The operational criteria can be used immediately and directly to determine the need for appropriate protective actions and other response actions. These operational criteria are used as 'triggers' at the early stage of an emergency.

5.2 Generic Criteria (GC)

Generic criteria should be established on the basis of generic optimization in consideration of the range of conditions that prevail in an emergency. Generic criteria should be in terms of dose that can be projected or dose that has already been received. Generic criteria should be established for precautionary urgent protective actions, UPA and early protective actions, as well as for other response actions that may be required in an emergency. Precautionary urgent protective actions /Urgent protective actions (e.g. evacuation) should be taken promptly (e.g. within hours) to be effective, because their effectiveness will be reduced if there is a delay. Early protective actions can be implemented within days or weeks to be effective. They can be long lasting, even after the emergency (e.g. temporary relocation). In no case the urgent protective actions and early protective actions based on the generic criteria should cause more detriment than they avert.

The generic criteria are provided for:

(a) Protective actions and other response actions that are expected to be undertaken under any circumstances to avoid or to minimize severe deterministic effects;
(b) Protective actions and other response actions that are taken to reasonably reduce the risk of stochastic effects;
(c) Restriction of trade if warranted; and
(d) Use as a target dose for the transition to an existing exposure situation.

These generic criteria shall be optimized for taking appropriate protective actions and other response actions in a nuclear or radiological emergency. The situation is 'Safe' when the generic criteria in Table 2 and Table 3 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.

5.2.1 Generic Criteria to Avoid or Minimize Severe Deterministic Effects

Generic criteria for acute doses for which protective actions and other response actions are expected to be undertaken under any circumstances to avoid or to minimize severe deterministic effects are provided in Table 2. This table provides generic criteria along with examples of protective actions and response actions for developing a protection strategy and operational criteria for effective implementation of protective actions and other response actions to avoid or to minimize severe deterministic effects.

TABLE 2: GENERIC CRITERIA FOR ACUTE DOSES FOR WHICH PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS ARE TO BE TAKEN UNDER ANY CIRCUMSTANCES TO AVOID OR TO MINIMIZE SEVERE DETERMINISTIC EFFECTS [1]

<table>
<tr><th colspan="2">Generic criteria</th><th>Examples of protective actions and other response actions</th></tr>
<tr><td colspan="3">External acute exposure (<10 hours)</td></tr>
<tr><td>Whole Body (bone marrow)</td><td>1 Sv</td><td rowspan="6">If the dose is projected:
- Take precautionary urgent protective actions immediately (even under difficult conditions) to keep doses below the generic criteria
- Provide public information and warnings
- Carry out urgent decontamination

If the dose has been received :
- Perform immediate medical examination, consultation and indicated medical treatment
- Carry out contamination control
- Carry out immediate decorporation (if applicable)
- Carry out registration for long term health monitoring (medical follow-up)
- Provide comprehensive psychological Counseling</td></tr>
<tr><td>Skin</td><td>10 Sv to 100 cm^2</td></tr>
<tr><td colspan="2">Internal exposure from acute intake
(Delivered in 30 days)</td></tr>
<tr><td>Thyroid</td><td>2 Sv</td></tr>
<tr><td>Lung</td><td>30 Sv</td></tr>
</table>

5.2.2 Generic Criteria for Protective Actions and other Response Actions to Reduce the Risk of Stochastic Effects in an Emergency.

Table 3 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.

TABLE 3: GENERIC CRITERIA FOR PROTECTIVE ACTIONS AND OTHER RESPONSE ACTIONS IN EMERGENCY EXPOSURE SITUATIONS TO REDUCE THE RISK OF STOCHASTIC EFFECTS [1]

<table>
<tr><th colspan="2">Generic criteria</th><th>Examples of protective actions and other response actions</th></tr>
<tr><td colspan="3">Projected dose that exceeds the following generic criteria: Take urgent protective actions/Protective actions and other response actions</td></tr>
<tr><td>Thyroid dose</td><td>50 mSv in the first 7 days</td><td>Urgent Protective Actions:
Iodine thyroid blocking</td></tr>
<tr><td>Whole body dose</td><td>100 mSv in the first 7 days</td><td>Urgent Protective Actions:
Sheltering; evacuation; decontamination; restriction on consumption of food, milk and water; contamination control; public reassurance</td></tr>
<tr><td>Whole body Dose</td><td>100 mSv per annum</td><td>Early Protective Actions:
Temporary relocation; decontamination; replacement of food, milk and water; public reassurance</td></tr>
<tr><td colspan="3">Dose that has been received and that exceeds the following generic criteria: Take longer term medical actions to detect and to effectively treat radiation induced health effects</td></tr>
<tr><td>Whole body dose</td><td>100 mSv in a month</td><td>Screening based on equivalent doses to specific radiosensitive organs (as a basis for medical follow-up), counseling</td></tr>
</table>

5.2.3 Generic Criteria for Food, Milk and Drinking Water to Reduce the Risk of Stochastic Effects in an Emergency

Table 3A provides generic criteria for 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.

Generic criteria of 1/10 of the generic criteria for early protective actions and other response actions given in Table 3 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 3.

TABLE 3A: GENERIC CRITERIA FOR FOOD, MILK AND DRINKING WATER TO REDUCE THE RISK OF STOCHASTIC EFFECTS IN AN EMERGENCY [2]

<table>
<tr><th colspan="2">Generic criteria</th><th>Examples of protective actions and other response actions</th></tr>
<tr><td colspan="3">Projected dose from ingestion of food, milk and drinking water that exceeds the following generic criteria: Take protective actions and other response actions as justified</td></tr>
<tr><td>Whole body Dose</td><td>10 mSv per annum</td><td rowspan="2">Stop consumption and distribution of non-essential food, milk and drinking water.

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 3.</td></tr>
<tr><td>H_{Fetus}</td><td>10 mSv for the full period of in utero development</td></tr>
</table>

5.2.4 Generic Criteria for Vehicles, Equipment and Other Items to Reduce the Risk of Stochastic Effects in an Emergency

Table 3B provides generic criteria for 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.

Generic criteria of 1/10 of the generic criteria for early protective actions and other response actions given in Table 3 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 3 for a member of the public.

TABLE 3B: GENERIC CRITERIA FOR VEHICLES, EQUIPMENT AND OTHER ITEMS TO REDUCE THE RISK OF STOCHASTIC EFFECTS IN AN EMERGENCY [2]

<table>
<tr><th colspan="2">Generic criteria</th><th>Examples of protective actions and other response actions</th></tr>
<tr><td colspan="3">Projected dose from the use of vehicles, equipment or other items from an affected area that exceed the following generic criteria: Take protective actions and other response actions as justified.</td></tr>
<tr><td>Whole body Dose</td><td>10 mSv per annum</td><td rowspan="2">Stop non-essential use.

Use essential vehicles, equipment and other items from an affected area until replacements are available if: (a) use will not result in doses exceeding the generic criteria in Table 3 for a member of the public or the guidance values in Table 10 for the emergency workers and helpers in an emergency, and (b) actions are taken to reduce the dose to the user as an emergency worker, helper in an emergency or a member of the public, as appropriate.

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 3</td></tr>
<tr><td>H_{Fetus}</td><td>10 mSv for the full period of in utero development</td></tr>
</table>

5.2.5 Generic Criteria for Response Actions for Commodities and Food Traded Internationally

Table 3C provides generic criteria for the resumption of international trade. 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 3 for early protective actions and other response actions to ensure that the dose to the public will be a small fraction.

Exceeding the generic criteria in Table 3C 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 2 or 3 are projected to be exceeded.

For food traded internationally that could contain radionuclides as a result of a nuclear or radiological emergency, the operational criteria (guideline levels) as published by the Joint FAO/WHO Codex Alimentarius Commission shall be used.

TABLE 3C : GENERIC CRITERIA FOR RESPONSE ACTIONS FOR COMMODITIES AND FOOD TRADED INTERNATIONALLY [2]

Generic criteria		**Examples of other response actions**
Projected dose from commodities that exceed the generic criteria: Take response actions to restrict international trade.		
Whole body Dose	1 mSv per annum	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 3 for the public; (c) actions are taken to control the use and reduce the dose to the member of the public.
H_{Fetus}	1 mSv for the full period of in utero development	

5.2.6 Generic Criteria as a Target Dose for the Transition to an Existing Exposure Situation

Generic criteria shall 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. The criteria shall be established at 1/5 of the generic criteria for the early protective actions and other response actions given in Table 3 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.

The decision to terminate the emergency phase and the concurrent transition to an existing exposure situation shall 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 characterized for all members of the public living normally 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.

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 may do more harm than good.

Event specific conditions may warrant modification of the generic criteria. The system of generic criteria and operational criteria is illustrated in Fig. 1.

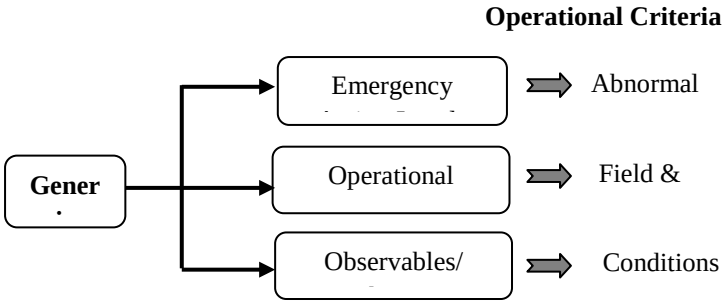

Fig. 1. System of generic criteria and operational criteria.

5.3 Operational Criteria

The operational criteria are values of measurable quantities or observables that include operational intervention levels (OILs), emergency action levels (EALs), specific observables and other indicators of conditions on the scene that may be used in decision making during an emergency. The operational criteria can be used immediately and directly to determine the need for appropriate protective actions and other response actions. These operational criteria are used as 'triggers' at the early stage of an emergency.

Precautionary urgent protective actions, as applicable and urgent protective actions should be taken on the basis of pre-calculated operational criteria (e.g radioactive releases, exposure etc). The majority of urgent protective actions and early protective actions are also implemented on the basis of pre-calculated operational criteria. However, if the characteristics of an emergency differ from those assumed in the calculations of operational criteria, the criteria should be recalculated. Methods for the recalculation to address prevailing conditions in an actual emergency should be established during the planning phase.

5.3.1 Emergency Action Levels (EAL)

The EAL are the specific, predetermined, observable operational criteria used to detect, recognize and determine the emergency class of an event at facilities in hazard categories I, II and III. The EALs are used for classification and for decisions on the implementation of precautionary urgent protective actions corresponding to a particular emergency class. These criteria should be predefined. The emergency preparedness and response plan should include the EALs of the respective facilities. There are two different types of EAL:

i. Symptom based EAL. Symptom based EAL are site specific instrument readings (e.g. reactor coolant system pressure higher / lower than a certain level) or other observable or quantifiable thresholds (e.g. failure of emergency power supply systems as indicated by a specific parameter).

ii. Event based EAL are more subjective criteria requiring the judgement of the operating staff. An example of an event based EAL would be 'fire detected in an area containing vital safety systems'.

When possible, symptom based EALs should be used because they make the classification process more timely and less subject to error. For facilities where safety significant systems are monitored by means of instruments and alarms, a large fraction of the EALs may be symptom based in nature, whereas classification procedures for simple facilities with few instruments will consist almost exclusively of event based EALs. The following guidelines should be used while developing EALs:

(a) Site-specific classification procedure should be designed for prompt (to be completed in a few minutes) and easy use during an event.

(b) To ensure that the classification procedures are usable under accident conditions;

(c) The performance of the instruments during an emergency should also be considered in developing the EALs.

(d) The site-specific EALs system should be tested / validated during exercises and walk-through sessions to ensure it is usable by the assigned control room staff under emergency conditions.

The EALs and corresponding procedures should be revised based on operational experience and feedback from exercises. The licensee should make arrangements for the prompt identification of an actual or potential nuclear or radiological emergency and determination of the appropriate level of response. Any conditions that would warrant the use of Emergency Operating Procedures (EOPs) should be classified as an emergency alert and would trigger a predetermined emergency response at the site.

Once conditions of actual or imminent core damage exist, a transition from the domain of emergency operating procedures to the domain of emergency management guidelines should take place. To ensure a consistent and coordinated response to accident conditions, the emergency operating procedures and accident management guidelines should be integrated into the plant emergency response plan.

Plant conditions in the emergency operating procedures and accident management guidelines should provide clear inputs for accident classification for declaring appropriate emergency action levels (EALs).

Similarly, it should be ensured that there are no conflicts between accident management guidelines and severe accident management guidelines.

5.3.2 Operational Intervention Levels (OIL) : For Radionuclide Deposition, Personal / Individual Contamination and Contamination of Food, Milk and Water

5.3.2.1 General

OILs are expressed in terms of dose rates or of activity of radioactive material released, time integrated air concentrations, ground or surface concentrations, or activity concentrations of radionuclides in environmental, food or water samples. OILs can be measured by means of instruments in the field or can be determined by means of laboratory analysis or assessment. OILs are categorised into OIL1 to OIL6 and indicate decreasing order of severity of emergency situation.

OIL is a type of action level that can be used immediately and directly to determine the appropriate protective actions. The OILs are used with the other operational criteria (EALs and observables) to determine appropriate protective actions and other response actions.

The appropriate protective action should be promptly invoked if OILs are exceeded, but the action will not normally be taken if the levels are not exceeded. OILs should be developed based on the site specific condition if required and should be included in the emergency preparedness and response plan.

Arrangements should be made for promptly assessing the results of environmental monitoring and monitoring for contamination on people in order to decide on or to adapt urgent protective actions to protect workers and the public, including the application of operational intervention levels (OILs).

For effective emergency response actions arrangement should exist to revise the OILs as appropriate based on the conditions prevailing during the emergency with intimation to the regulatory body.

5.3.2.2 OIL1 - Measured Value of Ground Contamination for Urgent Protective Actions

OIL1 is a measured value of ground contamination calling for:

- Urgent protective actions (e.g. evacuation) to keep the dose to any person living in a contaminated area below the generic criteria for urgent protective actions provided in Table 3;

- Medical actions, as required, because the dose received by evacuees may be above the generic criteria for medical actions provided in Table 3.

TABLE 4: TYPICAL VALUES OF GROUND CONTAMINATION FOR URGENT PROTECTIVE ACTIONS (OIL 1) [1]

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
	Environmental measurements	
OIL1	Gamma (γ) 1000 μSv/h at 1m from surface or a source 2000 counts/s direct beta (β) surface contamination measurement 50 counts/s direct alpha (α) surface contamination measurement	— Immediately evacuate — As an alternate provide substantial shelter — Provide for decontamination of evacuees — Consider providing iodine thyroid blocking — Avoid inadvertent ingestion — Stop consumption of local produce, rainwater and milk from animals grazing in the area — Register and provide for a medical examination of evacuees — If a person has handled a source with a dose rate equal to or exceeding 1000 μSv/h at 1m, provide an immediate medical examination

5.3.2.3 OIL2 - Measured Value of Ground Contamination Calling for Early Protective Actions

OIL2 is a measured value of ground contamination calling for early protective actions to keep the dose for one year to any person living in the area below the generic criteria for taking actions to reasonably reduce the risk of stochastic effects provided in Table 3.

TABLE 5: TYPICAL VALUES FOR GROUND CONTAMINATION CALLING FOR EARLY PROTECTIVE ACTIONS (OIL 2) [1]

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
	Environmental measurements	
OIL2	Gamma (γ) 100 μSv/h at 1m from surface or a source 200 counts/s direct beta (β) surface contamination measurement 10 counts/s direct alpha (α) surface contamination measurement	— Consider providing iodine thyroid blocking — Stop consumption of local produce, rainwater and milk from animals grazing in the area until they have been screened and contamination levels have been assessed using OIL5 and OIL6 — Temporarily relocate those living in the area; before relocation, reduce inadvertent ingestion; register and estimate the dose to those who were in the area to determine if medical screening is warranted; relocation of people from the areas with the highest potential exposure should begin within days — If a person has handled a source with a dose rate equal to or exceeding 100 μSv/h at 1m, provide medical examination and evaluation; any pregnant women who have handled such a source should receive immediate medical evaluation and dose assessment

5.3.2.4 OIL3 - Measured Value of Ground Contamination Calling for Immediate Restrictions

OIL3 is a measured value of ground contamination calling for immediate restrictions on the consumption of leaf vegetables, milk from animals grazing in the area and rainwater collected for drinking to keep the dose to any person below the generic criteria for taking the urgent protective actions provided in Table 3.

TABLE 6: TYPICAL VALUES OF GROUND CONTAMINATION CALLING FOR IMMEDIATE RESTRICTIONS ON CONSUMPTION OF FOOD (OIL 3) [1]

OIL	OIL value	Response action (as appropriate) if the OIL is exceeded
OIL3	Gamma (γ) 1 μSv/h at 1m from surface	— Stop consumption of non-essential local produce, rainwater and milk from animals grazing in the area until it has been screened and contamination levels have been assessed using OIL5 and

	20 counts/s direct beta (β) surface contamination measurement 2 counts/s direct alpha (α) surface contamination measurement	OIL6 — Screen local produce, rainwater and milk from animals grazing in the area out to at least 10 times the distance to which OIL3 is exceeded and assess samples using OIL5 and OIL6 — Consider providing iodine thyroid blocking for fresh fission products and for iodine contamination if replacement for essential local produce or milk is not immediately available — Estimate the dose of those who may have consumed food, milk or rainwater from the area where restrictions were implemented to determine if medical screening is warranted

5.3.2.5 OIL4 - Measured Value of Skin Contamination

OIL4 is a measured value of skin contamination calling for performing decontamination or providing instructions for self-decontamination and for limiting inadvertent ingestion so as:

- To keep the dose due to skin contamination to any person below the generic criteria for taking urgent protective action (Table 3);

- To initiate medical treatment or screening, as required, because the dose received by any person may exceed the generic criteria for medical actions (Table 3).

TABLE 7: TYPICAL VALUES OF SKIN CONTAMINATION CALLING FOR PERFORMING DECONTAMINATION OR MEDICAL EXAMINATION (OIL 4) [1]

OIL	**OIL value**	**Response action (as appropriate) if the OIL is exceeded**
	Skin contamination	
OIL4	Gamma (γ) 1 μSv/h at 10 cm from the skin 1000 counts/s direct beta (β)skin contamination measurement 50 counts/s direct alpha (α) skin contamination measurement	— Provide for skin decontamination and reduce inadvertent ingestion — Register and provide for a medical examination

Beta monitors should detect both high and low energy beta emitters. Instrument coefficient (IC = Axη) in (counts/s x cm^2)/Bq of contamination monitors should be greater than or equal to 1 (for high energy beta), 0.2 (for low energy beta) and 0.5 for alpha emitters suitable for contamination monitor. Where A is area (cm^2) of detector and η is efficiency of detector (cps/Bq).

5.3.2.6 OIL5 and OIL6- Measured Values of Concentrations in Food, Milk or Water

OIL5 and OIL6 are measured values of concentrations in food, milk or water that warrant the consideration of restrictions on consumption so as to keep the effective dose to any person below 10 mSv per annum. OIL values for restriction of food, milk or water is given in Tables 8 and 9 for deciding response action if the OIL is exceeded. If more than one radionuclide is present then the rule of mixtures should be applicable and the sum of the fraction of the actual concentration of each radionuclide to the specified OIL should be less than one.

TABLE 8: SCREENING OILs FOR FOOD, MILK AND WATER CONCENTRATIONS (OIL5)[1]

OIL	OIL value	Response action if the OIL is exceeded
OIL5	Gross beta (β): 100 Bq/kg Or Gross alpha (α): 5 Bq/kg	Above OIL5: Assess using OIL6 Below OIL5: Safe for consumption during the emergency phase

TABLE 9: RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS (OIL 6) [1]

Radionuclide	OIL6 (Bq/Kg)	Radionuclide	OIL6 (Bq/Kg)
H-3	$2x10^5$	Cr-51	$8x10^5$
C-14	$1x10^4$	Mn-54	$9x10^3$
F-18	$2x10^8$	Fe-59	$9x10^3$
Na-24	$4x10^6$	Co-60	$8x10^2$
Zn-65	$2x10^3$	Sr-90	$2x10^2$
Rb-87	$2x10^3$	Y-90	$9x10^4$
Ru-106	$6x10^2$	Zr-95	$6x10^3$
Sb-122	$2x10^5$	Nb-95	$5x10^4$
Sb-124	$5x10^3$	Tc-99	$4x10^3$
La-140	$2x10^5$	Tc-99m	$2x10^8$
Ce-144	$8x10^2$	I-131	$3x10^3$
Ir-192	$8x10^3$	I-132	$2x10^7$
Th-232	4.0	I-133	$1x10^5$
U-232	20	I-134	$2x10^8$
U-233	100	I-135	$2x10^6$
U-235	$2x10^2$	Cs-134	$1x10^3$
U-238	100	Cs-137	$2x10^3$
Pu-238	50	Tl-204	$3x10^3$
Pu-239	50	Pb-210	2.0
Pu-240	50	Po-210	5.0
Pu-241	$4x10^3$	Ra-224	$2x10^3$
		Am-241/Be-9	50
		Pu-239/Be-9	50

5.3.3 Observables

For emergencies in hazard category I, II & III, the typical observables can be a major fire incident affecting safety systems, major earthquake, Loss of Coolant Accident (LOCA), station blackout, etc.

For emergencies in hazard category IV, observable on the scene could be radiation symbol on damaged container.

5 GUIDANCE VALUES FOR EMERGENCY WORKERS

6.1 General

An emergency worker is a person having specified duties as a worker in response to an emergency who might be exposed while taking response actions. Emergency workers may include those employed by registrants and licensees as well as personnel from response organizations, such as police officers, fire-fighters, medical personnel, drivers and crews of evacuation vehicles.

6.2 Guidance Values

Guidance values should be established for managing, controlling and recording the radiation dose of emergency workers for different types of response activities and should be included in the emergency preparedness and response plan. In setting the guidance values of dose for emergency workers the contribution to doses via all exposure pathways should be taken into account.

Pregnant female workers should be excluded from emergency duties. The following guidance values should be used for the protection of emergency workers responding to an emergency;

TABLE 10: GUIDANCE VALUES FOR EMERGENCY WORKERS

Tasks	**Guidance value**
Life saving actions	*Effective Dose <500 mSv* This value may be exceeded under circumstances in which (a) the expected benefits to others clearly outweigh the emergency worker's own health risks, and (b) the emergency worker volunteers to take the action and understands and accepts this health risk
Actions to prevent severe deterministic effects and actions to prevent the development of catastrophic conditions that could significantly affect people and the environment	*Effective Dose <500 mSv*
Actions to avert a large collective dose	*Effective Dose <100 mSv*

Life saving actions resulting in doses that approach or exceed the threshold for severe deterministic effects should be considered only if (a) the expected benefit to others would clearly outweigh the emergency worker's own risk and (b) the emergency worker volunteers to take the action, and understands and accepts the risk associated with the response activities.

Emergency workers who undertake response actions having the potential of radiation doses expected to exceed 50 mSv should be clearly informed in advance of the associated health risks, as well as of available protective measures, and should be trained to the extent possible the actions that they may be required to take. The voluntary basis for response actions by the emergency workers should be addressed in the emergency response plan.

Emergency workers should be given appropriate medical attention. The doses received and information concerning the consequent of health risks should be communicated to the workers. Female workers who are aware that they are pregnant should be encouraged to notify the appropriate authority and should be excluded from emergency duties.

The operational guidance provided to emergency workers should be based on measurements of radiation (e.g. as displayed on an active or self-reading dosimeter). The dose from intake or skin contamination should be limited by means of the use of protective equipment, the use of stable iodine prophylaxis and the provision of instructions concerning operations in potentially hazardous radiological conditions.

Available information about the radioactive conditions on the site should be used in aiding decisions on the appropriate protection of emergency workers.

When undertaking intervention, all reasonable efforts should be made to keep doses to workers below 100 mSv, except for life saving actions in which every effort should be made to keep doses below guidance dose value (500 mSv) in order to avoid deterministic effects on health. In addition, workers undertaking actions in which their doses may approach or exceed guidance dose level should do so only when the benefits to others clearly outweigh their own risk.

Once the emergency phase of an intervention is over, workers undertaking recovery operations, such as repairs to the facility and buildings, waste disposal or decontamination / remediation of the site and surrounding area should be subject to the system of occupational protection requirements and procedures.

Workers should not normally be precluded from incurring further occupational exposure because of doses received in an emergency exposure situation. However, qualified medical advice should be obtained before any such further exposure if a worker who has undergone an emergency exposure receives a dose exceeding ten times the maximum single year dose limit or at the worker's request.

APPENDIX – I

HAZARD CATEGORISATION OF NUCLEAR AND RADIATION FACILITIES

I-1 General

The potential of nuclear and radiation emergencies depends on the nature and scope of the facility. The emergency preparedness and response infrastructures / system can be optimised by categorising the facilities based on the nuclear and radiation related hazards and preparing the preparedness and response plan in-line with the hazard categories of the facilities.

I-2 Hazard categorisation of nuclear and radiation facilities

The nuclear and radiation facilities should be categorized into five categories based on the nuclear and radiation related hazards for the purposes of establishing the emergency preparedness and response plan. Typical hazard categorisation of nuclear and radiation facilities is given in Table 11.

Hazard categories I, II and III represent the decreasing levels of radiation related hazard. Hazard category IV involves transport of sources / orphan sources and category V involves contamination at distant places from the accident. The stringency of requirements for emergency preparedness and response decrease from category I to V.

The licensee should carry out the hazard assessment of the facility by analysing the hazards associated with facilities, activities or sources within or beyond the site, on-site / off-site. The assessment should also include the following:

- events and the associated areas for which protective actions are required; and
- actions that would be effective in mitigating the consequences of such events.

TABLE 11: CATEGORISATION OF NUCLEAR AND RADIATION FACILITIES BASED ON HAZARD POTENTIAL

Hazard category	Criteria	Typical Example of Facilities
I	Facilities, such as nuclear power plants, for which on-site events (including very low probability events) are postulated that could give rise to severe deterministic health effects off the site, or Facilities for which such events have occurred in similar facilities. Off-site: Emergencies involving severe core damage have the potential to cause severe and even fatal deterministic effect. Onsite: Emergencies involving severe core damage, doses sufficient to result in and even fatal deterministic effect.	Nuclear Power Plants (>100 MWth), freshly discharged spent fuel pool storage
II	Facilities, such as spent fuel pool storage and some types of research reactors, for which on-site events are postulated that could give rise to doses to people off the site that warrant urgent protective action, or Facilities for which such events have occurred in similar facilities. Off-site: Potential for doses in excess of generic criteria (GC) if fuel cooling is lost. Onsite: Potential for doses in excess of generic criteria (GC) if fuel cooling is lost.	Spent fuel pool storage, Reactors < 100MWth

III	Facilities, such as industrial irradiation facilities, for which on-site events are postulated that could give rise to doses that warrant or contamination that warrants urgent protective action on the site, or Facilities for which such events have occurred in similar facilities. Off-site: No potential for doses in excess of generic criteria (GC) Onsite: Potential for doses in excess of generic criteria (GC) is possible.	• Industrial irradiation facilities • Sealed source manufacturing • Hospitals • Radiopharmaceutical manufacturing • Teletherapy • High and medium dose rate brachytherapy • Fuel fabrication
IV	Activities that could give rise to a nuclear or radiological emergency that could warrant urgent protective action in an unforeseeable location. These include non-authorized activities such as activities relating to dangerous sources obtained illicitly. They also include transport and authorized activities involving mobile dangerous sources such as industrial radiography sources, nuclear powered satellites or radio thermal generators. Hazard category IV represents the minimum level of hazard, which is assumed to apply for all states and jurisdictions. Lethal dose is possible for persons handling sources.	• Dangerous sources; • Transport of radioactive or fissile material; • Severe overexposure. • Mobile radiography source
V	Preparedness for events in hazard category V is intended for providing prompt restrictions on food, water or products in accordance with standards. Off-site: deposition or contaminated material may lead to dosses in excess. Onsite: Risk would arise from unknowingly brining radioactive material.	Accidents in category I & II resulting into contamination at distant place.

In case of facilities belonging to hazard category I, II or III, a comprehensive safety analysis should be carried out to identify all sources of exposures and to evaluate the radiation doses that could be received by workers at the facility and the public, as well as the potential effects on the environment. The hazard / safety analysis should examine the event sequences that may lead to an emergency situation. On the basis of this analysis, the emergency preparedness and response plan should be established.

The licensee should carry out the hazard assessment of the facility and the emergency response plan of the facility should meet the potential of hazard arising from that facility. If more than one facility is located in a particular site, the hazard assessment should consider the consequences due to the combination of all the facilities and the emergency preparedness and response plan should meet such consequences.

The nature and extent of emergency arrangements for preparedness and response should be commensurate with the magnitude and nature of the hazard associated with the facility or activities. All postulated events should be considered in the hazard assessment, including emergencies involving a combination of nuclear or radiological events and conventional emergencies such as an earthquake. The hazard assessment should also consider and identify the populations at risk and to the extent practicable, the likelihood, nature and magnitude of the various radiation related hazards.

In a hazard assessment, facilities, sources, practices, on-site areas, off-site areas and locations should be identified for which a nuclear or radiological emergency could warrant:

(a) Precautionary urgent protective action to prevent severe deterministic health effects by keeping doses below those for which intervention would be expected to be undertaken under any circumstances;

Urgent protective action to prevent stochastic effects to the extent practicable by averting doses, in accordance with prescribed standards;

(b) Agricultural countermeasures, countermeasures to ingestion and longer term protective measures, in accordance with established standards; or

(c) Protection for the workers responding (undertaking an intervention), in accordance with established standards.

Non-radiological hazards (such as the release of uranium hexafluoride (UF6) or other hazardous chemicals) to people on and off the site that are associated with the practice should be identified in the hazard assessment.

Locations at which there is a significant probability of encountering a dangerous source that has been lost, abandoned, illicitly removed or illicitly transported should also be identified in the hazard assessment.

Licensee of a facility or practice in hazard category I, II, III or IV should ensure that adequate arrangements are made for identifying a situation that warrants emergency response and generating adequate information promptly and communicating it to the responsible authorities, for:

(a) the early prediction or assessment of the extent and significance of any unplanned discharge of radioactive substances to the environment or exposures;
(b) rapid and continuous assessment of the nuclear or radiological emergency as it proceeds; and
(c) determining the need for protective actions for the public and workers.

Declaration of a particular class of emergency at a facility or practice in hazard category I, II, III or IV should promptly initiate appropriate level of co-ordinated and pre-planned emergency response action on and off the site. The responsibilities and initial response actions of all response organizations should be defined for each class of emergency.

For facilities in hazard category I and II the hazard assessment should demonstrate, for the range of postulated emergencies, that identification, notification, activation and other initial response actions can be performed in time to achieve the practical goals of emergency response. To perform the above response actions, the response organizations should have sufficient personnel available.

APPENDIX - II

USE OF OILS IN RESPONDING TO A NUCLEAR OR RADIOLOGICAL EMERGENCY

II-1 General

For the purposes of describing the use of the OILs, nuclear or radiological emergencies resulting in contamination can be of three types:

(a) A nuclear or radiological emergency resulting in contamination of a large area (hundreds of square kilometres) with the possible involvement of a large number of people; that is, contamination of an area is so large, that in order to be effective, implementation of urgent protective actions and early protective actions should be performed in two phases: first, urgent protective actions (e.g. evacuation) are taken, followed by early protective actions (e.g. relocation). An emergency of this type could occur at nuclear facilities such as nuclear power plants that are in hazard category I or II.

(b) A nuclear or radiological emergency resulting in contamination of a moderate area (tens of square kilometres) with the possible involvement of a large number of people; that is, contamination of an area small enough that urgent protective actions and early protective actions can be effectively performed at the same time without the need for a phased response. An emergency of this type could be the result of an explosion of a radiological dispersal device or could be caused by a damaged dangerous radioactive source.

(c) A nuclear or radiological emergency resulting in contamination of small areas and/or with the possible involvement of a small number of people; that is, contamination of small areas that can easily and quickly be isolated, with the involvement of a small number of people who can all be decontaminated and medically assessed by using available resources, without causing any major disruptions. This type of emergency includes those confined to a single room or a single spill. For this type of emergency, the response involves isolating the potentially contaminated area and decontaminating all those involved without necessarily using the OILs.

II-2 RESPONDING TO A NUCLEAR OR RADIOLOGICAL EMERGENCY THAT RESULTS IN CONTAMINATION OF A LARGE AREA

The process of assessing and responding to an emergency of this type, starts with the first protective actions being taken on the basis of conditions observed on the scene or on the basis of an emergency classification before data from radiological monitoring become available (Figure 2).

Within hours, areas where ground deposition levels exceed or are likely to exceed OIL1, the default OIL should be identified and the appropriate urgent protective actions should be taken such as evacuation, stopping the consumption of local produce and medical evaluation of evacuees.

Within hours, actions should also be taken to reduce the consequences of contamination for those people who were in the area where OIL1 was exceeded. If OIL4 is exceeded, the evacuees should be monitored and decontaminated (if these actions can be carried out promptly). If monitoring and decontamination are not immediately possible, the evacuees should be released and instructed to take actions to reduce inadvertent ingestion, and to shower and change their clothing as soon as possible. OIL4 levels may be very difficult to detect under emergency conditions. Therefore, any person who may have been contaminated, including those who were monitored and had contamination levels below OIL4, should take actions to reduce inadvertent ingestion, and should shower and change their clothing as soon as possible.

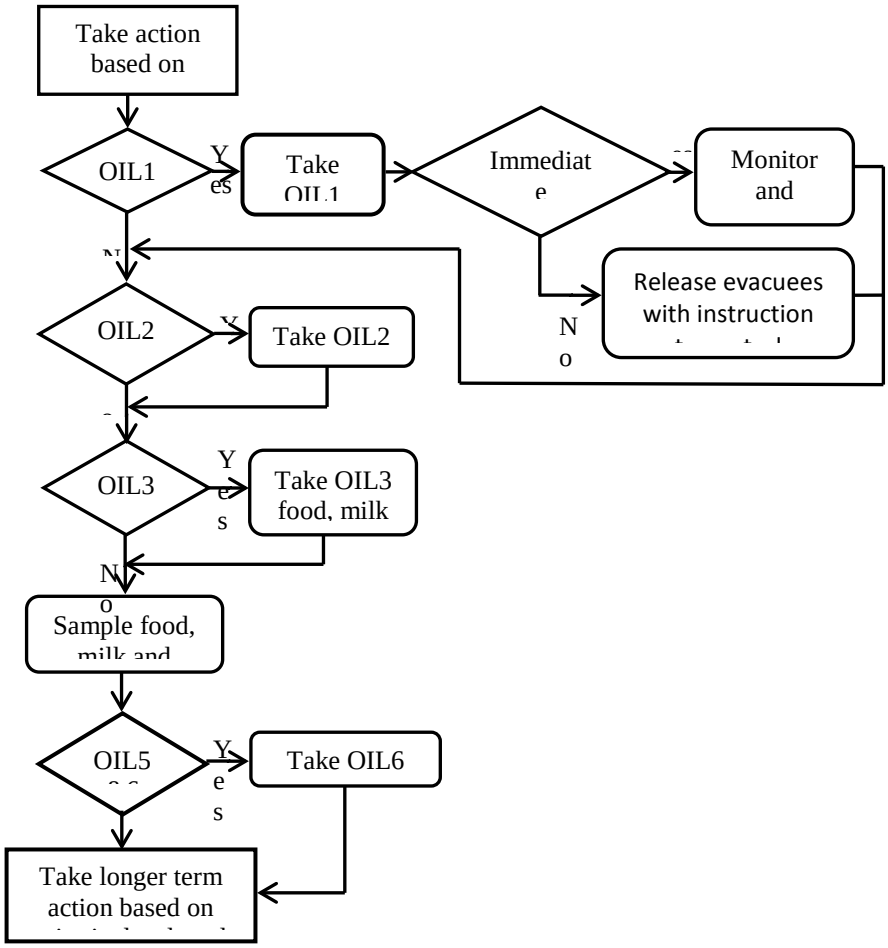

Figure 2: Process of assessment of a nuclear or radiological emergency resulting in contamination of a large area

The dose to evacuees should also be evaluated and the medical actions as appropriate based on the dose received should be taken.

Within a day, the areas where ground deposition levels exceed default OIL2 should be identified and early protective actions should be taken such as stopping the consumption of locally produced vegetables and milk and commencing the process of implementing temporary relocation. Relocation should be accomplished within a week.

Within days, the areas where ground deposition levels exceed default OIL3 should be identified and actions should be taken to stop consumption of locally produced vegetables and milk, and of rainwater collected for drinking, until they have been screened and analysed. Within a week, food, milk and water should be screened and analysed, possibly out to a distance of more than 100 km, and actions should be taken to restrict consumption of food, milk and water with concentrations of radionuclides in excess of OIL5 and OIL6.

Within days, the mixture of the radionuclides over the affected area should be determined and the OILs being used to make decisions should be revised, if required. Any recommendation to the public to take any protective actions should be accompanied by a plain language explanation of the criteria. After the emergency is over, further actions should be taken on the basis of criteria developed after careful assessment of conditions and in consultation with interested parties.

II-3 RESPONDING TO A NUCLEAR OR RADIOLOGICAL EMERGENCY RESULTING IN CONTAMINATION OF A MODERATE AREA

The process of assessing and responding to a nuclear or radiological emergency resulting in contamination of a moderate area through the implementation of protective actions are taken on the basis of conditions observed on the scene or on the basis of an emergency classification before data from radiological monitoring become available (Figure 3).

Within hours, areas where ground deposition levels exceed default OIL2 should be identified, and the appropriate urgent protective actions and early protective actions should be taken where OIL2 is exceeded. The dose to evacuees should also be evaluated and any medical actions if required should be taken.

Evacuees should be monitored and if OIL4 is exceeded, the evacuees should be decontaminated promptly. If monitoring and/or decontamination are not immediately possible, the evacuees should be released and should be instructed to take actions to reduce inadvertent ingestion, and to shower and change their clothing as soon as possible. OIL4 levels may be very difficult to detect under emergency conditions. Any person who may have been contaminated, including those who were monitored and had contamination levels below OIL4, should therefore take actions to reduce inadvertent ingestion, and should shower and change their clothing as soon as possible.

Within days, areas where ground deposition levels exceed default OIL3 should be identified and actions should be taken to stop the consumption of rainwater and locally produced vegetables and milk until they have been screened and analysed. However, if only limited amounts of food (e.g. fruit and vegetables from local gardens) and non-essential food could have been affected, this 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.

Finally, food, milk and rainwater should be screened and analysed, out to a distance of several kilometres, and actions should be taken to restrict the consumption of food, milk and rainwater having concentrations of radionuclides in excess of OIL5 and OIL6.

Within days, the mixture of radionuclides over the affected area should be determined and the OILs being used to make decisions should be revised, if warranted.

Any recommendations to the public to take any protective actions should be accompanied by a plain language explanation of the criteria.

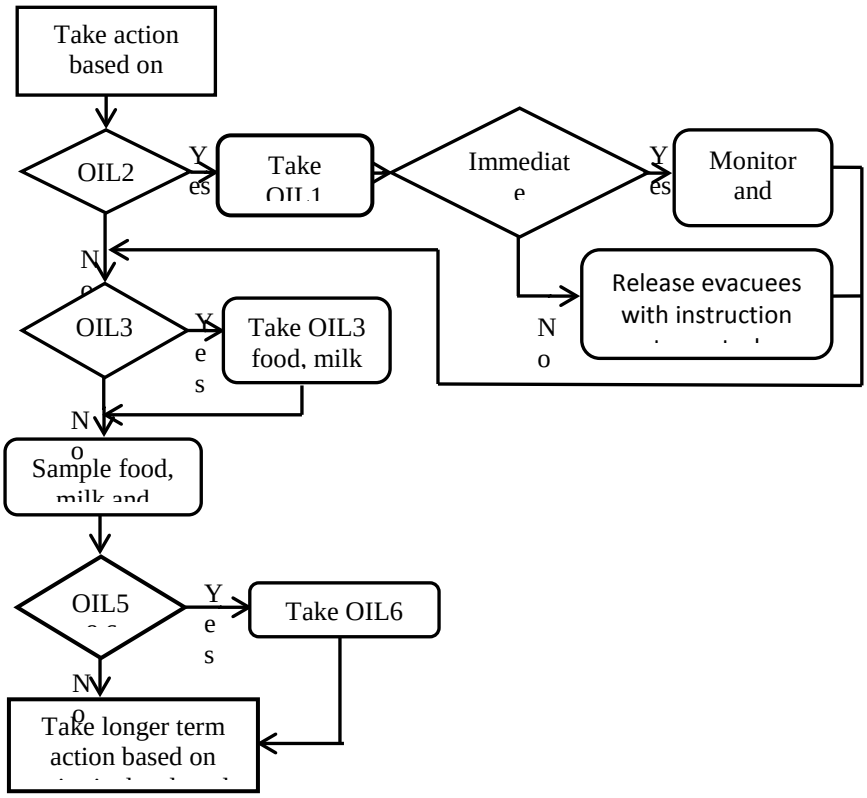

Figure 3: Process of assessment of a nuclear or radiological emergency resulting in contamination of moderate area

After the emergency is over, further actions should be taken on the basis of dose criteria developed after careful assessment of the conditions and in consultation with the interested parties.

APPENDIX – III

ADMINISTRATION OF STABLE IODINE

III-1 Administration of stable iodine means oral intake of KIO_3 tablets. Administration of KIO_3 tablets should be done as follows:

(a). All individuals above the age of 12 years:

170 mg (KIO_3) – as soon as possible
85 mg (KIO_3) – second and third day only;
170 mg (KIO_3) – repeat after two weeks, if required (based on assessment).

(b). Pregnant women and children of age 3 to 12years;

50 % of quantities given in (a)

(c). Children under the age of 3 years:

25% of quantities given in (a) above.

III-2 Time of administration of stable iodine is important for thyroid dose reduction. The reduction factors are given below:

TABLE 12: TIME OF ADMINISTRATION AND DOSE REDUCTION

Time of stable iodine Administration	Dose Reduction %
Before exposure	100
1 hr after exposure	80
6 hrs after exposure	50
1 day after exposure	negligible

III-3 For inhalation exposure, decision should be taken to administer stable iodine as soon as possible depending on the assessed potential and estimated quantity of radio-iodine release.

III-4 Administration of stable iodine prior to intake through ingestion route is as effective as for inhalation route.

APPENDIX – IV

ILLUSTRATIVE EXAMPLES FOR EMERGENCY DECLARATION AND PROTECTIVE ACTIONS

EXAMPLE-1

IV-1.0 Accident: Core meltdown and containment failure

IV-1.1 Use of operational criteria: For emergency classification and protective actions

Observables: Observations by operator

Emergency Action Levels (EALs): Exceeds as defined in the EAL for PHWR/PWR for Off-site emergency

Operational Intervention Levels (OILs): Radiological monitored data around the site

IV-1.2 Declaration of the emergency:

General Emergency / Off-site emergency based on observables and EALs

IV-1.3 Initiation of protective actions:

(a) Precautionary urgent protective actions: Based on substantial risk analysis (predefined) having potential to cause severe and even fatal deterministic effect, certain actions should be implemented urgently before the release. These precautionary urgent protective actions include sheltering, evacuation, restriction of consumption of food, milk and water; public reassurance. The PAZ size will depend on risk analysis. The suggestive size can be 2 km around site and 5 km downwind direction.

(b) Urgent protective actions: Based on projected dose and OIL1 levels.

(i) Gamma (γ) 1000 μSv/h at 1 m from surface or a source
(ii) 2000 counts/s direct beta (β) surface contamination measurement

If the risk of stochastic effects is the main concern and the risk of the development of severe deterministic effects is negligible, urgent and early protective actions and other response actions, all of which are justified and optimized, should be implemented. These actions must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed. These are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis and restriction of the consumption of potentially contaminated foodstuffs. The suggestive size of UPZ can be 16 km around site.

(c) Skin Contamination: OIL4

(i) Gamma (γ) 1 μSv/h at 10 cm from the skin
(ii) 1000 counts/s direct beta (β) skin contamination measurement
(iii) 50 counts/s direct alpha (α) skin contamination measurement

— Provide for skin decontamination and reduce inadvertent ingestion
— Register and provide for a medical examination

(d) Protective actions based dose received: If the dose exceeds a particular generic criterion identified in Table 2 or 3, individuals should be provided with appropriate medical attention, including medical treatment, long term health monitoring and psychological counselling. Other response actions for treatment and management of severe deterministic effects should include immediate medical examination, consultation and treatment as indicated, contamination control, decorporation where applicable, registration for long term health monitoring, and comprehensive psychological counselling.

IV-1.4 Termination of urgent protective actions and early protective action:

This shall be initiated when the projected dose is within or below reference level.

(a) Reference level for protection of people during emergency situation

Residual dose (which includes dose contributions via all exposure pathways): Protective actions should be optimised for highest planned residual dose in the band of 20 to 100 millisieverts (mSv) of projected dose. To the extent possible the residual dose should be close to 20 mSv.

IV-1.5 Long term protective action (OIL5 & OIL6):

Long term protective action is a protective action that is not an urgent protective action. Such protective actions are likely to be prolonged over weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.

Long term health monitoring of the persons affected should be carried out, such as to provide advanced medical care, to reduce their concern with regard to their health status and to advance scientific knowledge.

(a) Long term health monitoring is always justified at levels of dose above the thresholds for deterministic effects.

(b) Justification of long term health monitoring at levels of dose below the thresholds for deterministic effects requires proper identification of populations at higher risk of developing radiation induced cancers.

(c) Reference levels for protection of people after emergency situation: People living in long-term contaminated areas after a nuclear accident or a radiation emergency

Even after the radiation source is under control, contaminated areas may remain. Authorities will often implement all necessary protective measures to allow people to continue to live there rather than abandoning these areas. In this case, reference levels in the band of 1 to 20 mSv per year, with the long-term goal of reducing reference levels to 1 mSv per year are recommended.

EXAMPLE-2

IV-2.0 Accident: LOCA and containment intact

IV-2.1 Use of operational criteria: for emergency classification and protective actions

Observables: Observations by the operator

Emergency Action Levels (EALs): EALs are exceeded as defined in the EAL for PHWR/PWR for Off-site emergency

Operational Intervention Levels (OILs): Radiological monitored data around the site

IV-2.2 Declaration of the emergency:

Declaration of general emergency / Off-site emergency should be based on observables and EALs.

IV-2.3 Initiation of protective actions:

(a) Precautionary urgent protective actions: Based on substantial risk analysis (predefined): No substantial risk Off-site.

No precautionary urgent protective actions required.

(b) **Urgent protective action:** Based on projected dose and OIL3 levels.

(i) Gamma (γ) 1 μSv/h at 1 m from surface or a source
(ii) 20 counts/s direct beta (β) surface contamination measurement

If the risk of stochastic effects is the main concern urgent and early protective actions and other response actions, all of which are justified and optimized, should be implemented. These actions must be taken promptly (normally within hours) in order to be effective, and the effectiveness of which will be markedly reduced if it is delayed. These are evacuation, decontamination of individuals, sheltering, respiratory protection, iodine prophylaxis and restriction of the consumption of potentially contaminated foodstuffs.

(c) **Skin Contamination:** OIL4

(i) Gamma (γ) 1 μSv/h at 10 cm from the skin
(ii) 1000 counts/s direct beta (β) skin contamination measurement
(iii) 50 counts/s direct alpha (α) skin contamination measurement

— Provide for skin decontamination and reduce inadvertent ingestion
— Register and provide for a medical examination

(d) **Protective actions based dose received:** If the dose exceeds a particular generic criterion identified in Table 2 or 3, individuals should be provided with appropriate medical attention, including medical treatment, long term health monitoring and psychological counselling. Other response actions for treatment and management of severe deterministic effects should include immediate medical examination, consultation and treatment as indicated, contamination control, decorporation where applicable, registration for long term health monitoring, and comprehensive psychological counselling

IV-2.4 Termination of urgent protective actions and early protective action:

When the projected dose is within or below reference level termination of urgent protective actions and early protective action shall be initiated.

(a) **Reference level for protection of people during emergency situation**

Residual dose (which includes dose contributions via all exposure pathways): Protective actions should be optimised for highest planned residual dose in the band of 20 to 100 millisieverts (mSv) of projected dose. To the extent possible the residual dose should be close to 20 mSv.

IV-2.5 Long term protective action: OIL5 & OIL6 A protective actions that is not an urgent protective action. Such protective actions are likely to be prolonged over weeks, months or years. These include measures such as relocation, agricultural countermeasures and remedial actions.

Long term health monitoring of the persons affected should be carried out, such as to provide advanced medical care, to reduce their concern with regard to their health status and to advance scientific knowledge.

(a) Long term health monitoring is always justified at levels of dose above the thresholds for deterministic effects.

(b) Justification of long term health monitoring at levels of dose below the thresholds for deterministic effects requires proper identification of populations at higher risk of developing radiation induced cancers.

(c) Reference levels for Protection of People after emergency situation: People living in long-term contaminated areas after a nuclear accident or a radiation emergency

Even after the radiation source is under control, contaminated areas may remain. Authorities will often implement all necessary protective measures to allow people to continue to live there rather than abandoning these areas. In this case, reference levels in the band of 1 to 20 mSv per year, with the long-term goal of reducing reference levels to 1 mSv per year are recommended.

APPENDIX –V

RADIONUCLIDE SPECIFIC OPERATION INTERVENTION LEVELS (OILs)

TABLE 13: RADIONUCLIDE SPECIFIC OILs FOR FOOD, MILK AND WATER CONCENTRATIONS FROM LABORATORY ANALYSIS

Radionuclide	OIL6 (Bq/kg)	Radionuclide	OIL6 (Bq/kg)
H-3	2×10^5	Sc-44	1×10^7
Be-7	7×10^5	Sc-46	8×10^3
Be-10	3×10^3	Sc-47	4×10^5
C-11	2×10^9	Sc-48	3×10^5
C-14	1×10^4	Ti-44	6×10^2
F-18	2×10^8	V-48	3×10^4
Na-22	2×10^3	V-49	2×10^5
Na-24	4×10^6	Cr-51	8×10^5
Mg-28	4×10^5	Mn-52	1×10^5
Al-26	1×10^3	Mn-53	9×10^4
Si-31	5×10^7	Mn-54	9×10^3
Si-32	9×10^2	Mn-56	3×10^7
P-32	2×10^4	Fe-52	2×10^6
P-33	1×10^5	Fe-55	1×10^4
S-35	1×10^4	Fe-59	9×10^3
Cl-36	3×10^3	Fe-60	7×10^1
Cl-38	3×10^8	Co-55	1×10^6
K-40	NA	Co-56	4×10^3
K-42	3×10^6	Co-57	2×10^4
K-43	4×10^6	Co-58	2×10^4
Ca-41	4×10^4	Co-58m	9×10^7
Ca-45	8×10^3	Co-60	8×10^2
Ca-47	5×10^4	Ni-59	6×10^4
Ni-63	2×10^4	Sr-89	6×10^3
Ni-65	4×10^7	Sr-90	2×10^2
Cu-64	1×10^7	Sr-91	3×10^6
Cu-67	8×10^5	Sr-92	2×10^7
Zn-65	2×10^3	Y-87	4×10^5
Zn-69	6×10^8	Y-88	9×10^3
Zn-69m	3×10^6	Y-90	9×10^4
Ga-67	1×10^6	Y-91	5×10^3
Ga-68	2×10^8	Y-91m	2×10^9
Ga-72	1×10^6	Y-92	1×10^7
Ge-68	3×10^3	Y-93	1×10^6
Ge-71	5×10^6	Zr-88	3×10^4
Ge-77	6×10^6	Zr-93	2×10^4
As-72	4×10^5	Zr-95	6×10^3
As-73	3×10^4	Zr-97	5×10^5
As-74	3×10^4	Nb-93m	2×10^4
As-76	4×10^5	Nb-94	2×10^3
As-77	1×10^6	Nb-95	5×10^4
Se-75	4×10^3	Nb-97	2×10^8
Se-79	7×10^2	Mo-93	3×10^3
Br-76	3×10^6	Mo-99	5×10^5
Br-77	5×10^6	Tc-95m	3×10^4
Br-82	1×10^6	Tc-96	2×10^5
Rb-81	8×10^7	Tc-96m	2×10^9
Rb-83	7×10^3	Tc-97	4×10^4
Rb-84	1×10^4	Tc-97m	2×10^4

Rb-86	1×10^4	Tc-98	2×10^3
Rb-87	2×10^3	Tc-99	4×10^3
Sr-82	5×10^3	Tc-99m	2×10^8
Sr-85	3×10^4	Ru-97	2×10^6
Sr-85m	3×10^9	Ru-103	3×10^4
Sr-87m	3×10^8	Ru-105	2×10^7
Ru-106	6×10^2	Sb-126	3×10^4
Rh-99	1×10^5	Te-121	1×10^5
Rh-101	8×10^3	Te-121m	3×10^3
Rh-102	2×10^3	Te-123m	5×10^3
Rh-102m	5×10^3	Te-125m	1×10^4
Rh-103m	5×10^9	Te-127	1×10^7
Rh-105	1×10^6	Te-127m	3×10^3
Pd-103	2×10^5	Te-129	2×10^8
Pd-107	7×10^4	Te-129m	6×10^3
Pd-109	2×10^6	Te-131	4×10^8
Ag-105	5×10^4	Te-131m	3×10^5
Ag-108m	2×10^3	Te-132	5×10^4
Ag-110m	2×10^3	I-123	5×10^6
Ag-111	7×10^4	I-124	1×10^4
Cd-109	3×10^3	I-125	1×10^3
Cd-113m	4×10^2	I-126	2×10^3
Cd-115	2×10^5	I-129	NA
Cd-115m	6×10^3	I-131	3×10^3
In-111	1×10^6	I-132	2×10^7
In-113m	4×10^8	I-133	1×10^5
In-114m	3×10^3	I-134	2×10^8
In-115m	5×10^7	I-135	2×10^6
Sn-113	1×10^4	Cs-129	1×10^7
Sn-117m	7×10^4	Cs-131	2×10^6
Sn-119m	1×10^4	Cs-132	4×10^5
Sn-121m	5×10^3	Cs-134	1×10^3
Sn-123	3×10^3	Cs-134m	3×10^8
Sn-125	2×10^4	Cs-135	9×10^3
Sn-126	5×10^2	Cs-136	4×10^4
Sb-122	2×10^5	Cs-137	2×10^3
Sb-124	5×10^3	Ba-131	1×10^5
Sb-125	3×10^3	Ba-133	3×10^3
Ba-133m	9×10^5	Eu-156	2×10^4
Ba-140	1×10^4	Gd-146	8×10^3
La-137	4×10^4	Gd-148	1×10^2
La-140	2×10^5	Gd-153	2×10^4
Ce-139	3×10^4	Gd-159	2×10^6
Ce-141	3×10^4	Tb-157	9×10^4
Ce-143	5×10^4	Tb-158	3×10^3
Ce-144	8×10^2	Tb-160	7×10^3
Pr-142	6×10^5	Dy-159	7×10^4
Pr-143	4×10^4	Dy-165	7×10^7
Nd-147	6×10^4	Dy-166	6×10^4
Nd-149	8×10^7	Ho-166	5×10^5
Pm-143	3×10^4	Ho-166m	2×10^3
Pm-144	6×10^3	Er-169	2×10^5
Pm-145	3×10^4	Er-171	6×10^6
Pm-147	1×10^4	Tm-167	1×10^5
Pm-148m	1×10^4	Tm-170	5×10^3
Pm-149	3×10^5	Tm-171	3×10^4
Pm-151	8×10^5	Yb-169	3×10^4
Sm-145	2×10^4	Yb-175	4×10^5

Sm-147	1×10^{2}	Lu-172	1×10^{5}
Sm-151	3×10^{4}	Lu-173	2×10^{4}
Sm-153	5×10^{5}	Lu-174	1×10^{4}
Eu-147	8×10^{4}	Lu-174m	1×10^{4}
Eu-148	2×10^{4}	Lu-177	2×10^{5}
Eu-149	9×10^{4}	Hf-172	2×10^{3}
Eu-150b	3×10^{6}	Hf-175	3×10^{4}
Eu-150a	4×10^{3}	Hf-181	2×10^{4}
Eu-152	3×10^{3}	Hf-182	1×10^{3}
Eu-152m	4×10^{6}	Ta-178a	1×10^{8}
Eu-154	2×10^{3}	Ta-179	6×10^{4}
Eu-155	1×10^{4}	Ta-182	5×10^{3}
W-178	2×10^{5}	Hg-194	2×10^{2}
W-181	1×10^{5}	Hg-195	2×10^{7}
W-185	2×10^{4}	Hg-195m	8×10^{5}
W-187	1×10^{6}	Hg-197	1×10^{6}
W-188	3×10^{3}	Hg-197m	2×10^{6}
Re-184	2×10^{4}	Hg-203	1×10^{4}
Re-184m	3×10^{3}	Tl-200	5×10^{6}
Re-186	1×10^{5}	Tl-201	3×10^{6}
Re-187	5×10^{5}	Tl-202	2×10^{5}
Re-188	7×10^{5}	Tl-204	3×10^{3}
Re-189	8×10^{5}	Pb-201	2×10^{7}
Os-185	2×10^{4}	Pb-202	1×10^{3}
Os-191	8×10^{4}	Pb-203	2×10^{6}
Os-191m	1×10^{7}	Pb-205	2×10^{4}
Os-193	7×10^{5}	Pb-210	2.0
Os-194	8×10^{2}	Pb-212	2×10^{5}
Ir-189	2×10^{5}	Bi-205	7×10^{4}
Ir-190	6×10^{4}	Bi-206	8×10^{4}
Ir-192	8×10^{3}	Bi-207	3×10^{3}
Ir-194	6×10^{5}	Bi-210	1×10^{5}
Pt-188	6×10^{4}	Bi-210m	2×10^{2}
Pt-191	9×10^{5}	Bi-212	7×10^{7}
Pt-193	8×10^{4}	Po-210	5.0
Pt-193m	3×10^{5}	At-211	2×10^{5}
Pt-195m	3×10^{5}	Ra-223	4×10^{2}
Pt-197	2×10^{6}	Ra-224	2×10^{3}
Pt-197m	1×10^{8}	Ra-225	2×10^{2}
Au-193	8×10^{6}	Ra-226	2×10^{1}
Au-194	1×10^{6}	Ra-228	3.0
Au-195	2×10^{4}	Ac-225	3×10^{3}
Au-198	3×10^{5}	Ac-227	5.0
Au-199	5×10^{5}	Ac-228	7×10^{6}
Th-227	9×10^{1}	Pu-242	5×10^{1}
Th-228	2×10^{1}	Pu-244	5×10^{1}
Th-229	8.0	Am-241	5×10^{1}
Th-230	5×10^{1}	Am-242m	5×10^{1}
Th-231	2×10^{6}	Am-243	5×10^{1}
Th-232	4.0	Am-244	4×10^{6}
Th-234	8×10^{3}	Am-241/Be-9	5×10^{1}
Pa-230	5×10^{4}	Cm-240	4×10^{3}
Pa-231	2×10^{1}	Cm-241	3×10^{4}
Pa-233	3×10^{4}	Cm-242	5×10^{2}
U-230	8×10^{2}	Cm-243	6×10^{1}
U-232	2×10^{1}	Cm-244	7×10^{1}
U-233	1×10^{2}	Cm-245	5×10^{1}
U-234	2×10^{2}	Cm-246	5×10^{1}

U-235	2×10^{2}	Cm-247	6×10^{1}
U-236	2×10^{2}	Cm-248	1×10^{1}
U-238	1×10^{2}	Bk-247	2×10^{1}
Np-235	7×10^{4}	Bk-249	1×10^{4}
Np-236l	8×10^{2}	Cf-248	2×10^{2}
Np-236s	4×10^{6}	Cf-249	2×10^{1}
Np-237	9×10^{1}	Cf-250	4×10^{1}
Np-239	4×10^{5}	Cf-251	2×10^{1}
Pu-236	1×10^{2}	Cf-252	4×10^{1}
Pu-237	2×10^{5}	Cf-253	3×10^{4}
Pu-238	5×10^{1}	Cf-254	3×10^{1}
Pu-239	5×10^{1}	Es-253	5×10^{3}
Pu-240	5×10^{1}	Pu-239/Be-9	5×10^{1}
Pu-241	4×10^{3}		

APPENDIX –VI (A)

TABLE 14: EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR PHWR

For the following entry conditions	Emergency Alert	Declare plant emergency if	Declare site emergency if	Declare Off-site emergency if
A	B	**C**	**D**	**E**
1. REACTIVITY AND POWER DISTRIBUTION ANOMALIES				
a) Uncontrolled reactivity addition to the core during power operations by any means such as uncontrolled withdrawal of adjusters/ZCC for large reactors, loss of reactor regulation, mal-operation of moderator purification system or heavy water addition resulting in decrease in boron concentration or precipitation of gadolinium poison etc. (LORA)	Global power(AP) increase leading to auto actuation of PSS orSDS-1 or SSS or SDS-2 on neutronic parameters(Lin N, Log rate)	----	----	----
b) During S/D condition failure to maintain reactor in long term subcritical state due to decrease in boron concentration (or any other neutron poison) in moderator system	AP/DP (Pre-trip alarm),AP/DP more than one decade -Occurrence of unintended reactor power rise /criticality or; - AP-DP>4%FP (alarm)and manual/auto actuation of SSS/SDS-2	----	----	----
2. DECREASE IN PHT SYSTEM INVENTORY				
a) Rupture at any location of PHT system piping of a size bigger than double ended largest feeder pipe and including up to double ended guillotine break of biggest piping in the system (Large break LOCA)	- Auto actuation of Reactor trip on neutronic parameter (Log rate , Lin N) with auto initiation of LOCA signal	- Condition B and appearance of pump room pressure very high and initiation of ECCS light water injection.	Condition C with containment impairment or Condition B and Failure of ECCS or Condition C with Multiple radiation monitors of RB showing >100 times increase (persistent) in radiation fields.	Condition B and failure of ECCS with loss of moderator heat sink or Multiple radiation monitors of RB showing >1000 times increase (persistent) in radiation fields.
b) Rupture at any location of PHT feeders (small LOCA)	- Auto actuation of reactor trip on process parameters (PHT low pressure/Storage tank low level) with auto initiation of LOCA signal	-Condition B and appearance of Pump room pressure very high and -Initiation of ECCS light water injection.	Condition B and Failure of ECCS or Condition C with containment impairment or Condition C with multiple radiation monitors of RB showing >100 times increase (persistent) in radiation fields.	Condition B and failure of ECCS with loss of moderator heat sink or Multiple radiation monitors of RB showing >1000 times increase (persistent) in radiation fields.

APPENDIX –VI (A)

TABLE 14: EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR PHWR

For the following entry conditions	Emergency Alert	Declare plant emergency if	Declare site emergency if	Declare Off-site emergency if
A	B	**C**	**D**	**E**
c) Failure of coolant channel closer plug leading to ejection of fuel bundles from coolant channels and consequential LOCA (Small LOCA)	Auto actuation of reactor trip on process parameters(PHT low pressure/storage tank low level) with auto initiation of LOCA signal	-Condition B and appearance of pump room pressure very high and -Initiation of ECCS light water injection.	Condition C with multiple radiation monitors of RB showing >100 times increase (persistent) in radiation fields..	-Condition C with containment impairment or -Condition B and failure of ECCS with Loss of moderator heat sink or Multiple radiation monitors of RB showing >1000 times increase (persistent) in radiation fields.
d) PHT system leak coupled with the following i. Leak into containment	-Sharp drop in PHT storage tank level and beetle alarm -Increasing trend in stack loss; and -Auto actuation of reactor trip; and -Auto initiation of PHT fast cool down and small leak handling system	Condition B and failure of any of the mitigating systems ; -Small leak handling system; or -Containment box up	Condition C with multiple radiation monitors of RB showing >100 times increase (persistent) in radiation fields.	----
ii. SG tube rupture	-Sharp drop in PHT storage tank level and sharp, increase in SG feed water activity ; and Auto actuation of reactor trip; or Auto initiation of PHT system fast cool down and small leak handling system	Condition B and persisting very high activity in SG feed water system; and activity release to environment through unauthorized route viz ASDVs	----	----
e) Failure of Shutdown cooling system pumps to remove decay heat.	All SGs on either side are not filled from secondary side leading to loss of thermo siphoning when PHT system is in closed condition and failure to establish forced circulation for 30 minutes	Condition B and failure to inject emergency feed water to SGs or Failure to re-establish forced circulation and PHT heat up leading to opening of relief valves (PHT storage tank RV-/IRV/BCD)	Extended failure to establish core cooling either by forced circulation or by thermo-syphoning.	----
3. FAILURE OF ELECTRICAL AND PROCESS SYSTEMS				

APPENDIX –VI (A)

TABLE 14: EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR PHWR

For the following entry conditions	Emergency Alert	Declare plant emergency if	Declare site emergency if	Declare Off-site emergency if
A	B	**C**	**D**	**E**
a) Station black out	Class-IV Power Supply failure and Class-III Power Supply not restored on auto	Condition B continuing for 6 minutes and initiation of crash cool down and fire water injection into SGs	Inability to inject emergency feed water into SGs following Condition B or Condition C extending for > 8 hrs or Initiation of small break LOCA through PHT relief route (PHT storage tank RV/IRV/BCD)	----
b) Rupture at any location of any pipe in active process water system/Active process water cooling system	Inability to put fire water in S/D HX	Condition B and inability to put emergency feed water and / fire water in SG.	Condition C with initiation of Small Break LOCA through PHT relief route (PHT storage tank RV-/IRV/BCD)	----
c) Rupture in moderator system pipe.	Increase in tritium DAC >1000 in accessible areas or section of RB for more than a day ; or tritium release from the reactor building exceeds >10 times of the daily technical specification limits	Leak is non-isolable;	----	----
4. RADIATION LEVELS				
a) Loss of spent fuel cooling during FT operation	Loss of spent fuel cooling during FT operation leading to persistent FT room high radiation alarm	Persistence of condition B. and - RB exhaust activity high alarm/actuation of RB box up logic	Condition B and containment impairment (Failure of containment isolation logic/component) leading to activity release to site environment. and Multiple radiation monitors of RB showing >100 increase (persistent) in radiation fields..	----

APPENDIX –VI (A)

TABLE 14: EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR PHWR

For the following entry conditions	Emergency Alert	Declare plant emergency if	Declare site emergency if	Declare Off-site emergency if
A	B	**C**	**D**	**E**
b) Loss of cooling to spent fuel bay bundles	Loss of cooling of spent fuel for more than 48 hrs as identified by any of the following : -Low flow alarm - SFSB water level LO alarm on COIS -Bay water O/L temperature high.(50degC) or -Continuous drop in fuel pool water level	Loss of cooling of spent fuel for more than 7 days (Time to boil) leading to water temperature to rise to 100 degree C. or Continuous drop in fuel pool water level due to any reason.	Condition C and Release of activity more than ten times of limits through stack route. or Multiple radiation monitors of SB showing >100 times increase (persistent) in radiation fields.	----
c) Rupture of radioactive liquid storage tanks /storage tank dykes	Rupture of radioactive liquid storage tanks /storage tank dykes.	Rupture of radioactive liquid storage tanks /storage tank dykes resulting in spillage of radioactive water outside dyke area.	----	----
5.NATURAL CALAMITY, FIRE ,SECURITY AND OTHER EVENTS				
a) Seismic event	Occurrence of seismic event based on seismic alarm(ground acceleration very high; or notification received for tsunami for coastal site	Occurrence of seismic event of >OBE level and auto /manual Reactor trip.	Occurrence of seismic event of equal to or more than SSE level	Increase in radiation fields to 1µSv/h around site boundary and concurrence of seismic event
b) Turbine failure leading to missile being thrown off	Occurrence of turbine blade failure leading to fire and electrical power lost to major safety related equipments.	Turbine blade failure leading to oil /H2 fire.	----	----
c) Flood Event	Abnormal rains in and around the site; or The water body near the site at danger level; or Failure of pipe or tank in	Occurrence of Flood inside plant areas equal to or more than Design basis flood level due to any reason.; or Upstream dam failure, precipitation beyond the drainage capacity leading to	-Flood levels exceed design basis leading to –Impaired functions of safety systems i.e.-ECCS, Emergency AC power supply or Emergency feed water supply for a prolonged period	----

APPENDIX –VI (A)

TABLE 14: EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR PHWR

For the following entry conditions	Emergency Alert	Declare plant emergency if	Declare site emergency if	Declare Off-site emergency if
A	B	**C**	**D**	**E**
	the plant leading to localized flooding	flooding of plant areas	Flood water shows radioactive contamination more than 100Bq/kg of gross beta or 5Bq/kg of gross alpha.	
d) Cyclone Event	Advisory issued by meteorological department High wind speeds around the site	Cyclone hits the site; and Interruption in off-site power supply; or Movement of station personnel is affected	Cyclone hits the site; and Impaired functions of safety systems like ECCS, Emergency AC power supply or Emergency feed water supply for a prolonged period.	----
e) Dam failure leading to loss of ultimate heat sink	Dam failure leading to failure of plant make up water.	Extended failure of make up water system and decrease in stored water inventory of emergency make up pond ;	----	----
f) Fire in main control room ,Turbine ,reactor and control building,	Persistent fire in turbine building operating floor, inside pump room, control room, control equipment room, service building, control building	Failure of safety systems due to fire; or If there is a chance of interruption in core cooling; or Control room becomes uninhabitable due to smoke/fire	----	----
g) Other events such as aircraft attack, missile crash, explosion, entry of toxic/ flammable gases in vital areas		Major fires, number of plant personnel get injured Loss of power supply, failure of safety systems	----	----
i) A local social disturbance causing absence of station staff for safe operation of the plant.	Movement of plant personnel to and from the plant/colony is interrupted	Extended absence of access of key plant management personnel	----	----

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
CRITICAL SAFETY FUNCTION IMPAIRMENT				
Failure to stop nuclear reaction[1]	Failure to fully shut down (increasing neutron flux)[3] as part of normal shutdown with sufficient heat removal available (ultimate heat sink available and sufficient)	Failure to scram when above 5% power *[or insert site specific power level]* and abnormal conditions indicate that an automatic or manual scram is necessary	Failure to scram when above 5% power *[or insert site specific power level]* and abnormal conditions indicate that an automatic or manual scram is necessary	Failure to scram when above 5% power*[or insert site specific power level]*[2] **and** any of the following: —Pressurized water reactor negative cooling margin. **or** —Vessel water level below top of active fuel **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indication of actual or imminent core damage
Inadequate core cooling — vessel level[4]	Vessel water level decreasing over a longer time period than expected while systems are responding as designed	Vessel water level is or is projected to be below top of active fuel	Vessel water level is or is projected to be below top of active fuel for more than 10 min	Vessel water level is, or is projected to be, below top of active fuel for more than 15 min
Notes about level measurement: —Pressurized water reactor pressurizer levels may not be valid indicators of vessel water level under accident conditions —Pressurized water reactor water levels measured in the vessel can have considerable uncertainties (30%) and should only be used for trend assessment —Boiling water reactor high dry well temperature and low pressure accidents (e.g. LOCAs) can cause the water level to read erroneously high	----	----	----	Vessel water level is or is projected to be below top of active fuel **and** any of the following: —Vessel injection rate less than *[use capacity versus pressure curves of operating pumps]* **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indications of imminent or actual core damage **Note:** Imminent reactor coolant system or containment boundary failure might be considered as additional criteria.[5]

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
Inadequate core cooling — core temperature[6]	Core exit thermocouple reading greater than 370°C	Core exit thermocouple reading greater than 500°C	Core exit thermocouple reading greater than 650°C	Core exit thermocouple reading greater than 800°C
Inadequate core cooling — decay heat removal (considering the operations of pumps, piping, heat exchangers, heat sinks, power supply, auxiliary fluid)	Unavailability of the normal feed water system for decay heat removal[7]	Actual failure or projected long term failure of the ability to remove decay heat to the environment,	Actual failure or projected long term failure of the ability to remove decay heat to the environment, potentially affecting the ability to protect the core	
Pressurized water reactor — abnormal primary system temperature inadequate core cooling) **Note:** Temperature should be measured in the vessel. Most pressurized water reactors have core exit thermocouples to measure temperatures in the vessel. Use the average of the highest four core exit thermocouple readings. If there is water flow, the hot leg temperature (T_{hot}) could be used if core exit thermocouples are not available, although this indication is less prompt.[8] For boiling water reactors there are no instruments that provide a valid reading of core temperature.	Pressurized water reactor — primary system pressure and temperature indicate negative cooling margin on the basis of Fig. 7 for more than 5 min **Note:** Negative cooling margin is read as soon as the system temperature is higher than the saturation temperature at the set pressure of the reactor coolant system safety valves.[11]	----	Pressurized water reactor — negative cooling margin on the basis of Fig. 7 for more than 15 min *[or insert site specific time that core damage is possible following a loss of coolant accident]*	Pressurized water reactor — negative cooling margin on the basis of Fig. 7 or primary system temperature exceeds scale for more than 15 min *[or insert site specific time for core damage following a loss of coolant accident]* **and** any of the following: —Vessel injection rate less than water loss due to decay heat boil off *[use Fig. 8 and capacity versus pressure curves of operating pumps]*[9] **or** —Vessel water level below top of active fuel **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indications of actual or imminent core damage **Note:** Imminent reactor coolant system or containment boundary failure might be considered as additional criteria.[10]
Loss of AC or DC power sources	AC or DC power needed for operation of safety systems and their supporting systems is lost or reduced to a single source	----	Actual or projected loss of AC or DC power needed for operation of safety systems and their supporting systems for more than 30 min *[or insert site specific time required to*	Actual or projected loss of all AC or DC power needed for operation of safety systems and their supporting systems is likely for more than 45 min *[or insert site specific time required to uncover core for more than 15 min]* Loss of all AC or DC power needed for safety systems operation **and** any of the following:

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
			uncover the core]	—Vessel water level below top of active fuel **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indication of actual or imminent core damage
Conditions of an unknown cause affecting safety systems	Conditions which are not understood and which could potentially affect safety systems	----	----	----
Loss of or degraded control of safety systems including post-accident instrumentation[12]	Unreliable functioning of several safety system instruments or controls in the control room for more than 15 min	Unavailability of safety system instruments or controls in the control room for more than 15 min and major transient in progress	Unavailability of safety system instruments or controls in the control room for more than 15 min and major transient in progress potentially affecting the ability to protect the core	Unavailability of safety system instruments or controls in the control room and remote control locations **and** any of the following: —Vessel water level below top of active fuel **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indications of imminent or actual core damage
LOSS OF FISSION PRODUCT BARRIERS				
Major increased risk of damage to the core or spent fuel **Note:** Core damage can occur if the core is uncovered for more than 15 min.	Actual or predicted failures leaving only one train to prevent core damage, spent fuel damage or a major release	----	Failure of an additional safety system component will result in uncovering of the core or spent fuel	Loss for more than 45 min of all the systems required to protect the core or spent fuel *[or insert site specific time required to uncover core for more than 15 min]*
High ^{131}I concentration in the primary coolant **Note:** Coolant samples should not be taken if they will result in high individual doses. —Use only concentrations from samples taken after the start of the	^{131}I concentration is greater than *[insert site specific value 100 times the technical specifications or other operational limits]*	^{131}I concentration is greater than *[insert site specific value 120 times the technical specifications or other operational limits]*	^{131}I concentration is greater than *[insert site specific value indicating release of 20% of the gap inventory]*	^{131}I concentration is greater than [*insert site specific values for release of 10% of core inventory]*

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
event —Coolant concentrations may not be representative —Assumes the core may not be coolable after 10% melt				
Confirmed core damage		*[Insert site specific readings from post accident sampling system indicating release of 0.5% of gap inventory]*	*[Insert site specific readings from post accident sampling system indicating release of 1% of gap inventory]*	*[Insert site specific readings from post accident sampling system*[13]*indicating release of 20% of gap inventory*[14]*]*
Primary system leak	Primary system leak rate for more than 15 min greater than 2% of normal full power feed water flow[17] (for boiling water reactor refer to the reactor coolant inventory control system) *[insert site specific indicators — as an alternative, reference to normal charging flow might be made]*	----	Primary system leak for more than 15 min requiring all normal and high pressure emergency core coolant systems to maintain primary system water level *[insert site specific indicators]*	Primary system leak requiring all normal and high pressure emergency core coolant systems to maintain primary system water level[15] **and** any of the following: —Injection into the vessel less than the required rate found. **or** —Vessel water level below top of active fuel and decreasing **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indications of imminent or actual core damage **Note:** Imminent containment boundary failure might be considered as an additional criterion[16].
Primary system leak directly to atmosphere, such as: —Pressurized water reactor: steam generator tube rupture —Boiling water reactor: main steam isolation valve failure outside of containment —A leak with a failure of the containment to achieve isolation —A plant with no containment	Pressurized water reactor: primary system leak to the secondary system requiring continuous operation of more than the usually operating[20]charging pumps to maintain primary system water level Boiling water reactor: main steam isolation valve failure without loss of integrity of steam piping to turbine and/or condenser[21]	----	Primary system leak directly to atmosphere[18] **or** Pressurized water reactor: significant leak from the primary to the secondary system[19]	Primary system leak directly to the atmosphere **and** any of the following: —Projected or confirmed vessel water level below top of active fuel **or** —Major (100–1000 times) increases in multiple radiation monitors **or** —Other indication of actual or imminent core damage

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
RADIATION LEVELS				
Effluent release rates greater than 100 times the release limits and any other indication of actual core damage	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating 50 times the release limits]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating 100 times the release limits]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 4 hours the off-site doses will be greater than 0.10 of the intervention levels for urgent protective actions, assuming average meteorological conditions]*	Effluent monitor readings for more than 15 min greater than *[insert site specific list of effluent monitors and readings indicating that in 1 hour the off-site doses will be greater than the intervention levels for urgent protective actions, assuming average meteorological conditions]*
High radiation levels in the control room or other areas requiring continuous access for safety system operation and maintenance **Note:** Inconsistent monitor readings could result from incomplete mixing, a failed monitor or irradiation from a contaminated system nearby. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the area.	Radiation levels greater than 0.10 mSv/h potentially lasting several hours	Radiation levels greater than 0.50 mSv/h potentially lasting several hours	Radiation levels greater than 1 mSv/h potentially lasting several hours	Radiation levels greater than 10 mSv/h
High radiation levels in areas requiring occasional occupancy to maintain or control safety systems	Radiation levels greater than 1 mSv/h potentially lasting several hours	Radiation levels greater than 5 mSv/h potentially lasting several hours	Radiation levels greater than 10 mSv/h potentially lasting several hours	Radiation levels greater than 100 mSv/h potentially lasting several hours and any other indication of actual core damage
Elevated containment (for boiling water reactors, dry well)[22] radiation levels **Note:** Inconsistent monitor readings could result from incomplete mixing or a failed monitor or irradiation from a contaminated system nearby[23]. Monitors may show high, low or centre range if they fail. Readings can be confirmed using hand held monitors outside the containment.	Containment radiation levels increase more than 0.10 mGy/h *[or insert site specific reading indicating release of greater than 10% coolant inventory]*	Containment radiation levels increase more than 0.50 mGy/h *[or insert site specific reading indicating release of greater than 50% coolant inventory]*	Containment radiation levels greater than 1 Gy/h *[or insert site specific reading indicating release of greater than 1% gap inventory]*	Containment radiation levels greater than 5 Gy/h *[or insert site specific reading indicating release of greater than 20% gap inventory]*

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
Unplanned increase in plant radiation levels	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and transient is in progress	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and a major transient is in progress potentially affecting the ability to protect the core	Multiple plant radiation monitors show an unplanned or unpredicted increase by a factor of 100 or more and any other indication of actual core damage
High ambient dose rates at or beyond[24] the site boundary	Ambient dose rates at or beyond the site boundary greater than 10µSv/h *[or insert site specific reading indicating 100 times the background]*	Ambient dose rates at or beyond the site boundary greater than 10µSv/h *[or insert site specific reading indicating 100 times the background]*	Ambient dose rates at or beyond the site boundary greater than 0.1 mSv/h *[or insert one tenth of the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [10]]*	Ambient dose rates at or beyond the site boundary greater than 1 mSv/h *[or insert the site specific operational intervention level for evacuation; see Procedure B1 in Ref. [10]]*
SECURITY EVENTS, FIRES, EXPLOSIONS, TOXIC GAS RELEASES, NATURAL AND OTHER EVENTS				
Security event (intruder or malicious act)	Security event with potential to affect safety system operation, or uncertain security conditions	----	Security event resulting in damage or impaired access to safety systems	Security event resulting in loss of the ability to monitor and control safety functions needed to protect the core
Fire or explosion (including turbine failure)	Fire or explosion potentially affecting areas containing safety systems	----	----	----
Toxic or flammable gases including, for boiling water reactors, hydrogen in the dry well[25]	Toxic or flammable gases in the plant	----	Flammable gas concentrations that prevent control or maintenance of safety systems	----
Evacuation of the main control room[26]	Plant can be controlled from emergency control room	----	Neither the main control room nor the emergency control room is habitable	----
Major natural disaster such as: —Earthquake —Tornado —Flood —High winds	Major natural events that threaten the plant such as: —Events beyond the design basis of the plant —Events resulting in actual or	Major natural events resulting in damage or impaired access to safety systems and/or decay heat removal systems or affecting their long term operation	Major natural events resulting in damage or impaired access to safety systems and/or decay heat removal systems or affecting their long term	----

APPENDIX – VI (B)

TABLE 15 : EMERGENCY CLASSIFICATION AND EMERGENCY ACTION LEVELS (EAL) FOR LWR

For the following entry conditions	Declare an alert if :	Declare plant emergency if:	Declare site emergency if:	Declare Off-site / general emergency if:
A	B	**C**	**D**	**E**
—Vehicle or aircraft[27] crash —Hurricane —Tsunami —Storm surge —Low water level —Lightning strike[28]	potential loss of access to the site for a long period of time		operation	
Loss of communications	Events resulting in actual or potential loss of communications to the site for a long period of time	----	----	----
Plant shift supervisor's opinion	Abnormal conditions that warrant obtaining immediate additional assistance for the on-site operations staff **or** Abnormal conditions that warrant increased preparedness on the part of off-site officials	Conditions that warrant taking protective actions at the plant **or** Abnormal conditions that warrant increased preparedness on the part of off-site officials	Conditions that warrant preparing the public to implement urgent protective actions **or** Conditions that warrant taking protective actions on the site	Conditions that warrant taking urgent protective actions off the site
SPENT FUEL POOL EVENTS				
Abnormal refuelling or spent fuel conditions	Loss of ability to maintain water level above spent fuel **or** Damage to spent fuel **or** Loss of ability to maintain pool water temperature below 80°C[29]	Water level below top of irradiated fuel **or** Radiation level in pool area greater than 20 mGy/h	Water level below top of irradiated fuel **or** Radiation level in pool area greater than 30 mGy/h	Fully drained pool containing more than one third of a core removed from the reactor within the past 3 years **or** Radiation level in pool area greater than 3 Gy/h

1. 'Stop nuclear reaction' is a general term that includes 'reactor scram', which is used only for the insertion of control rods into the reactor.
2 Failure to scram the reactor is usually evaluated if reactor power is greater than 5% and conditions indicate that scram is necessary (safety systems are usually capable of removing heat for the heating rate at less than 5% of nominal power). For some plants, different, plant specific values should be used.
3 Increasing neutron flux is an explicit symptom that the reactor is not fully shut down.
4 Inadequate core cooling is characterized by three kinds of entry condition: vessel level, core temperature and decay heat removal capability. These conditions are valid for both pressurized water reactors and boiling water reactors, and are put before the primary system temperature, which is relevant for pressurized water reactors only.
5 In the event of core damage, the status of the reactor containment system and the containment barriers will greatly affect the magnitude of the release of fission products.
6 Elevated core exit temperature is a direct symptom of core cooling degradation. Therefore, this symptom is used as an entry condition for inadequate core cooling. The critical water temperature above which liquid water cannot exist irrespective of system pressure is 370°C; 650°C is a value usually used for inadequate core cooling in emergency procedures and indicates that steam–Zr reaction will start to produce hydrogen; 800°C indicates core damage that starts at a core temperature of about 1200°C.
7 Normal feed water is used for heat removal in these modes. If normal feed water is not available, the alternate water sources should be used for steam generator feeding.
8 T_{hot} provides a backup for the core temperature since the flow through the core cannot readily be confirmed and T_{hot} changes are delayed relative to the core exit temperature.
9 This provides a more accurate description of the phenomena inside the reactor vessel.

10 In the event of core damage, the status of the reactor coolant system and containment barriers will greatly affect the magnitude of the release of fission products.
11 If adequate coolant injection flow cannot be established to restore core heat removal, the reactor coolant system liquid starts to become saturated. If the system temperature is higher than the saturation temperature at the set pressure of the reactor coolant system safety valves, this prevents further pressurization of the reactor coolant system.
12 Safety system control capability can be either degraded or completely lost; both cases are reflected. Unreliable functioning of several safety system instruments or alarms and unavailability of safety system instruments or controls are considered. Post-accident instrumentation provides the essential information to support safety system operation and control.
13 Reference to a failed fuel monitor in a pressurized water reactor and off-gas monitor in a boiling water reactor is replaced by reference to a post-accident sampling system.
14 The gap inventory is the amount of fission products in the fuel pin gap during normal operations.
15 The criterion was replaced by the same requirement used for site area emergency to refer to the leak rate instead of the (previously misleading) operational core cooling system.
16 In the case of a loss of coolant accident and core damage, the status of the containment barrier will directly affect the magnitude of the fission product release.
17 Leak rate with respect to normal feed water flow for normal full power operation is used instead of leak rate with respect to the number of operating pumps. Such leak rate specification better covers the concern during a loss of coolant accident (i.e. to ensure sufficient core cooling). For some plants, the leak rate should also be determined on the basis of the normal charging flow rate.
18 Any significant primary leak directly to the atmosphere will cause releases of fission products to the environment, and it is necessary to take immediate actions to stop the leak.
19 For pressurized water reactors, a significant primary system to secondary system leak could cause releases of fission products to the environment, and it is necessary to take immediate actions to stop the leak.
20 For pressurized water reactors, a primary system to secondary system leak at a rate above the normal charging system capability can quickly cause releases of fission products to the environment, and it is necessary to take appropriate actions to stop the leak.
21 For boiling water reactors, failure of the main steam isolation valve without loss of integrity of steam piping to the turbine and/or condenser could cause early releases of fission products to the environment, and it is necessary to take appropriate actions to stop the leak.
22 For boiling water reactors, the dry well instead of the containment is more appropriate.
23 Radiation from a contaminated system nearby could also affect the radiation monitors inside the containment.
24 Ambient dose rate is usually measured at the site boundary. However, if any measurement of ambient dose rate beyond the site boundary is available, it can be used for the purpose of this EAL.
25 For boiling water reactors, hydrogen concentration in the dry well could increase, which can cause significant damage in the event of ignition.
26 In the case of the need to evacuate the main control room, the ability to control the plant is affected (the severity of the situation depends on the plant design). If the emergency control room is used for plant control, an alert is the appropriate EAL; if both the main control room and the emergency control room are affected and the plant has to be controlled by alternative means, a site area emergency is the appropriate EAL.
27 An aircraft crash could also cause severe damage to the plant and reduce plant safety.
28 Lightning strikes could also cause severe damage to the plant and reduce plant safety.
29 High temperature in the spent fuel pool is a result of the degradation of heat removal from the spent fuel, and this temperature should also be used as an additional symptom of abnormal refuelling conditions or spent fuel conditions.

APPENDIX – VII

OBSERVABLES ON THE SCENE OF RADIOLOGICAL EMERGENCY

VII-1 General

In radiological emergency, initial response is to be carried out based on indications of the hazards such as labels, signs or placards indicating the presence of a hazardous material, the appearance of medical symptoms in exposed individuals or readings from specialized instruments.

VII-2 Observables in radiological emergency

In a radiological emergency, the inner cordoned area is where protective action is implemented to protect responders and the public. Initially the size of the area is determined on the basis of information that can be directly observed (e.g. markings on container / flask/scene). The size of the area may be expanded on the basis of dose rates and environmental measurement OILs (see sec. 5.3.2) when these data become available. Table 16 provides suggestions for the approximate radius of the inner cordoned area. The actual boundaries of the safety and security perimeters should be defined in such a way that they are easily recognizable (e.g. by roads) and should be secured. However, the safety perimeter should be established at least as far from the source as is indicated in the table until the radiological assessor has assessed the situation.

TABLE 16 : SUGGESTED RADIUS OF THE INNER CORDONED AREA (SAFETY PERIMETER) IN A RADIOLOGICAL EMERGENCY

Situation	**Initial inner cordoned area (safety perimeter)**
Initial determination — Outside	
Unshielded or damaged potentially dangerous source	30 m radius around the source
Major spill from a potentially dangerous source	100 m radius around the source
Fire, explosion or fumes involving a dangerous source	300 m radius
Suspected bomb (possible radiological dispersal device), exploded or unexploded	400 m radius or more to protect against an explosion
Conventional (non-nuclear) explosion or a fire involving a nuclear weapon (no nuclear yield)	1000 m radius
Initial determination — Inside a building	
Damage, loss of shielding or spill involving a potentially dangerous source	Affected and adjacent areas (including floors above and below)
Fire or other event involving a potentially dangerous source that can spread radioactive material throughout the building (e.g. through the ventilation system)	Entire building and appropriate outside distance as indicated above
Expansion of safety perimeter based on radiological monitoring	
OIL1 and OIL2 from Table 4 & 5	Wherever these levels are measured

ANNEXURE – I

TOOLS FOR EFFECTIVE MANAGEMENT OF EMERGENCIES ARISING OUT OF NUCLEAR ACCIDENTS

AI-1 Introduction

The general objectives of emergency planning and management are to reduce the risk of health effects owing to radiation exposure or mitigate the consequences of the accident.

These objectives are accomplished by implementation of timely emergency response using the tools such as reference levels, generic criteria and operational criteria derived from generic criteria. The important protective actions as a part of emergency response are, in the early phases of an accident (mostly precautionary in nature), sheltering, evacuation, iodine prophylaxis, and control of access. In the later phase, foodstuff restrictions and relocation for example are relevant protective actions.

AI-2 Phases of Emergency Response Based on Time of Radioactivity Release after a Nuclear Accident

Emergency response undertaken by the authorities (Figure AI-1) is often divided into three phases: a pre-release phase, a release phase with a time scale of hours/days and a post-release phase with a time scale of weeks/months/years, depending on the nature of the release.

In the early stages of an accident, the plume exposure pathways including inhalation are most likely to dominate, although deposition of short-lived γ-emitting radionuclides could result in significant external exposures from the ground. In later stages, when the release contains particulates, the dominating pathways will include ingestion of contaminated food, and external radiation from deposited radionuclides.

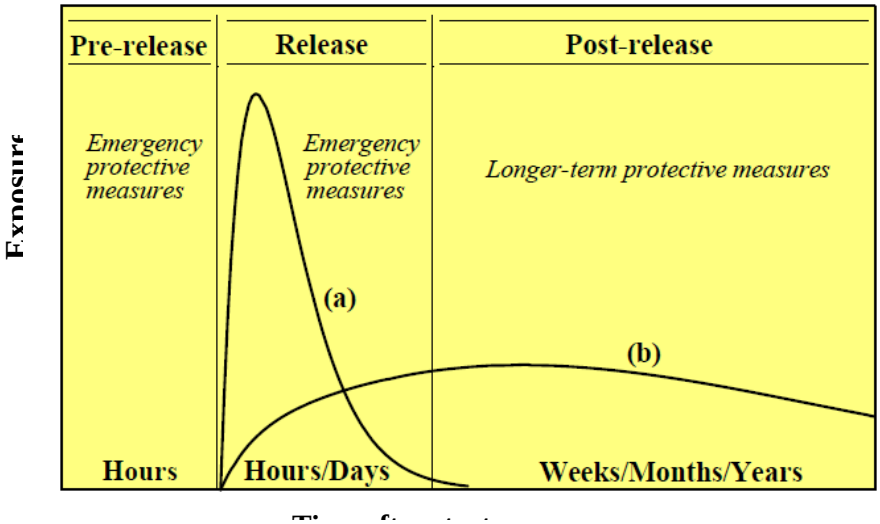

Fig. AI-1. Time phases of a nuclear accident involving atmospheric releases of radioactive materials. During the release phase the exposure predominantly stems from the plume exposure pathways (*a*). *In the post-release phase the exposure is dominated by the ground deposition pathway* (*b*), *the exposure rate is relatively low while the exposure time may be very long.*

At the onset of the accident, decisions are necessarily based on very limited information and the operational criteria e.g. plant conditions (EALs) or environmental dose rate measurements (OIL) act as important decision aiding tools. As the accident evolves, management decisions will be based on more complete picture of the accident and its off-site radiological consequences. While the accident assessment is a probabilistic endeavour the uncertainty in the assessment constantly decreases. With time a more complete picture of the accident emerges and the decision on implementation of protective measures is based directly on an estimate of the residual doses.

AI-3 Tools for Emergency Management

Reference Levels: In emergency exposure situations, the reference levels represent the level of dose or risk, above which it is judged to be inappropriate to plan to allow exposures to occur, and for which therefore protective actions should be planned and optimised. Reference levels for protection of public during emergency situation are set within an effective dose range of 20–100 mSv, expressed in terms of residual dose, which includes dose contributions via all exposure pathways. The protection strategy shall be optimized to reduce exposures below the reference level.

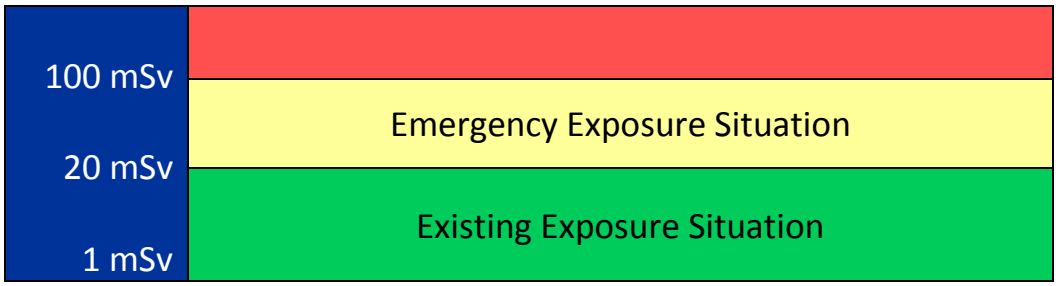

Fig. AI-2. Reference levels in emergency exposure situation and existing exposure situation.

During emergency situation emergency response actions (protective and other actions) are undertaken to ensure that the reference levels are not exceeded. The type and scale of protective and other actions undertaken in turn are based on:

i. **Generic Criteria:** Generic criteria are set by considering two types of the health consequences (i) severe deterministic effect and (ii) increase in stochastic effect. Generic criteria start at levels of dose that are approaching the threshold for severe deterministic effects (could be as high as 1 Sv). Normally the generic criteria deal with estimated quantities such as projected dose and can not be directly seen or easily measured.

ii. **Operational Criteria:** The generic criteria form the basis for developing the operational criteria. Operational criteria include (i) Emergency Action Levels (EALs) (ii) Operational Intervention Levels (OILs) and (iii) Observables (by Operators or first responders); for decision making on emergency categorisation and initiating the protective actions. Operational criteria are established in advance (e.g control room indications, radiation and contamination levels in public domain etc.) by using the generic criteria and these are normally the observables.

Thus the system of protective actions and other response actions in an emergency include numerical values of generic criteria as well as of the corresponding operational criteria that form the basis for decision making in an emergency so as to ensure that the residual doses normally remain well below reference levels.

ANNEXURE – II

POST ACCIDENT EMERGENCY MANAGEMENT IN PUBLIC DOMAIN AROUND FUKUSHIMA DAIICHI NUCLEAR POWER PLANTS (FDNPP, JAPAN) USING SIMILAR SAFETY STANDARDS

AII-1 Introduction

In the year 2011, serious external events (earth quake followed by tsunami) resulted in prolonged interruption of core cooling and spent fuel cooling at Fukushima Daiichi Plants which ultimately led to release of large quantities of radioactive materials from the plants.

AII-2 Implementation of Protective Actions

The Japanese authorities initiated and implemented precautionary urgent protective actions/urgent protective actions based on plant conditions alone to prevent severe deterministic health effects and to minimize stochastic effect on similar lines as prescribed in this document.

Further, to mitigate the consequences of the accident, actions taken by authorities i.e. restriction /control on food stuff, temporary relocation, lifting of restriction etc were also based on similar safety guidelines.

Use of safety standards such as IAEA GSR part-7 (revised GS-R-2), GS-G2, GS G2.1, GSR-part-3 (revised BSS) etc. (on which this document is also based) has amply demonstrated the effectiveness of this guidance in an actual emergency situation.

Using this kind of guidance, the actions taken to protect the public (evacuation and sheltering) significantly reduced the radiation exposures that would have otherwise been received. More than 95% of the members of public received doses well below 10 mSv as against the reference level of 20 mSv to 100 mSv. Thus, the exposure received by Japanese population was low, leading to correspondingly low risks of health effects later in life.

Some of the actions taken by the authorities consistent with this guidance are reproduced below:

i. Precautionary urgent protective actions (evacuation, sheltering) based on EALs (March 11 to March 15, 2011 in 20 km downwind sector from FDNPP [viz. Minami Soma (N24)] before release of radioactivity.

ii. Urgent protective actions (foodstuff and water restrictions) based on EALs & OILs (March 16 to March 23, 2011).

iii. Early protective actions (preparation for temporary relocation) based on OILs (March 16 to March 23, 2011).

iv. Use of OILs for evacuation & classification of new emergency zones [Rearrangement of area, Termination of area].

v. Transition from emergency exposure situation to existing exposure situation

ANNEXURE – III

CONCEPTUAL PLAN FOR ESTABLISHING AREAS ON THE SCENE AND USING OILS FOR RADIOLOGICAL EMERGENCY

AIII-1 Introduction

Radiation and radioactive substances have many beneficial applications, ranging from power generation to uses in medicine, industry and agriculture. The radiation risks to workers, the public and to the environment that may arise from these applications have been assessed and controlled by regulating the practices. Also, regulations are in place to prevent accidents and to respond to emergencies so as to mitigate any harmful consequences.

Initially, the first responders / local emergency services (e.g. medical, law enforcement agency and fire brigades) may use the following indications to identify the possible potential radiological emergency:

(a) Suspected or actual bomb.
(b) Credible threats or threatening messages.
(c) Device that appears intended to spread contamination.
(d) Signs of possible contamination (e.g. spill).
(e) Gamma dose rates: > 100 μSv/h at 1 m from object or at 1m above the ground.
(f) Medical symptoms of radiation injuries (such as burns without an apparent cause).
(g) Building / area marked with the radiation symbol.
(h) Results of assessment of a radiological assessor.
(i) Neutron radiation.
(j) Dangerous source that is lost, stolen, damaged, in a fire, leaking, or potentially involved in a terrorist act or explosion.

The initial response is carried out based on indications of the hazards such as labels, signs or placards indicating the presence of a hazardous material, the appearance of medical symptoms in exposed individuals or readings from specialized instruments. Indications of a dangerous source are:

(a) A heavy container with the radiation symbol.
(b) Item with labels pertaining to radioactivity.
(c) Item with transport UN numbers or markings.
(d) Device used for cancer treatment (teletherapy or brachytherapy).
(e) Radiography cameras or sources.
(f) Well logging sources used in drilling operations.
(g) Dangerous quantity of material (> D-value), as assessed by a radiological assessor.

AIII-2 Use of Operational Intervention Levels (OILs) for Emergency Management

In case of a radiological emergency, to prevent the severe deterministic effects, the response actions can include:

i. immediate medical examination,
ii. consultation and treatment
iii. contamination control,
iv. administration of de-corporation agents where applicable,
v. registration for long term health monitoring, and
vi. comprehensive psychological counselling.

Similarly some of the early and other response actions to minimize the stochastic effects can include:

i. relocation
ii. long term restriction of consumption of contaminated food
iii. screening based on individual doses to specific organs,
iv. considering the need for registration for medical follow up

As the situation becomes clearer with time following actions are to be considered:

i. Determining the boundary of the inner cordoned area
   Ambient dose rate of 100 μSv/h at 1 metre
   > 1000 Bq/cm^2 gamma/beta deposition
   > 100 Bq/cm^2 alpha deposition
   (Temporary relocation (30 mSv averted in 30 days))

ii. For determining if skin and clothing decontamination is warranted
   > 1 μSv/h at 10 cm
   > 10000 Bq/cm^2 beta/gamma contamination
   > 1000 Bq/cm^2 for alpha emitters

iii. Screening of groups and locations
   > 100 μSv/h at 1 metre

iv. Equipment or vehicle contamination criteria
   Ambient dose rate at 10 cm:

   Use of equipment or vehicle for response activities only
   > 1 μSv/h and < 10 μSv/h
   Allow use of equipment or vehicle for critical response activities only
   > 10 μSv/h and < 100 μSv/h
   Isolation of equipment or vehicle and use only with approval of radiological assessor
   > 100 μSv/h

v. Ban on consumption of Food, Water, Milk as per OILs

vi. Follow up

   Decontamination of Soil, Building etc
   Termination of radiological emergency and restoration of normalcy

AIII-3 Conceptual Plan for Establishing Areas for Radiological Emergency Management

The conceptual plan for establishment of inner cordon area, out cordon area and emergency resource facilities for management of radiological emergency is given in figure AIII-1.

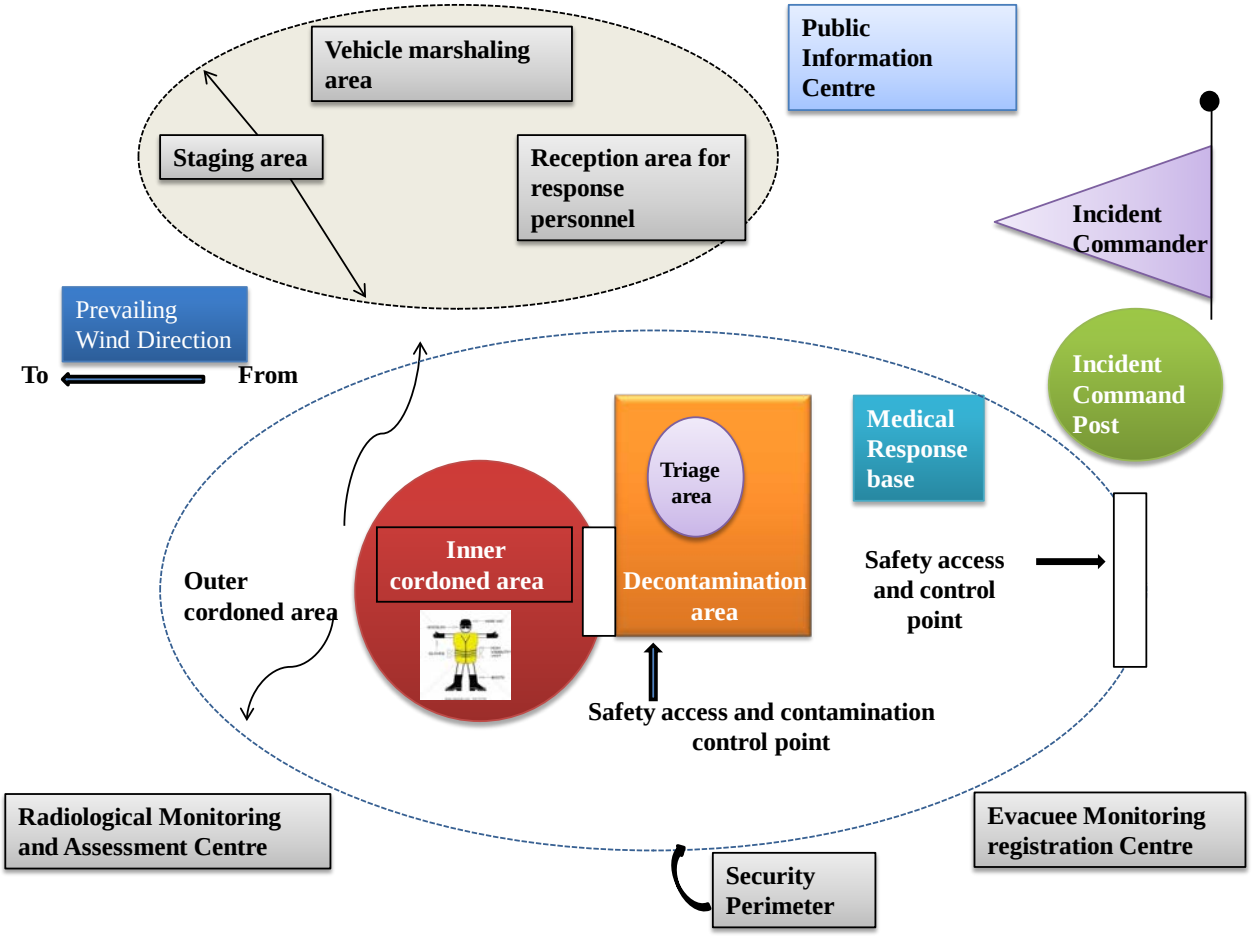

Fig AIII-1: Conceptual plan for establishing areas to carry out emergency management

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EXPERT COMMITTEE FOR PREPARATION OF CRITERIA FOR PLANNING, PREPAREDNESS AND RESPONSE FOR A NUCLEAR OR RADIOLOGICAL EMERGENCY

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Date of meeting: March 6, 2014

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PROVISIONAL LIST OF REGULATORY SAFETY DOCUMENTS ON EMERGECNY PREPAREDNESS AND RESPONSE

AERB/SG/EP-1	Preparation of Site Emergency Preparedness Plans for Nuclear Installations
AERB/SG/EP-2	Preparation of Off-Site Emergency Preparedness Plans for Nuclear Installations
AERB/SG/EP-3	Preparation of Site Emergency Preparedness Plans for Non-Nuclear Installations
AERB/SG/EP-4	Preparation of Off-Site Emergency Preparedness Plans for Non-Nuclear Installations
AERB/NRF/SG/EP-5	Criteria For Planning, Preparedness and Response for Nuclear or Radiological Emergency
AERB/SG/O-6	Preparedness of the Operating Organisation for Handling Emergencies at Nuclear Power Plants
AERB/SC/TR-3	Emergency Response Planning and Preparedness for Transport Accidents Involving Radioactive Material