National Disaster Management Guidelines

Management of Nuclear and Radiological Emergencies

National Disaster Management Guidelines—Management of Nuclear and Radiological Emergencies

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The National Guidelines are formulated under the Chairmanship of Shri B. Bhattacharjee, Hon'ble Member, NDMA in consultation with various specialists, regulators and stakeholders in the subject field concerned from all across the country.

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National Disaster Management Authority
Government of India

Vision

The National Vision is to prevent nuclear and radiological emergencies which are essentially man-made in nature. However, in rare cases of their occurrence, due to natural or man-made factors beyond human control, such emergencies will be so managed through certain pre-planned and established structural and non-structural measures by the various stakeholders, as to minimise risks to health, life and the environment.

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Vice Chairman
National Disaster Management Authority
Government of India

FOREWORD

The formulation of guidelines to assist ministries and states for preparing plans for various types of disasters constitutes an important part of the mandate given to the National Disaster Management Authority (NDMA). The Guidelines on *Management of Nuclear and Radiological Emergencies* assume great importance in our context, as our country has extensive and varied programmes for peaceful uses of nuclear energy. Even while we have an enviable and impeccable record of safety and virtually fail-safe arrangements in all our nuclear establishments, the possibility, however, remote it may be, of human error, systems failure, sabotage, earthquake and terrorist attacks leading to the release of radioactive matter in the public domain, cannot be entirely ruled out. Through these Guidelines, we aim to further strengthen our existing emergency management framework and generate public awareness, which will go a long way in allaying misapprehensions, if any, amongst the public.

In these Guidelines, maximum emphasis has been laid on the prevention of nuclear and radiological emergencies, along with a detailed consideration of all other elements of the disaster management continuum. In this context, there may be two types of emergencies which will be of greatest concern to us. These can possibly arise as a result of (i) possible malfunctioning in the nuclear fuel cycle and (ii) detonation of a Radiological Dispersal Device (or dirty bomb) by gaining unauthorised access to radioactive materials that are routinely used in hospitals, research facilities, and industrial and construction sites. Owing to the highly complex and specialised nature of nuclear and radiological emergencies, the National Guidelines have been prepared and a consensus arrived on various technical and operational issues after a series of wide consultations and elaborate discussions amongst experts. These have included experts/officials from various units of the Departments of Atomic Energy (DAE), Atomic Energy Regulatory Board (AERB), Defence Research and Development Organisation, National Technical Research Organisation and other stakeholders.

For this meticulous work, I express my deep appreciation to Shri. B. Bhattacharjee, Member, NDMA, who, with his vast and intimate knowledge of this subject, has not only contributed immensely himself but also very efficiently coordinated the entire process of formulating the Guidelines. I am also thankful to the various units of DAE and AERB for their critical review and significant contributions in the preparation of this document. Finally, I express my gratitude for the sincere and untiring efforts of the members of the Core Group of Experts in assisting the NDMA in the formulation of these Guidelines.

I am certain that these Guidelines, when converted to action plans and implemented by all the stakeholders at various levels of administration, will go a long way in eliminating even the remotest chances of any nuclear or radiological accidents.

New Delhi
February 2009

General NC Vij
PVSM, UYSM, AVSM (Retd)

Member
National Disaster Management Authority
Government of India

ACKNOWLEDGEMENTS

At the outset, I must express my sincere thanks to all the Members of the Extended Core Group in general and to those of the Core Group in particular for their invaluable contribution and whole-hearted cooperation in helping NDMA to prepare the *National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies*. But for the high standard of the technical inputs from the Members of the Core Group, it would have not been possible to bring these National Guidelines to their present shape.

I must also place on record my sincere gratitude and appreciation for the guidance and constructive suggestions made by Dr. Anil Kakodkar, Chairman, Atomic Energy Commission, Shri. S.K. Sharma, Chairman, AERB and Dr. Srikumar Banerjee, Director BARC, which have helped in improving the content as well as presentation of these guidelines. In this context, the guidance and valuable contributions received time to time from Dr. K.V.S.S. Prasad Rao, Chairman, NTRO are also highly appreciated. Sincere thanks are also due to Shri. R.K. Sinha, Director, RD&D Group, BARC for his technical inputs.

The efforts of Dr. M.C. Abani, Specialist, NDMA in providing knowledge based technical inputs to the core group and for drafting the document are highly appreciated.

I am also happy to acknowledge the support and cooperation extended by Shri. H.S. Brahma, Special Secretary, NDMA along with his team, and members of my office Shri. Rajni Kant, Smt. Harshita Chauhan and Smt. Sajneet Kaur during the various phases of preparing this document.

Finally, I would like to express my gratitude to our Hon'ble Vice Chairman, General N.C. Vij, PVSM, UYSM, AVSM (Retd) for his critical review and inputs that have immensely added value to the content as well as the quality of these Guidelines. I must also acknowledge my gratitude to all the distinguished Members of NDMA for their valuable suggestions and feedback from time to time.

It is sincerely hoped that these Guidelines will enable all the stakeholders at various levels of administration in the country to formulate their respective action plans which, in turn, will ultimately lead to the building of a community resilient to Nuclear and Radiological Emergencies.

B. Bhattacharjee

New Delhi
February 2009

Abbreviations

AERB	Atomic Energy Regulatory Board
AGSS	Aerial Gamma Spectrometry System
ALARA	As Low As Reasonably Achievable
ATI	Administrative Training Institute
BARC	Bhabha Atomic Research Centre
CBDM	Community Based Disaster Management
CBO	Community Based Organisation
CBRN	Chemical, Biological, Radiological and Nuclear
CME	College of Military Engineering
CMG	Crisis Management Group
CPMF	Central Para Military Force
DAE	Department of Atomic Energy
DBA	Design Basis Accident
DDMA	District Disaster Management Authority
DM	Disaster Management
DMA	Disaster Management Authority
DoS	Department of Space
DRDE	Defence Research and Development Establishment
DRDO	Defence Research and Development Organisation
DST	Department of Science and Technology
ECC	Emergency Command Centre
EMP	Electro-Magnetic Pulse
EOC	Emergency Operations Centre
ERC	Emergency Response Centre
ERMNA	Environmental Radiation Monitor with Navigational Aid
ERT	Emergency Response Team
GIS	Geographic Information System
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IERMON	Indian Environmental Radiation Monitoring Network
IMD	India Meteorological Department
IND	Improvised Nuclear Device
IRODOS	Indian Real-time On-line Decision Support System
MFR	Medical First Responder
MGSS	Mobile Gamma Spectrometry System
MoD	Ministry of Defence
MHA	Ministry of Home Affairs

MHRD	Ministry of Human Resource Development
MoH&FW	Ministry of Health and Family Welfare
NCC	National Cadet Corps
NCMC	National Crisis Management Committee
NDCN	National Disaster Communication Network
NDMA	National Disaster Management Authority
NDMG-NRE	National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies
NDRF	National Disaster Response Force
NEC	National Executive Committee
NGO	Non-Governmental Organisation
NIDM	National Institute of Disaster Management
NPCIL	Nuclear Power Corporation of India Ltd.
NPP	Nuclear Power Plant
NREMP	National Radiation Emergency Management Plan
NRSA	National Remote Sensing Agency
NSS	National Service Scheme
NTRO	National Technical Research Organisation
NYKS	Nehru Yuva Kendra Sangathan
OBE	Operating Basis Earthquake
POL	Petroleum, Oil and Lubricants
PPG	Personal Protective Gear
PPRRE	Planning Preparedness for Response to Radiological Emergencies
QRMT	Quick Reaction Medical Team
QRT	Quick Reaction Team
RAD	Radiation Absorbed Dose
R&D	Research and Development
RDD	Radiological Dispersal Device
RED	Radiation Exposure Device
REM	Roentgen Equivalent Man
RITC	Radiation Injuries Treatment Centre
RM	Risk Management
RSO	Radiological Safety Officer
SCBA	Self-Contained Breathing Apparatus
SDMA	State Disaster Management Authority
SDRF	State Disaster Response Force
SEC	State Executive Committee
SOP	Standard Operating Procedure
TOT	Training of the Trainers
TREMCARD	Transport Emergency Card
UT	Union Territory
WMD	Weapons of Mass Destruction

Glossary of Key Terms

Absorbed Dose

Absorbed dose, D, is defined as the mean energy imparted by ionising radiation to the matter in a volume element divided by the mass of the matter in that element.

$$\text{Absorbed dose, } D = \frac{dE}{dm}$$

Unit of absorbed dose is Rad. One Rad deposits an energy of 100 ergs in one gram of tissue. The SI unit of absorbed dose is Gray (Gy) which is equivalent to deposition of 1 Joule per Kg (J/Kg) of tissue.

Accident

An undesirable or unfortunate event that occurs unintentionally arising from carelessness, unawareness, ignorance, system failure or a combination of these causes which usually leads to harm, injury, loss of life, livelihood or property or damage to the environment.

Becquerel

One disintegration per second.

Breeder

A reactor which produces more fissile nuclides than it consumes.

Contamination

Radioactive substances (in the form of dust, dirt, liquid) deposited on surfaces (e.g., skin, walls, etc.), or within solids, liquids or gases where their presence is normally neither expected nor desirable.

Curie

3.7×10^{10} disintegrations per second.

Deterministic Effect

The effect of radiation on human health for which there is generally a threshold level of dose above which the severity of the effect is greater for a higher dose. Such an effect is described as a ‘severe deterministic’, if it is fatal or life threatening or results in a permanent injury that reduces the quality of life.

Disaster

When the dimension of an emergency situation grows to such an extent that the impact of the hazard is beyond the coping capability of the local community and/or the concerned local authority.

Dose

Amount of energy delivered to a unit mass of material by the radiation travelling through it.

Dose Limit

The value of the effective or equivalent dose to individuals that shall not be exceeded from planned exposure situations.

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. From the definition of equivalent dose, it follows that:

$$E = \sum_{T} w_T . \sum_{R} w_R . D_{T,R}$$

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

Emergency

An abnormal situation or event that necessitates prompt action, primarily to mitigate the impact of a hazard or adverse consequences on human health and safety, quality of life, property or the environment. This includes nuclear and radiological emergencies and conventional emergencies such as fire, releases of hazardous chemicals, storms or earthquakes. It includes situations for which prompt action is warranted to mitigate the effects of a perceived hazard. Normally, in such an emergency, the impact of the hazard is within the coping capability of the administrative authority of the affected area.

Emergency Preparedness

To develop the capability during normal conditions to take action for utilising all available/mobilised resources that will effectively mitigate the consequences of an emergency and ensure safety and health of the people, quality of life, property and the environment.

Emergency Response

Actions under conditions of stress created by an emergency, to mitigate the consequences of the emergency on the safety and health of the people, their quality of life, property and the environment. It may also provide a basis for the resumption of normal social and economic activities.

Equivalent Dose

The quantity $H_{T,R}$, for a given type of radiation R, is defined as:

$$H_{T,R} = D_{T,R} . w_R$$

where $D_{T,R}$ is the absorbed dose delivered by radiation type R averaged over a tissue or organ T and w_R is the radiation weighting 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:

$$H_T = \sum_R w_R \cdot D_{T,R}$$

The unit of equivalent dose is J · kg^{-1}, termed the Sievert (Sv).

Exposure
The act or condition of being subjected to irradiation. Exposure can be either external (due to a source outside the body) or internal (due to source within the body).

First Responder
The member of an emergency service to arrive first at the scene of an emergency to provide rescue and relief operations.

Fission
The process in which a heavy nucleus splits into two small, intermediate mass nuclei with release of energy and one or more neutrons. A neutron is normally utilised to induce this process. Spontaneous fission refers to the process in which the fission occurs spontaneously without the need to induce it by any external agency.

Fuel Reprocessing
The physical and chemical processes carried out to separate the useful fissile material (e.g., plutonium) from the unutilised fertile material present in the spent fuel emanating from the nuclear reactor.

Fusion
An atomic reaction process where a heavier nucleus is formed from fusion of two smaller nuclei accompanied with the release of large amount of energy.

Gray (Gy)
The special name for the SI unit of absorbed dose: 1 Gy = 1 J · Kg^{-1}

Half-Life
The time taken by a sample of radioactive material to decay down to half the number of its original atoms.

Incident
An occurrence or event of minor importance.

Intervention
Any action intended to reduce or avert exposure or the likelihood of exposure to sources which are not part of a controlled practice or which are out of control as a consequence of an accident.

Intervention Level

The level of avertable dose at which a specific protective action or remedial action is taken in an emergency exposure situation or a chronic exposure situation.

Moderator

A substance that reduces the energy of fast neutrons through the process of collisions (without any significant capture or absorption) with its atoms/molecules.

Nuclear Power Reactor

A reactor where heat energy is released in the nuclear fuel placed inside the reactor by the process of nuclear fission to produce steam for the generation of electric power.

Nuclear or Radiological Disaster

When the impact of a nuclear or radiological emergency, caused by a nuclear attack (as happened at Hiroshima and Nagasaki in Japan) or large-scale release of radioactivity from nuclear/radiological facilities (like that at Chernobyl in Ukraine) is very high, it assumes the dimension of a nuclear disaster leading to mass casualties and destruction of large areas and property. Unlike a nuclear emergency, the impact of a nuclear disaster is beyond the coping capability of local authorities and such a scenario calls for handling at the national level, with assistance from international agencies, if required.

Nuclear or Radiological Emergency

An emergency in which there is, or is perceived to be, a hazard due to: (a) the radiation energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or (b) radiation exposure. Such emergencies are usually well within the coping capability of the plant/facility authority along with the neighbouring administrative agencies, if required.

Nuclear Wastes

Radioactive wastes resulting from the various activities in the nuclear fuel cycle or any other facilities handling radioactive materials/radioisotopes.

Off-Site

Outside the site area of the nuclear/radiological source.

On-Site

Within the site area of the nuclear/radiological source.

Radiation

Energy emitted from a radioactive atom/source is known as radiation. The three main types of radiations emitted by radioactive substances are alpha (α), beta (β) rays and photons (x-ray and gamma (γ) rays). There is yet another type of radiation, known as neutron radiation, which is emitted during a nuclear fission process. The radioactive substances are both natural as well as man-made. The magnitude of this radiation decays with time. Exposure to radiation can be reduced by applying the principles of Time, Distance and Shielding.

Radiation Weighting Factor

The radiation weighting factor is an ICRP multiplier used to modify the absorbed dose (Gy) to obtain a quantity called the equivalent dose (Sv). It is used because some types of radiation, such as alpha particles, are more biologically damaging internally than other types such as the beta particles. For example, radiation weighting factor of beta particles is 1 while that of alpha particles is 20.

Radiation weighting factors are dimensionless multiplicative factors used to convert physical dose (Gy) to equivalent dose (Sv); i.e., to place biological effects from exposure to different types of radiation on a common scale.

Radioactivity

Spontaneous emission of invisible radiation by certain unstable species of nuclei (man-made or naturally occurring) unaffected by chemical reactions, temperature or other physical factors.

Regulatory Body

An authority, or authorities, designated by the government of a state or country having legal authority for conducting the regulatory process, including issuing authorisations, and thereby regulating nuclear radiation, radioactive wastes and transportation safety.

Research Reactor

Reactors designed to produce a large flux of neutrons within the reactor volume needed for the purpose of research in various branches of nuclear science, basic science, material science, nuclear engineering and/or for the production of radioisotopes.

Response Organisation

An organisation designated or otherwise recognised by a state as being responsible for managing or implementing any aspect of an emergency response.

Roentgen

Before the SI system was adopted, the unit of X-ray exposure was called the Roentgen and was symbolised by R. It is different from the absorbed dose. Roentgen is defined as that quantity of X or gamma radiation that produces ions carrying one stat coulomb (one electrostatic unit) of charge of either sign per cubic centimeter of air at 0^0 C and 760 mm Hg.

Sievert (Sv)

The new SI unit for equivalent dose is Sievert (Sv).

$$1 \text{ Sievert} = 1 \text{ J} \cdot \text{Kg}^{-1}$$

Stochastic Effects

Effects resulting in the damage of the cells of living bodies leading to cancer and hereditary defects. The frequency of the event, but not its severity, increases with an increase in the dose. For protection purposes, it is assumed that there is no threshold dose (unlike deterministic effect) for stochastic effect. Protective actions in terms of rescue and relief operations to minimise the stochastic effect in case of a nuclear/radiological emergency are not always advisable, especially when doses are of a very low level.

Tissue Weighting Factor

The tissue weighting factor is an ICRP multiplier used to determine the effective dose from the equivalent dose in one or more organs or tissues. The factor takes account of the different sensitivities of different organs and tissues for induction of stochastic effects from exposure to ionising radiation (principally, for induction of cancer). For example, tissue weighting factor of lungs is 0.12 while that of liver is 0.05. Tissue weighting factors for the entire body as whole is 1, meaning, thereby, that the weighting factor is unity when the body is irradiated uniformly

Triage

A rapid method utilising simple procedures to sort affected persons into groups, based on the severity of their injury and/or disease, for the purpose of expediting clinical care to maximise the use of available clinical services and facilities.

Yield

The energy released in a nuclear weapon explosion is called ‘yield’, which is usually measured in kilotons or megatons of TNT equivalent. One ton of TNT releases 4.2 billion joules of energy on detonation.

Executive Summary

Background

India has traditionally been vulnerable to natural disasters on account of its unique geo-climatic conditions and it has, of late, like all other countries in the world, become equally vulnerable to various man-made disasters. Nuclear and radiological emergencies as one such facet of man-made disasters are of relevance and concern to us.

Any radiation incident resulting in or having a potential to result in exposure and/or contamination of the workers or the public in excess of the respective permissible limits can lead to a nuclear/radiological emergency.

Sad memories of the use of nuclear weapons dropped on Hiroshima and Nagasaki, and the wide publicity given to the reactor accidents at Three Mile Island (TMI) in USA and Chernobyl in erstwhile USSR, have strongly influenced the public perception of any nuclear emergency or disaster to be most often linked, erroneously though, to only these events. Even though such situations may not easily be repeated, one must be prepared to face nuclear/radiological emergencies of lower magnitudes and ensure that the impact of such an emergency (which, for a given magnitude, is likely to be much greater today because of higher population densities coupled with an enhanced urban infrastructure due to economic prosperity) is always kept under control.

For improving the quality of life in society, India has embarked upon a large programme of using nuclear energy for generation of electricity. As on date, India has 17 power reactors and five research reactors in operation along with six power reactors under construction. It is also planned to explore setting up Thorium based reactors to meet its ever increasing energy needs. Further, the country utilises radioisotopes in a variety of applications in the non-power sector, viz., in the field of industry, agriculture, medicine, research, etc. Due to the inherent safety culture, the best safety practices and standards followed in these applications and effective regulation by the Atomic Energy Regulatory Board, the radiation dose to which the persons working in nuclear/radiation facilities are exposed to, is well within the permissible limits and the risk of its impact on the public domain is very low.

However, nuclear emergencies can still arise due to factors beyond the control of the operating agencies; e.g., human error, system failure, sabotage, earthquake, cyclone, flood, etc. Such failures, even though of very low probability, may lead to an on-site or off-site emergency. To combat this, proper emergency preparedness plans must be in place so that there is minimum avoidable loss of life, livelihood, property and impact on the environment.

Genesis of the National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies

There has been a paradigm shift in Disaster Management in India in the recent past. A large number of casualties and heavy economic losses experienced during past major natural disasters in the country have led to the realisation that development cannot be sustained unless the

Disaster Management activities are mainstreamed into the development work as a national priority. Accordingly, the Government of India has decided to adopt a proactive, multi-disciplinary and holistic approach in Disaster Management for building disaster resilience in all infrastructure and constructed work, to cope with both natural and man-made disasters. To usher in this paradigm shift in the national approach of Disaster Management, India has taken a defining step by enacting the Disaster Management Act in December 2005 with the formation of the National Disaster Management Authority as the apex body, with the Prime Minister as its Chairperson, and similar authorities in the states with the Chief Ministers as the Chairpersons. This will bring about better Disaster Management in the country which, in turn, would make development work sustainable. Also, District Disaster Management Authorities will be set up with the District Collectors as the Chairpersons with the elected representatives of the local bodies as the Co-chairpersons.

With this new mandate, the National Disaster Management Authority has assumed the responsibility of strengthening the existing nuclear/radiological emergency management framework by involving all the stakeholders in a holistic approach through a series of mutually interactive, reciprocal and supplementary actions to be taken on the basis of a common thread—the National Guidelines. Based on these Guidelines, Disaster Management plans will be drawn out by the stakeholders at all levels of administration.

To achieve this goal, a National Workshop on Nuclear Disaster Management was organised on 17 May 2006 by the National Disaster Management Authority where all the possible scenarios of nuclear/radiological emergencies were discussed in detail and the basic structure of the National Guidelines to handle both nuclear and radiological emergencies were agreed upon. Pursuant to that, the National Disaster Management Authority constituted a Core Group of Experts consisting of 20 specialists that included many experts from the Department of Atomic Energy. During the last year and a half, the Core Group deliberated the various technical and administrative issues to arrive at a national consensus during the course of eight meetings, in addition to many meetings that were held in smaller subgroups, to prepare the draft document of the Guidelines. The document was subsequently discussed at two National Workshops of the Extended Group of Experts consisting of approximately 40 members from various ministries of the Government of India, state governments, specialists from the Department of Atomic Energy, the Defence Research and Development Organisation, the National Technical Research Organisation, the Indian Army and Air Force, etc. The suggestions/comments of all the participants have been duly taken into account in preparing the Guidelines. This document has been finally discussed threadbare in a number of meetings with the senior officials of the Department of Atomic Energy and the Atomic Energy Regulatory Board. The final draft of the Guidelines, after incorporation of all the comments that emerged during these meetings, has the concurrence of the Department of Atomic Energy as well as the Atomic Energy Regulatory Board.

Nuclear/radiological emergencies being man-made in nature, maximum emphasis has been laid on the prevention of such emergencies without diluting other aspects of the disaster continuum. However, in the event of any such emergency taking place due to circumstances beyond control, these Guidelines recommend a series of actions on the part of the various stakeholders at different levels of administration that would (i) mitigate the accident at source;

(ii) prevent deterministic health effects in individuals and limit the probability of stochastic effects in the population; (iii) provide first aid and treatment of injuries; (iv) reduce the psychological impact on the population; and (v) protect the environment and property, all under the constraint of available resources.

Structure of the Guidelines

The Guidelines have been prepared to provide direction to the central ministries/ departments, state governments and local authorities for preparing detailed action plans to ensure inbuilt capabilities to handle nuclear and radiological emergencies as part of an all-hazard Disaster Management plan in the public domain.

The National Guidelines consist of 10 chapters that are briefly mentioned in the succeeding paragraphs:

Chapter 1 – Introduction: This provides a brief of all the possible scenarios of nuclear and radiological emergencies. After due consideration of the nature and consequences of all the possible scenarios, these emergencies have been broadly classified into the following five categories:

i) An accident taking place in any nuclear facility of the nuclear fuel cycle including the nuclear reactor, or in a facility using radioactive sources, leading to a large-scale release of radioactivity in the environment.

ii) A 'criticality' accident in a nuclear fuel cycle facility where an uncontrolled nuclear chain reaction takes place inadvertently, leading to bursts of neutrons and gamma radiations.

iii) An accident during the transportation of radioactive material.

iv) The malevolent use of radioactive material as a Radiological Dispersal Device by terrorists for dispersing radioactive material in the environment.

v) A large-scale nuclear disaster, resulting from a nuclear weapon attack (as had happened at Hiroshima and Nagasaki) which would lead to mass casualties and destruction of large areas and property.

Normally, nuclear or radiological emergencies (referred to in points (i) to (iv) above) are within the coping capability of the plant/ facility authorities. A nuclear emergency that can arise in nuclear fuel cycle facilities, including nuclear reactors, and the radiological emergency due to malevolent acts of using Radiological Dispersal Devices are the two scenarios that are of major concern. The impact of a nuclear disaster (scenario at [v]) will be well beyond the coping capability of the local authorities and it calls for handling at the national level.

As regards the vulnerability of various nuclear fuel cycle facilities to terrorists attacks, these facilities have elaborate physical protection arrangements in place to ensure their security. The structural design of these facilities ensures that even in the event of a physical attack, the structural barriers prevent the release of any radioactivity outside the plant area itself and hence the public are not likely to be exposed to radiation.

Because of their wide spread application, access to availability of radioactive sources has become easy. While their radioactive strength is in itself a deterrent to pilferage, the radioactive sources can still be stolen and used in a Radiological Dispersal Device or Improvised Nuclear Device. Essentially, a Radiological Dispersal Device is a conventional explosive device in which the radioactive material has been so added that, on its being exploded, there would be dispersal of radioactivity in the environment.

A Radiological Dispersal Device is not a Weapon of Mass Destruction; at worst it can be called a Weapon of Mass Disruption. Normally, the use of a Radiological Dispersal Device by itself would not result in fatalities due to radiation. The fatalities, if any, would primarily be due to the explosion. However, it may contaminate a reasonably large area, besides its main potential of causing panic and disruption.

There are well-established international treaties for the control of fissile materials, because of which the possibility of fissile material falling into the hands of terrorists is extremely low. However, if these treaties are violated through state-sponsored activities, access to fissile materials by terrorist groups cannot be ruled out.

Accidents during the transportation of radioactive materials are of low probability due to the special design features of the containers in which they are transported and special safety and security measures (to take care of all possible threats/eventualities, including the threat from misguided elements) which are laid down to be followed during actual transportation.

Backed by the legal mechanism, the main focus of these Guidelines is to institutionalise a holistic and integrated approach to the management of disasters at all levels and covering all components of the disaster continuum — prevention, mitigation, preparedness, response, relief, rehabilitation, reconstruction, recovery, etc. These also take into account the need to have a community which is well informed, resilient and geared up to face nuclear and radiological emergencies, if and when encountered.

Of all the possible types of nuclear and radiological emergencies described above, it is only the nuclear weapons attack (scenario [v]) by an adversary which could result in a large-scale disaster. Though the probability of a nuclear attack is low, there should be a plan in place to handle such an event, as it would have devastating consequences. The Standard Operating Procedures for responding to such a scenario are addressed separately in a classified document and are not a part of this document.

Chapter 2 – Approach to Nuclear and Radiological Emergency Management: This spells out a four-pronged strategy to be adopted for a holistic management of nuclear/radiological emergencies, viz.:

i) The Nuclear Emergency Management Framework will be supported on the prominent mainstay of strengths such as prevention, mitigation, compliance of regulatory requirements, preparedness, capacity development, response, etc. that constitute the Disaster Management continuum.

ii) The existing legal framework will be strengthened through various legal and regulatory means.

iii) The framework is to be institutionalised by identifying the stakeholders at various administrative levels with their respective responsibilities in a people-centric, bottom-up approach.

iv) The framework will be implemented through the strengthening of existing action plans, or by preparing new action plans at the national, state and district levels.

The Atomic Energy Regulatory Board is the nuclear regulatory authority in the country which, as per the Atomic Energy Act (1962), has the mandate for issuance of licenses to nuclear and radiological facilities and ensuring compliance with the applicable standards and codes.

The Atomic Energy Regulatory Board has powers to not only license the operation of a facility but also to order partial or full shutdown of any facility that violates its guidelines. It ensures that while the beneficial aspects of a nuclear programme and use of ionising radiation are fully exploited, their use does not cause undue risk to public health and the environment.

For the success of a nuclear emergency management programme, it is essential to develop an institutional framework which will transform the Guidelines into reality by preparing action plans and implementing them. Accordingly, for handling nuclear/radiological emergencies as part of an all-hazard approach for any type of disasters in the country, the following four types of administrative bodies have been instituted:

i) Creation of the National Disaster Management Authority at the National Level under the Chairmanship of the Prime Minister of India.

ii) Creation of State Disaster Management Authorities at the state level, under the Chairmanship of the Chief Ministers.

iii) Creation of District Disaster Management Authorities at the district level, under the Chairmanship of the District Collectors/ Magistrates, with the elected representative as the Co-chairpersons.

iv) Local authorities to also deal with mitigation, preparedness and response.

Chapter 3 – Present Status and Situation Analysis: This chapter highlights some of the technical and administrative issues yet to be addressed in a holistic approach, besides analysing the present status.

For responding to any nuclear/radiological emergency in the public domain, the Crisis Management Group of the Department of Atomic Energy activates the emergency response. It coordinates with the local authority in the affected area to provide technical inputs for effective response to such an emergency.

Based on the severity of the radiological conditions and their likely consequences, the emergencies at nuclear facilities are categorised as emergency standby, personnel emergency, plant emergency, on-site emergency and off-site emergency. Detailed plant-specific emergency response plans are in place at all the nuclear facilities and are functional for the entire lifetime of the facility. Barring off-site emergencies, all other emergency plans are the responsibility of the facility operator. The most critical type of emergency of a nuclear plant is an off-site emergency where members of the public may get affected. To cope with such an off-site emergency, detailed response plans are required to be put in place by the collector of the concerned district in coordination with the plant authorities. The Atomic Energy Regulatory Board does not permit the operation of a new or existing power plant or radiation facility unless preparedness plans are in place for the postulated emergency scenarios. It is also mandatory for the power plant operators to periodically conduct on-site and off-site emergency exercises.

For all radiation facilities outside the nuclear fuel cycle having the potential for high exposure, the Atomic Energy Regulatory Board has laid down guidelines which include safe design of equipment, operation within the permissible range of parameters and availability of a suitably qualified Radiological Safety Officer.

A network of 18 Emergency Response Centres has presently been established by the

Bhabha Atomic Research Centre to cope with radiological emergencies in the public domain, like transport accidents, handling of orphan sources, explosion of Radiological Dispersal Devices, etc. The task of these Emergency Response Centres is to monitor and detect radiation sources, train the stakeholders, maintain adequate inventory of monitoring instruments and protective gear, and provide technical advice to first responders and local authorities. Further expansion plans for Emergency Response Centres have been mandated in these guidelines.

The Bhabha Atomic Research Centre is also actively involved in training personnel from various paramilitary forces, particularly those from the National Disaster Response Force and Central Industrial Security Force.

This chapter also analyses the issues yet to be addressed to (i.e. the Gap Analysis) for putting the existing nuclear / radiological emergency management system on a holistic platform. Some of these gaps are indicated hereunder:

i) The fact that one cannot see, feel or smell the presence of radiation, coupled with a lack of credible and authentic information on radiation and radiation emergencies, there is a fear in the public mind that a small accident in a nuclear facility will lead to a situation like that at Hiroshima, Nagasaki or Chernobyl. These misconceptions of the general public can be removed only through conducting intense public awareness generation programmes in the country. Once people are sensitised on this issue, they are likely to accept a nuclear/radiological emergency like any other type of emergency.

ii) In the event of an off-site emergency situation, the emergency response plan envisages evacuation of the public from the affected zone. The availability of adequate transport vehicles and good motorable roads along the evacuation routes are the main issues to be tackled at the district level.

iii) Some emergency scenarios envisage sheltering a large number of people, and that calls for an adequate number of shelters/camping facilities to be identified.

iv) In case of a nuclear emergency, it is also likely that the food and water in the affected area are contaminated and hence become unsuitable for consumption. Accordingly, alternate sources of food and water have to be identified in advance and included in the plan.

v) In addition to the specially trained teams of the National Disaster Response Force, the involvement of civil defence personnel and home guards as the first responders, besides the police force, will be very useful.

vi) High-strength radioactive sources are used in industry and hospitals with very low possibility of loss of the sources. Even then, there is an urgent need to further strengthen the regulatory and security aspects in these areas.

vii) To cope with the increasing demand for Nuclear Power, in cases where private industry is involved in the nuclear power programme, regulatory authority must ensure that necessary knowledge-base does exist and expertise is available with the private industry concerned, to cope with any radiation emergency arising within and outside the plant.

viii) For a large and densely populated country like India, the 18 Emergency Response

Centres established so far by the Bhabha Atomic Research Centre are highly inadequate. Many more are to be set up as mandated in this document.

ix) To handle a nuclear emergency in the public domain, a large number of monitoring instruments and personal protective gear are needed. Presently, the holding of such items is very small and needs to be augmented to upgrade the capability to handle nuclear emergencies.

x) Because of very few cases of radiation related incidents, there are insufficient number of trained doctors in this field. It is, therefore, essential that a large number of doctors are trained to handle radiation related injuries. This capacity needs to be built on priority.

xi) A reliable communication set-up is one of the key elements in any response mechanism. Presently, the communication linkage between the district, state and national level stakeholders is not dedicated for Disaster Management.

xii) In the case of a large-scale nuclear disaster as a result of a nuclear attack, the population will be affected by the blast wave, burns and fire along with the effects of prompt as well as delayed radiations. In such situations, the persons carrying out the rescue and relief work are also likely to be exposed to high levels of radiation doses as well as contamination. Therefore, the radiation dose levels at which interventions can be made is urgently required to be established. Similarly, the values for the action levels are also to be made available for controlling the consumption of contaminated food in the affected area. These values are needed for handling both Radiological Dispersal Devices and nuclear emergencies/disaster cases.

xiii) For any major nuclear accident wherein the situation is beyond the coping capability of the civil administration, the services of the armed forces may be called for, to take over several critical functions. Civil-military coordination will thus be comprehensively developed so that the specially trained teams of armed forces personnel can be inducted to assist the civil administration.

A detailed programme to handle any type of nuclear/radiological emergency will be worked out initially for all cities with population of, say, 20 lakh or more and other vulnerable places. This cover will be progressively extended to cities with a population of approximately 10 lakh or more after three years and on completion of the first phase. This preparedness acquires an even more important dimension for the metros in the country.

Chapter 4 – Prevention of Nuclear/ Radiological Emergencies: This chapter enumerates how nuclear and radiological emergencies are prevented in nuclear facilities by adopting the defence-in-depth approach, where the safety systems are inbuilt with adequate redundancy and diverse working principles. Several levels of protection and multiple barriers prevent the release of radioactive material into the public domain. Defence-in-depth is structured in five levels. Should one level fail, subsequent levels come into play automatically. Further, the engineered systems are inbuilt and operated by adopting the best available technologies and practices during various phases of the lifetime of the facilities. Even though such practices are already in place at all the nuclear facilities in the country, there is the scope and need for further strengthening the arrangement in the light of newer threat perceptions.

'Criticality' control is an issue which is unique to nuclear fuel cycle facilities. It is prevented by proper design of the facility and strict adherence to safety norms during operation. This aspect has been well taken care of in nuclear installations in the country.

To prevent accidents during the transportation of radioactive material, the regulatory guidelines specify the design of the container, the quality control tests, the manner in which the radioactive material will be handled and transported, etc. During actual transportation, other restrictions like the speed of the transport vehicle, the type of physical protection, etc., are also imposed.

Radiological accidents can take place at locations/facilities involving the use of radiation or radioactive sources, viz., industry, medicine, agriculture and research. The regulatory guidelines of the Atomic Energy Regulatory Board ensure the application of necessary safety standards for the prevention of such accidents.

The main step to prevent a Radiological Dispersal Device or Improvised Nuclear Device incident is to ensure implementation of the regulatory requirements regarding security and safety of radioactive sources throughout the country. This will be backed by administrative measures to prevent smuggling or illicit trafficking of the radioactive materials.

Chapter 5 – Mitigation of Nuclear/ Radiological Emergencies: This explains the various engineered safety features and accident management procedures that are in place in a nuclear plant as accident mitigation measures for minimising the impact of a nuclear emergency by keeping the radioactivity release in the environment to levels as low as possible. The application of the defence-in-depth concept in a nuclear facility ensures three basic safety functions, viz., controlling the power, cooling the fuel and confining the radioactive material, so that even in case of an emergency the radioactive materials do not reach the public or the environment. The inbuilt safety measures, including biological shields, safety systems and interlocks, safety audits, operations strictly following safety procedures, etc., mitigate the consequences of accidents, if any.

Chapter 6 – Preparedness for Nuclear/ Radiological Emergencies: This chapter covers the various aspects of preparedness for nuclear/radiological emergencies. The planning and preparedness for response to nuclear/ radiological emergencies will be integrated in an all-hazards approach with the planning for response to all types of conventional emergencies.

It is mandatory for the nuclear facilities to have a comprehensive emergency preparedness plan for on- and off-site emergencies. For handling an off-site emergency in a nuclear power plant, there are off-site emergency committees headed by the collector of the concerned district and supported by district subcommittees which ensure implementation of countermeasures such as, sheltering, prophylaxis, evacuation, resettlement including providing civil amenities and maintaining law and order. All these activities are guided and controlled from a pre-designated emergency response centre located outside the boundary of the nuclear facility.

The quality of the required emergency preparedness is maintained by periodic training courses for on-site and off-site administrative personnel, including state government officials and various other stakeholders. Also, the primary evaluation of the same is based on periodic mock-drills and exercises.

A large number of organisations/agencies like the police, fire and emergency services, medicos, paramedicos, non-governmental organisations, civil defence and home guards, etc., have to be fully integrated into the nuclear emergency programmes both at the state and district levels. State governments will undertake actions in a proactive manner to establish formal linkages of these organisations with the nearest Emergency Response Centre.

In the handling of any nuclear/radiological emergency, the foremost requirement is the availability of instruments for radiation detection and monitoring. A sufficient inventory of radiation monitoring instruments and protective gear will be built up by all State and District Disaster Management Authorities and the selected first responders will be trained in their use.

Four battalions of the National Disaster Response Force are being trained to provide specialised response during nuclear/radiological emergencies. In addition, there are four more NDRF battalions which can provide a supporting role.

Chapter 7 – Capacity Development for Nuclear/Radiological Emergencies: This deals with the capacity development for coping with nuclear/radiological emergency situations. This capacity needs to be enhanced at all levels, which calls for requisite financial, technical, and infrastructural supports.

The confidence level in the community to handle any nuclear/radiological emergency can be enhanced only through education and awareness generation and preparedness. The main focus will be on the student community, which is the most effective segment of the society, to spread disaster awareness in the community. The topics pertaining to radiation, effects of radiation, nuclear/radiological emergencies etc., will be included in the syllabi at the school and college levels nationwide.

In recent years, the corporate sector in India has shown willingness to support disaster relief programmes and infrastructure building in the country as part of their social responsibility. The modalities for the type of help that they can render and are volunteering for, will be worked out by the National Disaster Management Authority/states concerned, in consultation with them.

Since the number of radiation applications in various areas is growing continuously along with the growth of the nuclear power programme, the Atomic Energy Regulatory Board will analyse the need of opening regional regulatory centres to share the volume of regulatory work by decentralising and delegating the regulatory powers.

Chapter 8 – Response to Nuclear/Radiological Emergencies: This describes the action to be taken in nuclear/radiological emergencies.

The response to a nuclear/radiological emergency in a nuclear facility has many elements in common with the response to other man-made and natural disasters, in terms of services like medical, fire and emergency services, police, civil defence, etc. However, some special features of nuclear emergencies need to be taken care of additionally.

The response to an emergency will always be commensurate with the level of the hazard.

Timely and effective medical response is a crucial component in reducing morbidity and mortality on the one hand and alleviating fear and suffering of the affected population on the other hand.

i) In this context, the Ministry of Health and Family Welfare and the health departments of the concerned states will activate their respective Emergency Support Action Plans.

ii) If required, the district hospitals will deploy their Quick Reaction Medical Teams to assist the specialised teams of response forces at the national, state and district levels in providing necessary help in decontamination, triage, administration of de-corporating agents, basic and advance life-support, etc.

Chapter 9 – Implementation of the Guidelines: This spells out preparation of Action Plans by various levels of stakeholders. Such plans will indicate the detailed work plan and milestones with recommended time-frame and suitable indicators to enable monitoring and review of the actual progress made.

Like conventional disaster management plans, the nuclear/radiological emergency plan is also to be implemented following a bottom-up approach, where the community, in association with individuals, non-governmental organisations, community based organisations, private sector, etc., will develop and implement the emergency management programme tailored to their local needs.

The main stakeholders in nuclear emergency response are the Ministries of Home Affairs, Defence, Health and Family Welfare, Transport, Railways, Civil Aviation, Urban Development, Earth Sciences, Petroleum and Natural Gas; and Departments of Atomic Energy, Space, India Metrological Department and other concerned central and state departments; scientific and technical institutes; professional bodies; non-governmental organisations; corporate sector; and the community.

The central government, state governments and local authorities will be responsible for ensuring speedy implementation of these Guidelines.

The National Disaster Management Authority, as the apex body, is responsible for each of the three phases of disaster management continuum with six major responsibilities viz., pre-disaster (prevention, mitigation and preparedness), during disaster (rescue and relief) and post-disaster (rehabilitation and reconstruction) scenarios. National Disaster Management Authority will be assisted by the National Executive Committee, which is the executive arm of National Disaster Management Authority. Immediate response and relief operations will be carried out by the National Crisis Management Committee/National Executive Committee on behalf of the National Disaster Management Authority. The preparation of action plan at macro-level will be carried out by the National Crisis Management Committee /National Executive Committee with technical assistance from the Department of Atomic Energy.

The District Management Authorities of States/Union Territories will be responsible for implementing the nuclear/radiological disaster risk management programmes in their respective areas. Each state will develop a detailed micro-level action plan in a mutually interactive and supplementary mode with its district level plans.

The implementation schedule at national/state level will be in three phases:

The short term plan (0–3 years) envisages capacity development through education and awareness generation, training and community participation, etc., for upgradation of human resources, establishment of critical infrastructure like expansion of the network of Emergency Response Centres, communication systems, strengthening of regulatory framework, and emergency medical preparedness including formation of Quick Reaction Medical Teams, etc.

The medium term plan (0–5 years) includes further upgradation of all the infrastructure, enhancement of regulation and extension of the risk reduction framework, enhanced preparation for better response with a well-informed and trained community, etc.

The long term plan (0–8 years) includes, inter alia, the capacity development to the optimum level with preparedness and response mechanisms fully integrated up to the community level. Establishment of secondary and tertiary care units for treatment of radiation exposure cases is another priority area.

The objectives and targets indicated in these Guidelines are considered desirable and attainable. The non-structural measures will be implemented in accordance with the defined timelines. As far as the structural measures are concerned, their implementation schedule may be reviewed, where inescapable, at the time of formulation of plans, subject to availability of financial resources, technical manpower, etc. However, changes required, if any, will be discussed by the authorities concerned with the National Disaster Management Authority on a case to case basis.

Chapter 10 – Summary Of Action Points: This sums up the major recommendations that have been made in the text of the National Guidelines, that are to be complied with by the stakeholders at various levels of the administrations. The consolidation of the major recommendations have been made for the ease of reference to the stakeholders for their compliance, without compromising the need for implementation of all the recommendations made in the various chapters of the Guidelines that are essential to ensure management of nuclear and radiological emergencies with a holistic approach.

1 Introduction

1.1 Introduction

Since times immemorial, mankind has been continuously exposed to naturally occurring ionising radiation. However, it was only towards the end of the nineteenth century that human beings became aware of it, when X-rays were discovered in 1895 by Wilhelm Roentgen and radioactivity in uranium salts was discovered by Henri Becquerel in 1896. This was followed by the discovery of nuclear fission by German chemists Otto Hahn and Fritz Strassman in 1939 and the demonstration of a self-sustaining chain reaction in natural uranium oxide in a graphite pile by Enrico Fermi in 1942. Since then, there has been an exponential growth in the application of nuclear science and technology in the fields of power generation, medicine, industry, agriculture, research and defence. Today there are about 440 nuclear power reactors operating in 31 countries, meeting 16% of the world's electricity needs, with contribution in some countries ranging from 20% to 70%. As on date, 17 power reactors and five research reactors are in operation in India, six power reactors are under construction, and plans exist to set up thorium-based reactors to meet the ever-increasing energy needs. Further, India uses nuclear radiation in a variety of applications in the fields of medicine, industry, agriculture and research. The phenomenal growth in the applications of radioisotopes and radiation technology has helped in improving the quality of life of the human race. India is also one amongst the seven declared nuclear weapon states which uses nuclear technology for strategic purposes.

The dreadful memory of the use of nuclear weapons in 1945 by USA on Hiroshima and Nagasaki in Japan and the wide publicity given to the reactor accidents at Three Mile Island (TMI) in USA and Chernobyl in erstwhile USSR has strongly influenced the public perception of any nuclear emergency to be linked most often, though erroneously, to only these events.

It is a matter of fact that applications of nuclear energy/radioisotopes are among the world's best regulated ones, with the highest safety record because of the best safety practices and standards followed in these applications the world over. An analysis of nearly 140 major radiation related accidents that have occurred worldwide during the period 1960–2005, shows that these have resulted in about 150 fatalities attributable to radiation—a number which is quite small, though not desirable—compared to more than 5,000 fatalities in coal mine accidents or 1.2 million deaths in automobile accidents taking place worldwide every year.

Nuclear plants, in general, adopt a defence-in-depth approach and multiple physical barriers to ensure that radioactivity is contained at all times. However, a finite number of very low probability events are postulated to occur, releasing radioactivity into the environment. Consequently, emergency preparedness and response plans are in place to cope with nuclear or radiological emergency scenarios ranging from minor incidents like a small spillage of radioactive material to a major nuclear accident releasing large-scale radioactivity (like Chernobyl) in the public domain.

There could also be malevolent acts like the explosion of a Radiological Dispersal Device (RDD), commonly known as a 'dirty bomb', by a terrorist group or a large-scale nuclear disaster resulting from a nuclear attack by an adversary.

Some important applications of radioactive materials are given in Annexure 1. Because of their widespread applications, the availability of radioactive sources has become more common which can lead to their possible use for malevolent purposes. Some such areas of concern are also given in Annexure 1.

As the programme on nuclear power generation expands along with a similar growth in application of radioisotopes in the areas of medicine, industry, agriculture and research (along with the associated security threat as mentioned above), it is essential that a holistic emergency/disaster management plan be in place to respond to all such eventualities.

1.2 Aims of the Guidelines

The aims of the guidelines are to develop plans, through a consultative approach involving all the stakeholders, that will lead to a society wherein the occurrence of nuclear and radiological emergencies are prevented and, in rare cases if they do occur, there is minimum risk to human health, life and the environment.

The main focus is to institutionalise the implementation of the initiatives and activities covering all components of the disaster continuum, viz., prevention, mitigation, preparedness, response, relief, rehabilitation, reconstruction, etc., by converting the guidelines into action plans by the respective stakeholders. This will lead to building a community which is well informed, resilient and geared to face nuclear and radiological emergencies, if any, with minimal loss of life, livelihood and property. The community will thus be able to face a disaster calmly, recover quickly and build back better in the post-event scenario.

The central government, state governments, local authorities and other stakeholders concerned will be responsible for ensuring speedy implementation of these guidelines.

1.3 Objectives of the Guidelines

The overall objective of this document on Nuclear and Radiological Emergency Guidelines is the realisation of the vision of the nation of putting the concept of prevention of nuclear and radiological emergencies into practice. However, in rare cases of their occurrence due to factors beyond human control, such emergencies will be managed through certain pre-planned and established structural and non-structural measures by the various stakeholders in a manner that will minimise risks to health, life and the environment.

Like many countries in the world, India has a major programme for using nuclear energy for the generation of electricity and radioisotopes in industry, medicine, agriculture, etc., for improving the quality of life of the people. Due to the inculcation of a safety culture and effective regulation by the Atomic Energy Regulatory Board (AERB), the radiation dose to which people working in these nuclear facilities are likely to be exposed, is normally well within the permissible limits and the risk of any adverse impact of radiation in the public domain is extremely low. However, there might be instances when the personnel in these facilities are exposed to high radiation doses due to the failure of safety systems and/or occasionally due to lack of proper safety precautions. Such failures, even though of very low probability, may lead to an off-site emergency situation leading to an adverse impact on the people and the environment. The possibility of such an emergency scenario also exists due to the malevolent acts of terrorist or antisocial elements.

While well-developed emergency response plans are in place at all Nuclear Power Plants (NPPs) to cope with nuclear emergencies, there is also the need to establish a well-developed nuclear/radiological emergency management plan in the public domain to cope with such unforeseen emergencies.

The basic objective of this document is to provide guidelines which are to be converted into action plans (including Standard Operating Procedures [SOPs]) by all the concerned stakeholders for the activities in the nuclear emergency continuum in general and those required to prevent any nuclear/radiological emergency in particular. This document also provides the guidelines to the various stakeholders that include the community at large, for getting prepared proactively to handle any nuclear and radiological emergency scenario so as to prevent the deterministic health effects of radiation in individuals and to limit the stochastic health effects in members of the public.

1.4 Scope of the Guidelines

These guidelines deal with nuclear/radiological emergencies and their objective is to ensure that such emergencies, should they occur, are effectively managed in a manner that the necessary mitigation measures are taken promptly and the impact of the incident on the public domain is kept to the minimum.

However, there is always the remote possibility of a major nuclear disaster resulting from a nuclear weapon attack. For obvious reasons, the SOPs for responding to this scenario have been addressed separately in a classified document. For the sake of completeness, however, some of the general aspects of this scenario have also been covered in these guidelines.

1.5 Nuclear and Radiological Emergency/Disaster Scenarios

Any radiation incident resulting in, or having a potential to result in, exposure to and/or contamination of the workers or the public, in excess of the respective permissible limits (given in Annexure 4) can be termed as a nuclear/radiological emergency. These emergencies, which are usually well within the coping capability of the plant/facility authority (along with neighbouring administrative agencies, if required) can be broadly classified in the following manner:

i) An accident taking place in any nuclear facility of the nuclear fuel cycle including the nuclear reactor, or in a facility using radioactive sources, leading to a large-scale release of radioactivity in the environment.

ii) A 'criticality' accident in a nuclear fuel cycle facility where an uncontrolled nuclear chain reaction takes place inadvertently leading to bursts of neutrons and gamma radiation (as had happened at Tokaimura, Japan).

iii) An accident during the transportation of radioactive material.

iv) The malevolent use of radioactive material as RDD by terrorists for dispersing radioactive material in the environment.

v) A large-scale nuclear disaster resulting from a nuclear weapon attack (as had happened at Hiroshima and Nagasaki in Japan) which would lead to mass casualties and destruction of large areas and properties. Unlike a nuclear emergency, the impact of a nuclear disaster is beyond the coping capability of local authorities and calls for handling at the national level.

In this context, it may be mentioned that the International Atomic Energy Agency (IAEA) classifies the above emergency scenarios under two broad categories—nuclear and radiological:

i) A nuclear emergency refers to an emergency situation in which there is, or is presumed to be, a hazard due to the release of energy along with radiation from a nuclear chain reaction (or from the decay of the products of a chain reaction). This covers accidents in nuclear reactors, 'criticality' situations in fuel cycle facilities, nuclear explosions, etc.

ii) All other emergency situations which have the potential hazard of radiation exposure due to decay of radioisotopes, are classified as radiological emergencies. Examples of such emergencies are the accidents that took place at Goiania in Brazil, San Salvador, Istanbul in Turkey, Panama, etc.

A brief description of different nuclear/ radiological emergency scenarios is given in the succeeding paragraphs.

1.5.1 Accidents in Nuclear Power Plants and Other Facilities in the Nuclear Fuel Cycle

The nuclear fuel cycle covers the entire range of activities associated with the generation of nuclear power, including uranium mines and mills, fuel fabrication facilities, NPPs, reprocessing plants and radioactive waste management facilities. India is one of the few countries which encompass all the activities of the nuclear fuel cycle.

Nuclear emergency scenarios at various nuclear fuel cycle facilities may arise due to the failure of multiple barriers, which include systems, equipment and human errors.

A national regulator, which in India's case is the AERB, stipulates on-site or off-site emergency level depending on whether the radioactivity is confined within the fence of the facility or crosses the facility boundary and enters into the public domain.

1.5.2 'Criticality' Accidents

These refer to incidents taking place at facilities other than a nuclear reactor (where the fission is normally intended to occur for power generation). 'Criticality' accidents occur when an uncontrolled nuclear chain reaction takes place inadvertently at facilities handling high-grade fissile material such as enriched uranium or plutonium, releasing bursts of neutrons and gamma radiation. Though the possibility is remote, the 'criticality' situation may arise due to breach of safety procedures that lead to vital changes in system parameters like mass, volume and shape. It may even happen due to some moderator or reflector material being inadvertently brought near or added to the system. It could cause induced radioactivity in the surroundings and also release radioactive material in the immediate vicinity. All these are dangerous for the people working nearby who could even face the risk of injury or fatality. It may be noted that these events are not nuclear explosions.

The effects of such accidents would be confined to the facility itself or, at the most, extend to the limited area surrounding the facility. The general public is not likely to be affected by such accidents.

1.5.3 Accidents during Transportation of Radioactive Materials

Depending on the nature of the radioactive material, its strength and its dispensability, there are statutory requirements with regard to the types of packages to be used to ensure their safe transportation. These packages (for transportation) are designed and subsequently certified through actual tests with scaled-down models to ensure that even in the event of an accident, the release of radioactivity from these packages does not lead to radiation exposure in the public domain beyond the prescribed limits.

For example, the containers used for transportation of high-strength radioactive materials like nuclear spent fuel are designed to withstand severe shock, fire, drop from a height etc., and additional constraints are imposed on the speed of the transport vehicle along with adequate physical protection by special security forces to take care of all possible threats/ eventualities, including the threat from misguided elements.

Though such accident scenarios are of low probability due to special design features and built-in physical protection systems, there will be some emergency scenarios that might lead to enhanced radioactive levels in the public domain and these need to be addressed with appropriate response plans in place.

1.5.4 Accidents at Facilities using Radioactive Sources

With the increase in applications of radiation in medicine, food preservation, industry and research, there will be a large number of radioactive sources in the public domain. These will range from the relatively low intensity sources used in nucleonic gauges to large sources used in industrial irradiators for sterilisation of medical products, preservation of food, etc. The mishandling of such sources, their loss during use or transportation, or accidents like a fire in the building where the source is housed/used, could result in a radiation emergency with the possibility of radiation exposure to the public.

1.5.5 Disintegration of Satellites during Re-Entry

Satellites which orbit the earth keep slowly falling back and may sometimes disintegrate when they re-enter the earth's atmosphere. The possibility of their disintegrated parts falling on a country is extremely low as is the subsequent possibility of causing widespread radioactive contamination (when such satellites use radioactive materials as a power source). For a country like India with a large landmass, the possibility of one of these nuclear powered satellites disintegrating over its landmass should be considered as a distant reality, and hence there is a need to have plans in place to respond to such an emergency. However, for all practical purposes, such an emergency can be handled in the same manner as that adopted in an emergency involving radioisotopes.

1.5.6 Nuclear/Radiological Terrorism and Sabotage at Nuclear Facilities

In the emerging security scenario, the possibilities of nuclear terrorism by use of an Improvised Nuclear Device (IND) or RDD or the sabotage of a nuclear facility are the emergency scenarios that need to be addressed.

The acquisition of the requisite quantity of high-grade fissile materials (uranium-235 or plutonium-239) needed for producing an IND is not an easy task. It is extremely difficult to acquire the quantity required, since these materials are kept in highly secured places the world over. However, such materials may be procured outside the country in a clandestine manner if supported by a terrorist group or backed up by a state-sponsored programme. If the clandestinely procured material is brought into the country, there is some probability, though very low, of diverting the same for an IND.

As mentioned earlier, radioactive sources are widely used for various applications. While their radioactive strength is in itself a deterrent to being stolen, still, they have the potential of being stolen and used in an RDD, which is a conventional explosive device in which some radioactive material has been mixed such that, on its being exploded, there would be dispersal of radioactivity in the public domain. An RDD does not involve any atomic or nuclear explosion and hence it is not a Weapon of Mass Destruction (WMD). At worst it can be called a weapon of mass disruption. Detailed analysis shows that use of RDD would not give rise to any significant radiological problem. However, the radioactive contamination due to dispersal of radioactive material, though not of any major radiological significance, has the potential of causing panic and denial of access for a significant time period to the area around the location of the explosion. It has to be recognised that the use of an RDD by itself would not result in fatalities due to radiation. The fatalities, if any, would primarily be due to the explosion. Emergency response measures would need to be in place to respond to such situations.

As regards the vulnerability of nuclear fuel cycle facilities like nuclear reactors, fuel fabrication facilities, reprocessing facilities, etc., to terrorists attack, these units have elaborate physical security arrangements in place to ensure their security. The structural design of these facilities ensures that even in the event of a physical attack, the structure would prevent the release of any radioactivity into the public domain. In case of nuclear reactors, even in the remote likelihood of these being breached, it would automatically result in the safe shutdown of the reactor by itself. It is well recognised that the assistance of an insider is essential for carrying out any such sabotage. Systems are in place to detect such acts, though an act of sabotage can never be ruled out completely.

1.5.7 State-Sponsored Nuclear Terrorism

There are well-established international treaties for the control of fissile materials because of which the possibility of nuclear fissile material falling into the hands of terrorists is extremely low. However, if international treaties are violated through state-sponsored activities, access to fissile material by nuclear terrorists cannot be ruled out. Because of the inherent characteristics of such fissile materials, these can be smuggled in unless very elaborate arrangements to detect them are made at various entry points to the country. Once accessible to terrorists, these can be utilised either through an IND or RDD.

1.5.8 Explosion of Nuclear Weapons

While all possible forms of radiation hazards described above would essentially result in a nuclear or radiological emergency (unless an accident leads to the release of a very large quantity of radioactivity in the public domain), the explosion of a nuclear weapon will result in a large-scale nuclear disaster which will be well beyond the scope of this document as understood by the use of the term ‘emergency’. The effects of a nuclear explosion depend upon the yield and type of weapon, the height of the burst (ground, air, upper atmosphere or water), location of the burst (ground zero), time of the burst and prevailing meteorological conditions at various heights. The explosion energy is transferred to the surrounding medium in three distinct forms, viz., blast, thermal and nuclear radiations (as explained in Annexure 3). Further details on these effects are provided separately in a classified document.

Given the current socio-political scenario and the lessons learnt from the past history of nuclear attacks, the probability of a nuclear attack is low. However, a comprehensive plan will be in place to handle even such a low probability event, particularly because of the devastating consequences of such an attack.

Unlike the management of radiation emergencies and natural disasters which essentially adopt the 'bottom-up' approach (where the response starts at the local level to begin with), a nuclear attack will require a 'top-down' approach through a well-established trigger mechanism where the National Crisis Management Committee (NCMC) will have a major role to play.

The Standard Operating Procedures (SOPs) 'to handle the aftermath of a nuclear attack' have already been put in place by the Nodal Ministry in a separate classified document. The assessment of an early scenario of a nuclear disaster with respect to type, yield, location of the burst, etc., plays a deciding role in the management of the aftermath of a nuclear attack.

1.5.9 Nuclear Medicine

Nuclear medicine is a branch of medicine where radioisotopes are used both for diagnostic and therapeutic purposes. For diagnosis, a radioactive substance is administered to the patient and the radiation emitted from the radioactive substance localised in the body is measured. Sources like Iodine-131, Technetium-99, etc., which emit low-energy radiation with low half-life ranging from minutes to days are used for such purposes. Similarly, in another advanced diagnostic technique, viz., Positron Emission Tomography (PET), very low-energy positron emitters which have a half-life of few hours are used. Therefore, the radioactive sources used in diagnostic applications have hardly any damage potential and terrorists are unlikely to use such sources.

In the field of therapy, especially for the treatment of cancer, high-strength and long half-life sources like Cobalt-60 are used. Such sources are normally not purchased from the vendor of the Cobalt therapy machine but from a radiological facility in the country that installs the sources in the machines under the direct supervision of the National Regulatory Authority. Once the source is installed in the machine, it will be very difficult to have unauthorised access to it. Also the high strength of the source, measuring up to thousands of curies, is by itself a deterrent. After the useful life of the source, it is sent to the appropriate unit of the Department of Atomic Energy (DAE) for its proper disposal. Under these circumstances, terrorists will not have easy access to these sources from Cobalt therapy machines.

In the light of above, use of radiation sources in the field of nuclear medicines is unlikely to lead to any nuclear/radiological emergency.

1.6 Need for a Comprehensive National Radiation Emergency Management System

In the light of the potential nuclear emergency/disaster scenarios listed above, there is an urgent need to strengthen the existing system along with developing a comprehensive National Radiation Emergency Management Plan

(NREMP). A robust platform of NREMP, based on a holistic approach with sustained inputs from front-level multi-disciplinary Research and Development (R&D) work, would go a long way in building a proper Disaster Management (DM) system in the country.

It is well recognised that emergency/disaster management is the quick and effective utilisation of all available and mobilised resources in a coordinated manner at all stages of the DM cycle that would result in minimal loss of life, livelihood and property. A typical DM cycle for nuclear or radiation emergencies, like that in the case of all types of disasters, will have six major constituents covering the various phases of DM—the pre-disaster phase, which includes prevention, mitigation and preparedness; and a post-disaster phase that includes fast response to the emergency to achieve the targeted goals of rescue and relief, rehabilitation and reconstruction.

It may be noted that for Indian NPPs, exhaustive preparedness plans are in place to cope with situations arising out of eventualities of accidents, if any.

1.7 Paradigm Shift in Disaster Management in India

The vulnerability to disasters is high in India due to the high population density, fast growing urbanisation, industrialisation and also partly due to the poor economic condition of people. The situation is further aggravated because some coastal areas (241 out of 612 districts) of the country are prone to multi-hazard risks. Floods, droughts, cyclones, earthquakes and landslides have been recurring phenomena in India, leading to extensive loss of life, livelihood and property.

The primary reason for such heavy losses can be attributed to the reactive and response-centric approach adopted in the erstwhile DM activities without assigning due importance to the pre-disaster activities of prevention, mitigation and preparedness in a proactive and holistic manner. The earlier response-centric approach towards the affected communities/ areas has not only been unsustainable but has also somewhat adversely affected the sustained development of the country.

It has been well realised over the past few years that development cannot be sustained unless the DM activities are mainstreamed into the development programme of the country as a national priority. After the super cyclone in Orissa in 1999, the Bhuj earthquake in January 2001 and tsunami in the Indian Ocean in December 2004, the Government of India has decided to adopt a multi-disciplinary and proactive approach in DM for building holistic capabilities to cope with both natural and man-made disasters. To bring about a paradigm shift in the national approach to the handling of DM in the country, India has taken a defining step in the legislature history of the country by setting up the National Disaster Management Authority (NDMA) headed by the Prime Minister, through an Act of Parliament. This Act got the consent of the President on 23 December 2005. Its aim is to initiate a holistic and integrated approach to DM in the country. The holistic, multi-disciplinary and integrated approach of NDMA in DM at all levels aims to mainstream DM into a developmental effort.

1.8 Highlights

Some of the highlights of this chapter are given below:

i) The dreadful memory of the use of nuclear weapons in 1945 by USA on Hiroshima and Nagasaki in Japan, along with the wide publicity given to the reactor accidents at Three Mile Island

(TMI) in USA and Chernobyl in erstwhile USSR, has had a strong influence on the public perception of any nuclear/ radiological emergency being linked most often, though erroneously, only to these events.

ii) The aims of the guidelines are to develop plans through a consultative approach involving all the stakeholders, that will lead to a society wherein the occurrence of nuclear and radiological emergencies are prevented and, in rare cases if they do occur, minimise the risk to human health, life and the environment.

iii) The overall objective of this document on Nuclear and Radiological Emergency Guidelines is the realisation of the vision of the nation of putting the concept of prevention of nuclear and radiological emergencies into practice. However, in rare cases of their occurrence due to natural or man-made factors beyond human control, such emergencies will be managed through certain pre-planned and established structural and non-structural measures by the various stakeholders, so as to minimise risks to health, life and the environment.

iv) There is always a remote possibility of a major nuclear disaster resulting from a nuclear weapon attack. For obvious reasons, the SOPs for responding to such a scenario have been addressed separately in a classified document by the Nodal Ministry.

v) Any radiation incident resulting in, or having the potential to result in, exposure to and/or contamination of the workers or the public in excess of the respective permissible limits, can be termed as a nuclear/radiological emergency. These emergencies, which are usually well within the coping capability of the plant/ facility authority (along with neighbouring administrative agencies, if required), can be broadly classified in the following manner:

a. An accident taking place in any nuclear facility of the nuclear fuel cycle, including the nuclear reactor or in a facility using radioactive sources, leading to a large-scale release of radioactivity in the environment.

b. A 'criticality' accident in a nuclear fuel cycle facility where an uncontrolled nuclear chain reaction takes place inadvertently leading to bursts of neutrons and gamma radiations (as had happened at Tokaimura, Japan).

c. An accident during the transportation of radioactive material.

d. A malevolent use of radioactive material as RDD by terrorists for dispersing radioactive material in the environment.

e. A large-scale nuclear disaster resulting from a nuclear weapon attack which would lead to mass casualties and destruction of large areas of land and property. Unlike a nuclear emergency, the impact of a nuclear disaster is beyond the coping capability of the local authorities and such a scenario calls for handling at the national level.

vi) The nuclear emergency scenarios at various nuclear fuel cycle facilities may arise due to failure of multiple barriers, which include systems, equipment and human errors.

vii) Though the possibility is remote, the 'criticality' situation may arise due to a breach of safety procedures that lead to vital changes in system parameters like mass, volume and shape. All these will be dangerous to the nearby personnel who could even face the risk of injury or fatality. It may be noted that these events are not nuclear explosions. The effects of such accidents would be confined to the facility itself and, at the most, may extend to the limited area surrounding the facility. The general public is not likely to be affected by such accidents.

viii) In the emerging security scenario, the possibilities of nuclear terrorism by the use of an IND or RDD or the sabotage of a nuclear facility, are the emergency scenarios that need to be addressed.

An RDD is not a weapon of mass destruction; at worst, it can be considered as a weapon of mass disruption where the radioactive contamination due to the dispersal of radioactive material, though not of any major radiological significance, has the potential of causing panic and denial of access for a significant time period to the area around the location of the explosion. It has to be recognised that the use of an RDD by itself would not result in fatalities due to radiation. The fatalities, if any, would primarily be due to the explosion.

ix) There are well established international treaties for the control of fissile materials because of which the possibility of nuclear fissile material falling into the hands of terrorists is extremely low. However, if international treaties are violated through state-sponsored activities, access to fissile material for nuclear terrorism cannot be ruled out. Because of the inherent characteristics of such fissile materials, these can be smuggled in, unless very elaborate arrangements to detect them are made at various entry points to the country. Once accessible to terrorists, these can be utilised either through an IND or RDD.

x) The containers used for transportation of high-strength radioactive materials like nuclear spent fuel, are designed to withstand severe shock, fire, drop from a height, etc., and additional constraints are imposed on the speed of the transport vehicle, along with adequate physical protection by special security forces to take care of all possible threats/ eventualities, including a threat from misguided elements.

xi) Unlike the management of radiation emergencies and natural disasters which essentially adopt the 'bottom-up' approach (where the response starts at the local level), a nuclear attack will require a 'top-down' approach through a well-established trigger mechanism where NCMC will have a major role to play.

The SOPs 'to handle the aftermath of a nuclear attack' have already been put in place by the Nodal Ministry in a separate classified document.

xii) For Indian NPPs, exhaustive preparedness plans are in place to cope with situations arising out of eventualities of accidents, if any.

2 Approach to Nuclear and Radiological Emergency Management

2.1 Strategies for Nuclear Emergency Management

As India's nuclear energy programme grows in both the power and non-power sectors, the nuclear emergency management approach in the country will be so formulated that the radiation exposure to occupational workers and the public and the release into the environment are not significantly beyond the permissible limits. Towards this goal, the existing nuclear emergency management approach in the country will be periodically reviewed and strengthened, as necessary, based on the following four-pronged strategy.

i) Support the nuclear emergency management framework on some prominent mainstays of strength like prevention, mitigation, compliance with regulatory requirements, capacity building, etc. (Figure 2.1). The existing DAE framework, needs to be further strengthened, wherever necessary, and established in all future facilities in line with the guidelines being issued in this document.

ii) Strengthen the existing legal framework through various legal and regulatory means.

iii) Institutionalise the DM framework by identifying the various agencies with their respective responsibilities in a people-centric, bottom-up approach (except the top-down approach in case of a nuclear disaster arising either from a large-scale release of radioactivity from a nuclear facility or from a nuclear weapon attack by an adversary).

iv) Implement the nuclear emergency management framework through close monitoring of the existing action plans or those to be prepared at the national, state and district levels in the country for future facilities in line with the guidelines being issued.

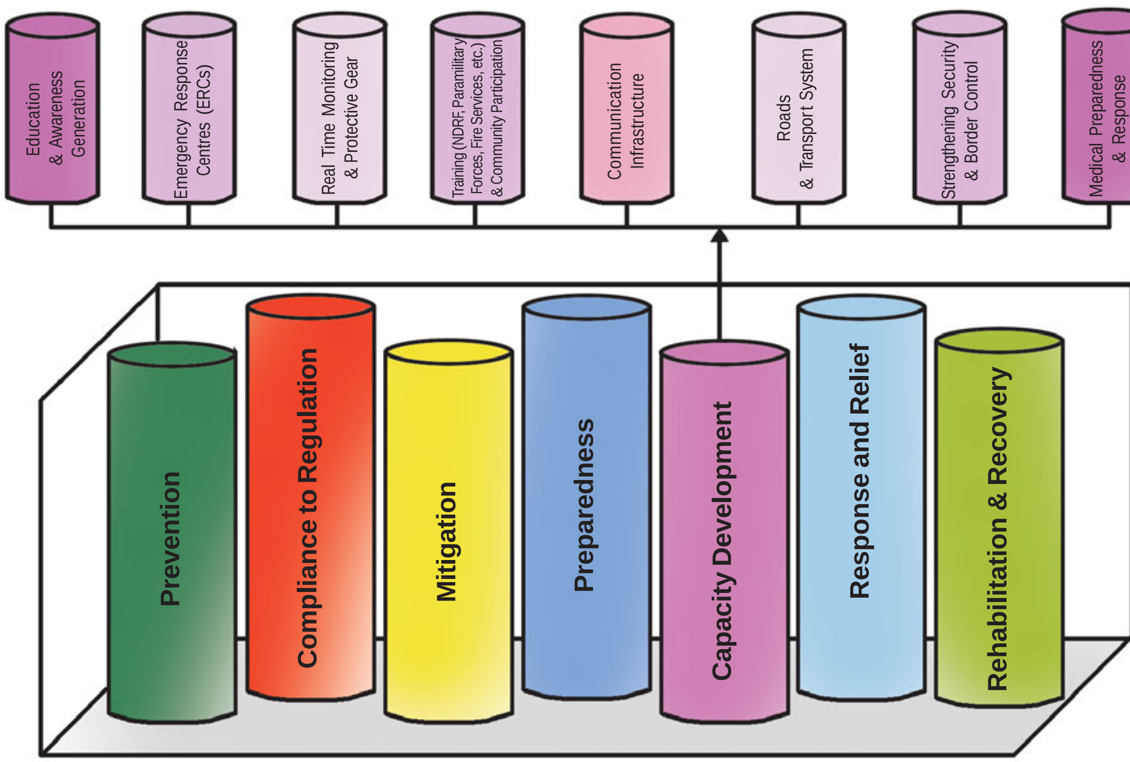
2.2 Nuclear Emergency Management Framework: Prominent Mainstays of Strength

The existing nuclear emergency management framework will be periodically reviewed and further strengthened by the following strategic supports, where highest priority is assigned to the prevention of nuclear emergency at any level in the country. While the details on these mainstays are provided in subsequent chapters, the same are being introduced here very briefly because of their extreme importance in providing the necessary strength to the nuclear emergency framework.

2.2.1 Prevention of Nuclear Emergencies

To prevent the occurrence of a nuclear emergency in the facilities, all engineered systems are built and operated by adopting the best available technologies and practices during the various phases of the life cycle of the facilities, viz., siting, design, construction, commissioning, operation and decommissioning. Following the defence-in-

Figure 2.1: The Mainstays of the Nuclear/Radiological Emergency Management Framework



depth approach, all safety systems are built with adequate redundancy and diverse working principles.

Nuclear power plants/facilities in India have been built on the basis of the above approach. However, sustained efforts will continue to improve the situation further through the induction of improved safety systems and state-of-the-art technologies.

2.2.2 Emphasis on Prevention (Risk Reduction) and Mitigation Measures

2.2.2.1 Prevention (Risk Reduction)

This strategic pillar aims at reducing the frequency of occurrence of nuclear emergencies in general, and ensuring that nuclear incidents/accidents do not escalate to a disaster level, in particular (through scientific understanding and incorporation of appropriate safety systems). Nuclear technology has continuously endeavoured to improve such features. Risk reduction calls for the implementation of transparent, comprehensive, efficient and effective risk management strategies to take care of, inter alia, the health and environmental effects along with the social and economic factors.

2.2.2.2 Mitigation Measures

While the design and operating conditions of nuclear power plants ensure that the likelihood of malfunctions/failures leading to unsafe conditions is very small, yet such conditions are postulated and safety systems provided to minimise the impact of these failures.

Inbuilt safety measures, including biological shields, safety systems and interlocks, safety audits, adherence to a safety culture combined with operational and administrative safety procedures prevent the chances of radiation accidents in the nuclear facilities in India and mitigate the impact in the event of an accident, if any.

However, efforts will continue for further improvement of safety measures in reactor systems.

2.2.3 Compliance with Regulatory Requirements

The prevention or mitigation of the impact of a nuclear emergency must be ensured by compliance with the applicable rules, standards and codes in all the activities involved in nuclear fuel cycle facilities as well as the organisations/ units using radioisotopes or radiation sources in any form, so that the use of ionising radiation and nuclear technology in India causes neither undue risk to the health of occupational workers and the public nor any adverse impact on the environment.

The AERB is the nuclear regulatory authority in India which, as per the legal framework of Atomic Energy Act, 1962, has the mandate for issuance of licenses to nuclear and radiation facilities upon ensuring compliance with the applicable standards and codes.

The AERB issues a large number of standards, codes and guides for various practices (during different nuclear and radiation applications) which must be strictly adhered to, for the prevention or mitigation of the impacts of any nuclear/radiological emergency. The codes issued by the AERB for various applications provide for a graded approach for regulatory control of a facility depending on the level of radiological hazard involved.

2.2.4 Nuclear Emergency Preparedness

Preparedness is 'getting ready' to respond to an emergency and it encompasses all DM activities, viz., planning, developing, training, exercising, maintaining capacity, etc., prior to the emergency that are essential to ensure a fast and effective response capability in the event of an actual emergency situation. It envisages the development and maintenance of such a capability in a well-structured and well-rehearsed fashion with seamless coordination among the various agencies involved. It does not have the pressure of time and stress associated with responding in an actual emergency.

The development of a preparedness programme for responding to nuclear emergencies is very essential even for these 'very low probability' emergency situations. It is recognised that an emergency preparedness and response system is in place, but its adequacy will be reviewed periodically.

Similarly, radiological emergencies arising in the country due to accidents involving radioactive sources are to be minimised by having strict administrative control. This ensures safety and security of the sources.

However, with the increasing use of a large number of radioactive sources in various applications or during their transportation, it is recognised that the adequacy of an emergency preparedness and response system will be reviewed periodically to counter the new threats.

The country should be prepared for responding to any of the five major categories of nuclear emergencies, viz., (i) accident in nuclear facilities, (ii) 'criticality' accident, (iii) accident during transportation of radioactive materials, (iv) emergency arising out of an RDD and (v) nuclear attack (which has been dealt with separately).

2.2.5 Capacity Development

Capacity development is an important component in the preparedness of nuclear/ radiological emergencies and it entails all those activities which are necessary to build and sustain the performance, across all domains of DM continuum, to ensure an effective emergency response. This includes a variety of time-bound programmes that would need to be taken up by all stakeholders for all-round development of the community and infrastructure in terms of trained manpower, knowledge enhancement, state-of-the-art monitoring systems and protective gear, communication, transport including technical upgradation of all those concerned with the management of nuclear/radiological emergencies/disasters.

2.2.6 Nuclear Emergency Response

Any action taken to mitigate the consequences during an actual emergency situation is termed as response. It always takes place under pressure of time with associated stress for the emergency responders. Even though an efficient response system would centre around effective utilisation of all available and mobilised resources by well-informed, well-trained and well-equipped responders for any given type of nuclear/radiological emergency, the response will be commensurate with the severity of the event.

However unlikely that event could be, there is a strong need for the country, also to be prepared for a quick and effective response to the worst scenario of a nuclear attack.

2.3 Strengthening the Framework of Nuclear Emergency Management through Legal and Regulatory Means

2.3.1 Legal Framework of the Atomic Energy Act, 1962

The Atomic Energy Act, 1962 is the main Nuclear Legislation in India. It was enacted to provide for the development, control and use of atomic energy for the welfare of the people of India and for other peaceful purposes and for matters connected therewith. The Act and the rules framed thereunder, provide the main legislative and regulatory framework pertaining to atomic energy. The DAE implements the provisions of the Atomic Energy Act, 1962 and controls the use of atomic energy in the country. The AERB regulates the safety provision envisaged in the Atomic Energy Act to ensure that the use of ionising radiations and nuclear energy in India does not cause undue risk to public health and the environment. It will consider establishing progressively regional regulatory centres to handle the increasing volume of work arising out of expansion of the country's nuclear power programme and the applications of radiation and radioisotopes in the non-power sector.

2.3.2 Private Participation in Future Nuclear Power Programmes

In the future, private entrepreneurs may play an important role in India's nuclear power programme. The utilisation of nuclear science and technology being quite complex and multi-disciplinary in nature, calls for the availability of a strong technological base with a large pool of highly skilled and experienced professionals to design, construct and operate any nuclear facility as per the stipulated safety standards of the AERB. Accordingly, while considering the proposal for private participation in India's growing nuclear energy programme, the AERB will evaluate, as is being done in the case of the Nuclear Power Corporation of India Ltd. (NPCIL) and BHAVINI, the suitability or otherwise of all such proposals by detailed and careful assessment of the party in terms of its techno-legal considerations right at the preliminary stage so as to ensure not only its technical capability for design and construction as per the codes and standards but also its capability for compliance with the safety rules and regulations stipulated by the AERB during the entire lifetime of the nuclear power plant.

2.3.3 Strengthening Disaster Management through Legislation in Parliament

To replace the erstwhile reactive and response-centric approach with a proactive and holistic DM in the country, the Government of India, backed by the unanimous support of all the political parties in Parliament, took a path-breaking decision by promulgating a new Disaster Management Act in December 2005 that has provided DM activities in India a statutory backing. This DM Act ushers in a paradigm shift in the DM framework in the country by adopting a holistic approach where prevention, mitigation and preparedness activities are to be addressed to as multi-disciplinary tasks spanning all sectors of development along with further improvement of response systems through well-trained, fully rehearsed and better equipped responders. Broadly, the enactment of the DM Act has stressed on the following:

i) Mainstreaming the disaster concerns into the development planning process.

ii) Promoting a culture of prevention and preparedness by centre staging DM as an overriding priority at all levels of development activity.

iii) Ensuring mitigation measures based on state-of-the-art technologies that are also environment friendly.

iv) Ensuring prompt and efficient rescue and relief operations through a caring approach towards the needs of the vulnerable sections of the society.

v) Undertaking all reconstruction activities as opportunities to build back better which will go a long way in establishing disaster resilience in the society.

2.4 Institutionalisation of Nuclear Emergency Management Framework

For the success of a nuclear emergency management programme, in addition to the task of identifying the agencies at different levels (which will be able to take up responsibility), it is essential to dovetail their respective responsibilities into the DM framework.

The National DM Act, 2005 proposes the creation of an institutional set-up at all the four levels of administration, viz., central, state, district and local, the details of which are given in Chapter 9.

For handling any type of disaster in the country, the following four types of organisations have been instituted by the Act to support, interact, coordinate and complement each other at all levels (instead of working in isolation at any level) of operations.

i) The creation of the NDMA at the national level under the chairmanship of the Prime Minister of India.

ii) The creation of State Disaster Management Authorities (SDMAs) at the state level under the chairmanship of the chief ministers.

iii) The creation of District Disaster Management Authorities (DDMAs) at the district level under the chairmanship of district magistrates/collectors with the elected representative as the co-chairperson.

iv) The creation of Local Authorities for mitigation and response.

NDMA, as the apex body, is responsible for each of the three phases of the DM continuum with eight major responsibilities, viz., pre-disaster (prevention, mitigation and preparedness), during the disaster (response, rescue and relief) that have been delegated to be carried out by the NCMC/National Executive Committee (NEC) on its behalf and post-disaster (rehabilitation and reconstruction) scenarios. NDMA will be assisted by NEC, as per the provision of the DM Act, as the implementing agency for the plans/programmes of NDMA.

The national guidelines are to be implemented through establishing appropriate DM plans at all levels of administration. NEC, with technical support from DAE (the nodal technical agency for nuclear/radiological emergency/disaster), will prepare the detailed national plan for management of nuclear emergencies in consultation with the various stakeholders. The most crucial stakeholder is the community at large, which is affected by any nuclear emergency/disaster.

All the central ministries will make their own DM plans, which are to be approved by NDMA. Similarly, all the states/Union Territories (UTs) will make their own DM plans in consultation with the district authorities. These plans will be based on the NDMA guidelines and in accordance with the national DM policy and plan.

2.5 Monitoring the Implementation of Nuclear/Radiological Emergency Action Plans

Planning, execution, monitoring and evaluation are the four steps of the comprehensive implementation cycle of the various action plans to be prepared on the basis of the guidelines being issued. While the nuclear emergency management framework for NPPs and transportation accidents are already in place, similar plans are to be prepared at different levels of administration in the country through an extensive consultative process for other possible scenarios in the public domain.

The detailed documents prepared will also specify the various indicators of progress to be adopted for enabling transparent monitoring for an objective and independent review of the implementation of nuclear/radiological emergency action plans. Specialists in Nuclear Science and Technology will be inducted at all levels of administration for formulation of the plans and their effective monitoring during implementation. In particular, implementing the *National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies* (NDMG-NRE) activities can be smooth and successful if a single-window system is adopted for execution and documentation of each of the above four phases, i.e., by having one person accountable for each of the above four phases of NDMG-NRE activities at each of the stakeholder ministries, departments, state governments, related agencies and organisations.

2.6 Highlights

Some of the highlights of this chapter are given below:

i) The existing nuclear emergency management framework will be periodically reviewed and further strengthened by some strategic supports, where the highest priority is assigned to the prevention of a nuclear emergency at any level in the country.

ii) While the design and operating conditions of nuclear power plants ensure that the likelihood of malfunctions/failures leading to unsafe conditions is very small, yet such conditions are postulated and safety systems provided to minimise the impact of these failures.

Inbuilt safety measures, including biological shields, safety systems and interlocks, safety audits, adherence to a safety culture combined with operational and administrative safety procedures prevent the chances of radiation accidents in the nuclear facilities in India and mitigate the impact in the event of an accident, if any.

iii) The prevention or mitigation of the impact of a nuclear emergency must be ensured by compliance with the applicable rules, standards and codes in all the activities involved in nuclear fuel cycle facilities as well as the organisations/units using radioisotopes or radiation sources in any form, so that the use of ionising radiation and nuclear technology in India causes neither undue risk to the health of the occupational workers and the public nor any adverse impact on the environment.

iv) The country will be prepared for responding to any of the five major categories of nuclear emergencies, viz., (a) accident in nuclear facilities, (b) 'criticality' accident, (c) accident during transportation of radioactive materials, (d) emergency arising out of an RDD and (e) nuclear attack (which has been dealt with separately) to ensure an effective emergency response.

v) Capacity development is an important component in the preparedness of nuclear/radiological emergencies and this includes a variety of time-bound programmes for the all-round development of the community and infrastructure in terms of trained manpower, knowledge enhancement, state-of-the-art monitoring systems and protective gear, communication, transport including technical upgradation of all those concerned with the management of nuclear/radiological emergencies/disasters.

vi) The national guidelines are to be implemented by preparing appropriate DM plans at all levels of administration. NEC, with the technical support of DAE (the nodal technical agency for nuclear/ radiological emergency/disaster), will prepare the detailed national plan for management of nuclear emergency in consultation with the various stakeholders.

All the central ministries will make their own DM plans, which are to be approved by NDMA. Similarly, all the states/UTs will make their own DM plans in consultation with the district authorities. These plans will be based on the NDMA guidelines and in accordance with the national DM policy and plan.

vii) Planning, execution, monitoring and evaluation are the four steps of a comprehensive implementation cycle of the various action plans to be prepared on the basis of the guidelines being issued. While the nuclear emergency management framework for NPPs and for transportation accidents are already in place, similar plans are to be prepared at different levels of administration in the country through an extensive consultative process for other possible scenarios in the public domain.

3 Present Status and Situation Analysis

3.1 Emergency Management Structure

The Government of India has identified DAE as the nodal agency for providing the necessary technical inputs to the national or local authorities for responding to any nuclear or radiological emergency in the public domain. The Ministry of Home Affairs (MHA) is the nodal ministry in such emergencies. For this purpose, a Crisis Management Group (CMG) has been functioning since 1987 at DAE. This Group is chaired by the Additional Secretary, DAE, and has on board expert members from different units of DAE and AERB. Each member has an alternate member and CMG is backed by resource agencies of various units of DAE. These resource agencies are expected to provide advice and assistance in the areas of radiation protection and measurement, medical assistance to persons exposed to high radiation doses, communication support, seismological inputs and help in the dissemination of information to the public.

In the event of any nuclear/radiological emergency in the public domain, CMG is immediately activated and it coordinates with the local authority in the affected area and all the concerning authorities at the centre (NCMC/NEC/NDMA) to ensure that the necessary technical inputs are available to respond to the nuclear/radiological emergency.

3.2 Regulatory Body

The basic regulatory framework for safety of all activities related to the atomic energy programme and the use of ionising radiation in India is derived from Sections 3 (e) (i), (ii) and (iii), 16, 17 and 23 of the Atomic Energy Act, 1962. The AERB carries out certain regulatory and safety functions under these Sections of the Act. The mandate for AERB, inter alia, includes:

i) Powers to lay down safety standards and frame rules and regulations with regard to the regulatory and safety requirements envisaged under the Atomic Energy Act, 1962.

ii) Powers of a Competent Authority to enforce the rules and regulations framed under the Atomic Energy Act, 1962 for radiation safety in the country.

iii) Authority to administer the provisions of the Factories Act, 1948 for ensuring industrial safety of the units of DAE as per Section 23 of the Atomic Energy Act, 1962 and enforce the rules and regulations promulgated there under.

Under the given mandate, the AERB carries out, inter alia, the following functions:

i) Develop safety policies in nuclear, radiological and industrial safety areas.

ii) Develop safety codes, guides and standards for siting, designing, construction, commissioning, operation and decommissioning of different types of nuclear and radiological facilities.

iii) Grant consent for siting, constructing, commissioning and decommissioning after appropriate safety review and assessment, for the nuclear and radiological facilities.

iv) Ensure compliance with the regulatory requirements during all stages of consenting through a system of review and assessment, regulatory inspection and enforcement.

v) Prescribe the recommended limits of radiation exposure to occupational workers and members of the public and approve acceptable limits of environmental releases of radioactive substances.

vi) Review the emergency preparedness plans for nuclear and radiological facilities and transportation of large radioactive sources, irradiated fuel and fissile material.

vii) Review the training programmes, qualifications and licensing policies for personnel of nuclear and radiological facilities and prescribe the syllabi for training of personnel in safety aspects at all levels.

viii) Take such steps as necessary to keep the public informed of major issues of radiological safety significance.

ix) Promote research and development efforts in the areas of safety.

x) Maintain liaison with statutory bodies in the country as well as abroad, regarding safety measures.

It is emphasised that the AERB, which oversees nuclear and radiological safety in the country, has the powers to not only licence the operation of a facility but also the power to order partial or full shutdown of any facility that violates its guidelines.

The AERB has been playing a very crucial role in the prevention of nuclear/radiological accidents by ensuring that proper safety design features and operating procedures in all nuclear and radiation facilities are in place.

3.3 Types of Possible Emergencies at Nuclear Power Plants, Preparedness and Response Plans for On-Site and Off-Site Emergencies

Elaborate and reliable safety systems are in place in all the nuclear facilities in India which are functional during the lifetime of the facility. As a matter of abundant caution, even though highly unlikely, certain 'beyond design basis accidents' are also postulated, which can lead to a radiation emergency in the public domain. Accordingly, while preparing the response plans to handle local emergencies within the plant, plans have also been drawn up for handling emergencies in the public domain, i.e., 'Off-site Emergencies'.

Based on the radiological conditions and their consequences, emergencies at nuclear facilities are categorised as emergency standby, personnel emergency, plant emergency, on-site emergency and off-site emergency. For the first three types of emergencies, in the order of severity which are foreseen as possible, though with very low probability, detailed plant-specific emergency response plans are already in place. In all these situations, the consequences of the accident are expected to be limited to the plant only.

Similarly, for the next higher level, viz., on-site emergency, where the consequences of an accident are not likely to cross the site boundary, a detailed response plan does exist. This emergency does not lead to any radiation release in the public domain.

The last type of emergency scenario (having the highest level of severity in the category of nuclear emergency in the nuclear facilities), even though with a very low possibility of radioactive releases in the public domain, is off-site emergency for which detailed response plans are put in place by the district magistrate/ collector of the area in coordination with the plant authorities.

Each nuclear power station of the present generation has an Exclusion Zone surrounding the power station in which no habitation is permitted and this area is under the administrative control of the plant authority. An area of larger radius outside the Exclusion Zone is declared as the Sterilised Zone where growth and development is restricted. The Emergency Planning Zone (EPZ) extends further beyond the Sterilised Zone.

It has been made mandatory by the AERB for all nuclear power plant operators to have comprehensive and well laid out plans to deal with all the above types of emergencies. It may be mentioned that the AERB does not permit the operation of a new power plant until preparedness plans are in place for the postulated emergency scenarios. Barring the off-site emergency response plan, the other plans fall within the domain of responsibility of the facility operator and the AERB has to approve these plans.

As per statutory requirements, the local district administration is responsible for drawing up and rehearsing the off-site emergency plan in coordination with the facility operator.

It is also mandatory for the power plant operators to periodically rehearse these plans by way of exercises and based on the feedback and experience, take corrective measures. As the first stage of the trigger mechanism, CMG, DAE, and the resource agencies are alerted even when a plant or site emergency exercise is conducted.

During off-site emergency exercises, which are conducted as per international norms once in two years at all nuclear power plant sites, all the members and alternate members of CMG, along with other key DAE officials in Mumbai, are alerted. In addition, the Secretary (Security) in the Cabinet Secretariat who is the contact person for DAE with NCMC, and the Secretary, Ministry of Environment and Forests, are also alerted during the off-site emergency exercises. In these exercises, the district administration is the key participant and the reports of the independent observers (from the AERB, NPCIL and CMG) are used as a feedback for further improvement of the emergency response system.

3.3.1 Emergency Plans at Radiation Facilities

All radiation facilities which have a potential for high exposures, depending upon the envisaged emergency scenarios, have emergency plans in place which include response actions and details of other agencies whose assistance will be sought. The competent authority (AERB), prior to issuance of licence, reviews these emergency plans of the facility. Barring the case of a loss of radioactive source, other scenarios do not have the potential to result in radiation exposures in the public domain. In case of any loss of source, the facility is required to immediately inform the AERB, CMG and the police.

The AERB has also laid down guidelines for the safe use of sources and safe operation of facilities which are to be adopted and followed by all the facilities using radioisotopes/radiation sources. These include safe design of the equipment used, its operation within the permissible range of parameters and availability of a suitably qualified Radiological Safety Officer (RSO) who is responsible for ensuring safe practices. The prescribed procedures also describe what will be done in the event of any radiation emergency—the precautions to be taken, the agencies to be notified, etc. The CMG, DAE, would also be available to direct the technical resources of DAE to the accident site and to assist the local authorities in handling the emergency situation.

3.3.2 Emergency Plans to Respond to Transportation Accidents

The AERB has laid down guidelines to be adopted for the transport of radioactive materials and emergency response plans for accidents during their transportation. The consignor of the material is responsible for ensuring that the prescribed safety procedures are followed. The AERB's safety code covers the design of the transport container, its handling and loading, procedures for transporting and unloading, including the procedures to handle any accident en-route. The SOPs also indicate what will be done in the event of any radiation emergency—the precautions to be taken, the agencies to be notified, etc. The CMG, DAE, will also be available to direct the technical resources of DAE to any location and to assist the transporters/local authorities in responding to the emergency situation.

3.4 Medical Preparedness for Nuclear Emergencies

In each constituent unit of DAE, a few doctors have been dedicated and given the necessary training in the medical management of radiation emergencies. All nuclear power plants and the Bhabha Atomic Research Centre (BARC) are equipped with radiation monitoring instruments, have personnel decontamination centres and the necessary stock of antidote medicines and specific de-corporation agents for typical radioisotopes.

A few hospitals in the country are also equipped with the facilities required for bone marrow transplantation, which will be useful in managing cases of acute whole body irradiation.

Further, doctors from various defence units and other organisations in the country are also to be trained in the medical management of nuclear emergencies.

3.5 Capacity Development

3.5.1 Emergency Response Teams

In addition to the basic training for teams of the National Disaster Response Force (NDRF), the training of 'First Responders' and Training of the Trainers (TOT) are being imparted by BARC. Further, BARC is also providing active help in imparting training to Quick Reaction Teams (QRTs) of the paramilitary forces. It has also been regularly conducting week-long training courses on Planning and Preparedness for Response to Radiological Emergencies (PPRRE) since 1999 at the College of Military Engineering (CME), Pune, for defence Chemical, Biological, Radiological and Nuclear (CBRN) officers, during which the participants are also trained in aerial survey for quick assessment of radiological impact in case of a nuclear/radiological emergency. Some units of the Defence Research and Development Establishment (DRDE) are also imparting training to these personnel in nuclear emergency preparedness.

3.5.2 Network of Emergency Response Centres and Crisis Management Group

As a basic regulatory requirement, emergency preparedness exists at all nuclear and radiation facilities to respond to any on-site or off-site emergency in their areas. But to handle radiological emergencies arising from a transport accident or from the movement/ handling of 'orphan sources' (radioactive sources that have lost regulatory control are called 'orphan sources') or due to malevolent acts like explosion of an RDD, Radiation Exposure Device (RED) or IND any time or anywhere in the country, a network of 18 units of Emergency Response Centres (ERCs) has been established by BARC, DAE. This number is far too inadequate and will be enhanced. This network is basically meant for responding to such emergencies and also providing timely advice and guidance to first responders at the state and national levels. These ERCs are equipped with radiation monitoring instruments, protective gear and other supporting infrastructure. The geographical locations of these 18 ERCs are shown in Figure 3.1. Many units of nuclear Emergency Response Teams (ERTs), consisting of personnel from different DAE units, are also being raised. The centralised agency, called the CMG, at DAE coordinates the nuclear/radiological emergency management activities not only by activating these ERCs and ERTs but also by mobilising resources from all DAE facilities at the time of crises.

3.5.3 Monitoring and Protective Equipment

A variety of hardware for radiation monitoring along with impact assessment software for the management of nuclear disasters have been developed at BARC. Similarly, a number of smart radiation monitoring systems like Environmental Radiation Monitor with Navigational Aid (ERMNA), Aerial Gamma Spectrometry System (AGSS), Mobile Gamma Spectrometry System (MGSS), Indian Environmental Radiation Monitoring Network (IERMON), Compact Aerial Radiation Monitoring System (CARMS), Indian Real-time On-line Decision Support System (IRODOS), etc., have also been developed. Some of these systems can quickly monitor and scan a contaminated area, process the data and present it in a colour-coded graphical format [superimposed on a Geographic Information System (GIS) map of the affected area] to help the decision-making process.

For procurement of essential radiation monitoring and protective gear for NDRF, civil defence agencies and other defence forces, BARC is assisting in preparing the technical specifications. The instruments/protective gear so procured will help these agencies in building up their capacity as 'first responders' to any nuclear/radiological emergency in the public domain.

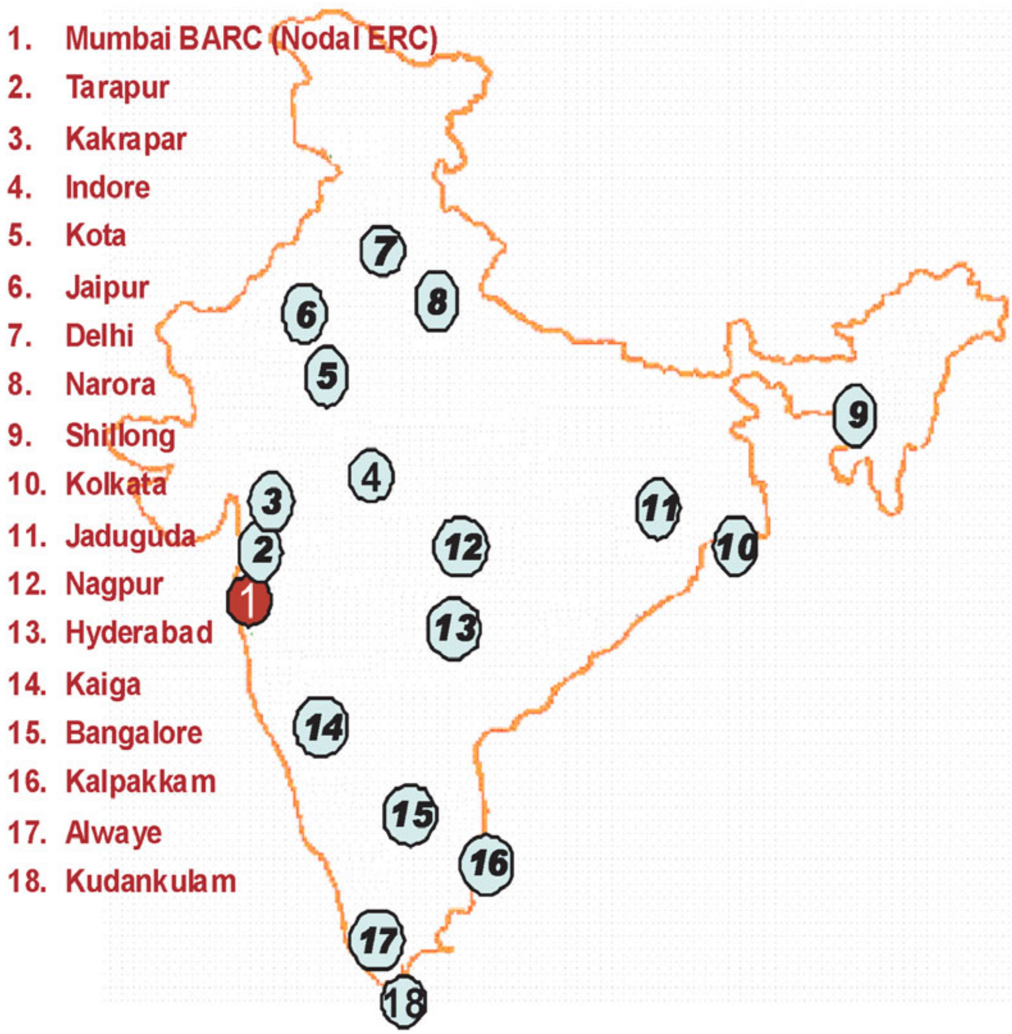
Based on the utilisation of various types of detectors, the Defence Research and Development Organisation (DRDO) has also developed a number of instruments, like the high-range radiation monitor for field use, personal dose monitor (a gadget used to measure an individual's dose), etc. They have also developed mobile systems like nuclear field laboratory, CBRN reconnaissance vehicle and reconnaissance laboratory.

3.6 Public Awareness

Public awareness plays a key role in the emergency preparedness and response plans for any type of emergency/disaster where the participation/role of the public is of prime importance. The fact that one cannot see, feel or smell the presence of radiation, coupled with a general lack of credible and authentic information to the public at large about radiation and radiation emergencies and the wide publicity given to any nuclear/radiation-related incident, has resulted in several erroneous perceptions about nuclear technology. Not surprisingly, most people perceive that any small nuclear/radiation-related incident will lead to a situation like Hiroshima or Nagasaki, or the Chernobyl accident.

To educate the people about the beneficial aspects of nuclear radiation and to remove their misgivings about it, the authorities of nuclear fuel cycle facilities in general, and that of nuclear power stations in particular, are actively involved in carrying out regular public awareness programmes for people living in the vicinity of these facilities. People are invited and taken on guided tours of the nuclear power stations, made conversant with the basics of radiation protection, safety limits, safety practices, and the dos and don'ts during a nuclear emergency. The station authorities also make visits to the surrounding villages and population centres to create awareness of the same. Good coordination is also maintained with the district officials. Prior to any off-site emergency exercise, awareness programmes are specially conducted for the public officials, making them conversant with their responsibilities during any off-site emergency.

Figure 3.1: Location of the Emergency Response Centres (ERCs) established by BARC*



* More of these are planned to be established in due course

DAE also participates in many exhibitions in the country, and puts up stalls and interactive models to create awareness among the public about the benefits and safety aspects of the nuclear energy programme.

3.7 Research and Development

Research and development related to radiation effects on health and on the environment has been continuing in various research wings of DAE, DRDO and certain universities in the country. Considerable fundamental knowledge has been gained and certain technologies have been developed for radiation detection and measurement.

Research on the development of anticancer drugs and radio-protectors is in progress at various institutions in the country. Nuclear establishments have put in place dosimetry procedures and regulatory standards for safe operation of nuclear facilities. R&D needs to be continued in the area of processing and disposal of high-level radioactive wastes.

3.8 Issues yet to be Addressed (Gap Analysis)

The excellent safety record in the nuclear industry worldwide in general, and that of India in particular, can be attributed primarily due to the high priority given to safety and its enforcement by an independent regulatory body. This is reinforced by a unique international mechanism that incorporates adoption of best practices, a continuous review of all aspects of safety on a learning mode, transparency and openness in sharing of safety related information at the international level, etc. This process has been fully assimilated by the nuclear power industry in India and there are ongoing efforts to ensure the same in other areas, including those pertaining to the applications of radiation.

Areas like security of nuclear facilities as well as that of radioactive sources and radiation monitoring in the public domain need periodic review under ever-changing threat perceptions and be strengthened further so as to prevent radiation emergencies in the public domain. Also, there is a need to periodically review the effectiveness of emergency response systems in the public domain, keeping in view the new dimensions of threat perceptions for which certain issues need to be addressed over a period of time.

These issues are discussed in the following sections.

3.9 Institutions for Education, Knowledge Management, Public Awareness and Training

3.9.1 Education and Knowledge Management

At present, practically no education is imparted at any level on nuclear/radiological emergencies in the national educational system. It goes against one of the basic concepts of good emergency response, which envisages that the culture of preparedness has to be imbibed right from childhood in all sections of the society. The basics of radiation, radioactivity and the use of nuclear radiation in day-to-day life (with its beneficial aspects) should be taught in schools and colleges. Once people are sensitised about this subject, it will help in removing prejudices/misconceptions of the general public about nuclear radiation/ programmes and they will treat a nuclear/ radiological emergency like any other type of natural or man-made emergency.

Further, presently there is no mechanism for maintaining a knowledge base or case studies in the public domain on the events of previous emergencies and their consequences. As a result, the lessons that should have been learnt from the handlings of those emergencies have been lost sight of.

3.9.2 Enhancing Public Awareness about Nuclear/Radiation Hazards

In general, there is very limited public awareness about radiation emergencies. Even the intelligentsia have misconceptions about nuclear energy in general. Ever since the reactor accidents at Three Mile Island and Chernobyl, any news of a nuclear/radiological emergency has always been of great interest that generates misconceptions in the minds of the public. The sensationalisation of such news by the media has also erroneously caused a perception that any radiation or nuclear emergency will result in cancer or death.

Such lack of public awareness is a major constraint in handling and objectively responding to these emergencies. To overcome this, sincere and concerted efforts are needed to create awareness amongst the general public with the target audience of school and college students, teachers, technocrats and government officials.

The fear in the minds of the public that even a small accident in nuclear facilities will lead to a situation like Hiroshima/Nagasaki, can be removed only through proper awareness generation and training programmes (Appendix 1).

People living in the vicinity of nuclear power plants, and particularly the student community, have been trained on these aspects to some extent. The existing atmosphere of openness and transparency will be continued and promoted further around the nuclear facilities covering a larger segment of the population.

3.9.3 Training of Stakeholders

There is much work to be done with regard to the training of all the agencies involved in the management of radiation emergencies. These include education of senior public functionaries like the district or state-level officials who would manage a radiation emergency as well as the first responders. This would also include RSOs, civil defence personnel and home guards, police and fire and emergency services personnel and medical professionals.

3.10 Strengthening the Institutional Frameworks (for Regulatory and Response Mechanisms)

It is well known that effective coordination mechanisms amongst the different agencies involved is the key to an efficient emergency response mechanism. This requires formal institutional frameworks and linkages, with the necessary statutory backing. Some of these issues pertain to the implementation of a regulatory and enforcement mechanism by the AERB and a coordination mechanism between DAE and the local/district officials who would be responding to any radiation emergency in the public domain.

3.10.1 Regulatory and Enforcement Issues

The AERB, the national regulatory authority, has been regulating the nuclear and radiation facilities in the country very effectively and has, over the years, issued a large number of codes, standards and guides. These cover the various activities relating to the nuclear fuel cycle as well as for radiation applications in medicine, industry, agriculture and research.

Till now, all activities pertaining to the nuclear fuel cycle (controlled and operated by DAE) have been handled by DAE in a safe manner because of the sharing of a common safety culture among the various units of DAE.

High-strength radioactive sources are extensively used in industry and hospitals in India. In the case of industry, these sources are mainly used for radiography, where there is a high potential of loss of sources. In this area, there is an urgent need to further strengthen the regulatory and security aspects by the AERB.

In the event of the private sector getting involved in the nuclear power programme, it might be required of the regulatory authority to ensure that the necessary knowledge base exists in the concerned private industry for building and operating the nuclear facility as per the stipulated safety standards of the AERB.

3.10.2 Formalising the Coordination Mechanism with Public Authorities

While DAE, as the nodal technical agency, has a system in place to respond to requests for assistance to any radiological/nuclear event in the public domain, the coordination mechanism of DAE with each state is yet to be formalised (the formal linkages of the state/district administration with CMG, DAE, and the nearest ERC, need to be strengthened significantly). Similarly, there is also a need to establish the linkages of SDMAs/DDMAs with the nearest NDRF battalion. This would require the state/district administration to develop their respective emergency plans and link up with the ERCs of DAE and NDRF battalions in the neighbourhood. Presently the empowerment of local administrative authorities is not adequate.

3.10.3 Intervention Levels and Action Levels in case of a Radiological Dispersal Device or Nuclear Disaster

In case of a large-scale nuclear disaster from, say a nuclear attack, the population will be exposed to the effects of blast (shock) wave, burns and fires (caused by the heat wave) along with effects of prompt as well as delayed radiations. As a result of all these effects, rescue and relief measures will be highly demanding in terms of the availability of adequate trained manpower as well as advanced instruments/equipment. It is important to note that the nature of relief measures would be different in many ways from those carried out in natural disasters like fire, floods, earthquakes, etc., (where there is very little detrimental effect to the health of the personnel involved in the relief work). In a nuclear emergency/disaster, however, the persons carrying out the relief work are also likely to be exposed to both high doses of radiation and/or high levels of contamination which, if not controlled, may affect their health as well as their potential to carry out the relief work effectively.

In the light of the above, a question that is frequently asked is about the radiation dose levels at which intervention is required for various actions (like sheltering, iodine prophylaxis, evacuation, etc.) in the case of nuclear disasters. The availability of this information on the avertable dose level is important not only for the public but also for the rescue and relief workers. In addition to the intervention levels, the action levels that will be needed to control the consumption of contaminated food items in the affected areas is another issue. These values are presently not available either for an RDD or a nuclear disaster and are needed to be generated because these are essential in respect of both (i) the members of the relief and rescue teams, and (ii) the public.

3.11 Strengthening the Infrastructure (to Ensure Safety and Effective Emergency Response)

3.11.1 Network of Emergency Response Centres

At present, 18 ERCs of BARC are available for giving the necessary technical support to local authorities for responding to any radiation emergency. For a large and densely populated country like India, this is not considered adequate.

In fact, several major metros and other vulnerable locations will need to have ERCs established in their areas. Local civil defence, police, fire brigade, hospitals and other agencies also need to develop liaison with these ERCs.

Some of the major functions of ERCs are:

i) To detect any radiation-related abnormal situation in a suspected area by detection and monitoring the radiation and to continuously assess the situation.

ii) To keep an inventory of radiation monitoring instruments and Personal Protective Gear (PPG).

iii) To provide training to first responders, administrative staff of SDMAs/DDMAs and the technical staff of government agencies in handling nuclear/radiological emergencies.

iv) To provide technical advice to first responders and the concerned local authorities in handling a nuclear/ radiological emergency; to guide them further in resource mobilisation and in the optimum utilisation of available manpower and equipment in case of a nuclear/radiological emergency.

3.11.2 Strengthening Monitoring and Detection Systems in the Public Domain to Control Malevolent Activities

While the regulatory mechanism does exist to ensure that radioactive sources are always under control, there is a possibility that they will be deliberately tampered with, stolen or misplaced and go out of regulatory control (leading to what are called 'orphan sources'). In the emerging security threat scenario, there is a possibility of such 'orphan' sources falling into the wrong hands and being used for malevolent purposes (through an RDD, also called a 'dirty bomb').

There is an immediate need to strengthen the mechanisms to detect such occurrences. At present, there is no mobile monitoring system available with law and order authorities which will warn them of any significant/abnormal rise in the background radiation level in the public domain. The establishment of such a monitoring system on priority is considered highly desirable, to detect any unauthorised presence or movement of radioactive material in the public domain.

3.11.3 Capacity Development for Radiation Detection/Monitoring Instruments and Protective Gear

To handle a nuclear emergency, including a large-scale nuclear disaster, a large number of radiation detection/monitoring instruments and personal protective gear are needed. Presently, outside the DAE/DRDO establishments, there is hardly any inventory of these units. Even in DAE establishments, the total numbers may just about suffice for an off-site emergency condition from nuclear power plants but not for any large-scale disaster. The non-availability of the required instruments/protective gear in large volumes as well as trained manpower will severely hamper the capability to effectively handle any nuclear emergency/disaster scenario.

3.11.4 Provision of a Portable Radiation Detection System

With increasing incidences of terrorists activities and impending threat of an RDD, it is imperative that the police, which in all probability will be the first to reach the site of an explosion, should have some simple portable monitoring instruments (at each police station within the areas with radiological threat perception) which will warn them as they approach the radiation area (from, say, a blast of RDD).

This will not only help the police to prevent exposure of its own personnel but will also help mitigate the impact of such a blast to a great extent by giving directions to onlookers. The deployment of this type of devices will reduce the critical gap, to a great extent, in the current situation.

3.11.5 Strengthening the Disaster Management Communication Infrastructure

A reliable communication infrastructure is one of the key elements in any response mechanism. Presently, the DM communication linkage from the district to the state headquarters and then to the national level (including linkages with DAE with regard to a radiation emergency) is neither dedicated nor adequate. There is a need to strengthen the same at the district and state levels. The creation of a dedicated National Disaster Communication Network (NDCN) is on the anvil at NDMA as a part of the mitigation project. It is an important requirement because public networks like landline telephones and mobile or cellular phones are the first to collapse due to a sudden increase in traffic in the event of an emergency.

3.11.6 Network of Roads and Transport Systems

In the worst-case scenario, i.e., an off-site emergency situation, the emergency response plans envisage evacuation of the public from the affected zone. This requires well-defined routes and evacuation strategies. The availability of both adequate transport and good roads (which will provide the evacuation routes), are the main issues to be tackled after taking into account the topology of the site.

These problems need to be addressed by the concerned DDMAs/SDMAs as a part of the preparedness/response programme in an all-hazards approach.

3.11.7 Sheltering

Certain radiation emergency scenarios envisage a sheltering requirement for a large number of people. Normally, community centres, schools, colleges, religious places, marriage halls, etc., are chosen for this purpose. These places need to be identified by SDMAs/DDMAs during a non-emergency period, with assistance from DAE/DRDO.

3.11.8 Alternate Sources of Food, Water and Hygiene Facilities

Another important requirement is to identify alternate sources of food, water and also to provide proper hygiene facilities. Because of the assembly of a large number of persons at the emergency shelters, poor hygiene facilities may lead to the spread of diseases, including epidemics. Thus, in addition to providing good hygiene facilities, good medical care with adequate stock of medicines, will be made available in all areas of possible nuclear emergencies/disasters.

3.12 Enhancing Security Systems for Radioactive Sources at Border Controls and Radiation Facilities

3.12.1 Strengthening Border Controls

There can always be a possibility of some radioactive sources going 'out of control' in some country and from there entering our country, either inadvertently or deliberately. Instances of the first type have occurred in the past in the form of the sources being present in the scrap imported by certain domestic steel foundries in our country.

Such unnoticed entry has the potential of the end products of the steel mills being contaminated or, in the worst scenario, the source being used in an RDD. Hence the strengthening of border controls will need to be addressed on priority by MHA.

In addition, there is also the potential that radioactive materials might be smuggled into the country by antisocial elements, terrorist organisations and state-sponsored activists. Presently, there is no monitoring system in place at the entry points to prevent such events.

3.12.2 Enhancing Security at Radiation Facilities and during Transportation of Radioactive Materials

Radiation safety is generally considered as the prime area of focus while security is not considered a serious issue. Security also has to be treated as an integral part of the entire arrangement to prevent people from getting unintentionally exposed to radiation. Safety-driven security measures are already in place at many facilities around the world.

Facilities using radioactive sources need to strengthen their physical protection systems along with proper inventory and control procedures of the radiation sources.

In the current security threat scenario, there is a need for enhancing the security of sources at radiation facilities and during their transportation, to ensure that they do not go 'out of control' by any deliberate acts of theft and sabotage and become a potential radiation hazard to the public.

3.13 Creating a Pool of Radiological Safety Officers at the National Level

An RSO is a trained and qualified radiation protection professional who is certified by the AERB for assisting in the area of radiological protection.

A nationwide capability for utilisation of the services of a large number of RSOs for managing both RDD related scenarios and large-scale nuclear disasters will be considered on priority. At present, no formal system exists in this regard.

3.14 Strengthening the Medical Preparedness and Response Mechanism

Due to the absence of any significant number of nuclear/radiation related incidents, there have been very few instances of radiation-related injuries. However, it is essential that the medical community is educated and kept informed about the management of radiation injuries.

Presently, there is no network of hospitals in the country which can handle radiation-induced injuries on a large scale. The establishment of such a network is essential for handling nuclear emergencies/disasters. There should also be a dedicated and reliable communication facility among hospitals so that they can pool their resources when required.

3.15 Role of the Police, Civil Defence and Home Guards in Handling Nuclear/Radiological Emergencies

In any type of disaster, the community will be the first to respond, but by and large the community is an unskilled force for nuclear/

radiological emergencies. Therefore, skilled 'first responders' will generally be the fire service personnel, the police force and medical professionals as well as the NDRF, which is being specially trained for such situations.

In the context of large-scale radiation disasters, the involvement of civil defence personnel and home guards is usually considered highly desirable.

3.16 Role of the Armed Forces

Because of their preoccupation with defending the nation from external threats, the armed forces are normally not always available to respond to a nuclear disaster scenario. However, for any major nuclear accident where the situation is beyond the coping capability of the civil administration, the services of the armed forces may be called for to take over several critical operations related to response (i.e., rescue and relief); rehabilitation (i.e., evacuation and sheltering) and reconstruction activities, including the immediate restoration of essential infrastructures like communication, electrical power, transportation, etc. For such operations, specially trained teams in the armed forces will always be available from within their existing sources. Civil-military coordination will be developed for such purposes so that specially trained and rehearsed teams of the Army can be inducted to assist the civil administration as and when called for and are available.

3.17 Disaster Management Plan for Metros and Important Cities

In the case of major nuclear/radiological disasters, a detailed programme for carrying out relief and rescue operations has to be worked out for all metros, important cities and other vulnerable places in the country. Since the implementation of such a programme will need large resources (both in terms of manpower and equipment/machinery), it is necessary that a beginning is made in this direction in phases.

To start with in phase I, it is aimed to cover all cities with a population of 20 lakh or more, that may be affected by a major nuclear/ radiological emergency. A detailed operations plan, followed by SOPs, will be prepared for all these locations by the SDMAs, State Executive Committees (SECs) and DDMAs concerned. This cover will be extended to other cities with population above 10 lakh after the completion of phase I in three years.

3.18 Availability of a GIS-Based Emergency Preparedness and Response System

Modern emergency preparedness and response systems depend largely on GIS for ensuring effective and prompt response. At present, response plans in the vicinity of nuclear power stations and cities are based on the data collected from census and conventional maps. They do not have GIS-based databases and digitised maps of appropriate scale, which are required to make full use of the software tools available for impact assessment and decision-making for the management of emergencies. The state governments, assisted by MHA, will take expeditious initiatives for completing this task.

3.19 Launching Research and Development Initiatives, Development of Instruments and Equipment

The development of safety instruments/ equipment and a security infrastructure to cope with events/accidents leading to large-scale contamination in the public domain need to be based on a 'threat perception analysis' in order to optimise resources. The threat perception analysis is a wider subject and encompasses theoretical modelling of perceived threats, evaluation of different scenarios, impact assessment of the entire event in general, and the counter/control measures needed in terms of types of instruments, equipment and infrastructure. The effect of such large radiation exposure/contamination on human health and psyche of the common public must also be studied. Though some data are generated for NPPs and projections are made, yet a well-concerted and directed R&D that covers all these issues is lacking.

3.20 Highlights

Some of the highlights of this chapter are given below:

i) In the event of any nuclear/radiological emergency in the public domain, CMG is immediately activated and it coordinates with the local authority in the affected area and all the concerned authorities at the centre (NCMC/NEC/NDMA) to ensure that the necessary technical/ administrative inputs are available to respond to the nuclear/radiological emergency.

ii) The AERB, which oversees nuclear and radiological safety in the country, has been playing a very crucial role in the prevention of nuclear/radiological accidents by ensuring that proper safety design features and operating procedures in all nuclear and radiation facilities are in place. The AERB has the power to not only licence the operation of a facility but also to order the partial or full shutdown of any facility that violates its guidelines.

iii) As per statutory requirements, the local district administration is responsible for drawing up and rehearsing the off-site emergency plan in coordination with the facility operator.

iv) It is also mandatory for the power plant operators to periodically rehearse various emergency preparedness plans by way of exercises, and based on the feedback and experience, take corrective measures. As the first stage of the trigger mechanism, CMG, DAE and the resource agencies are alerted even when a plant or site emergency exercise is conducted.

v) The basic training for NDRF teams, 'first responders' and TOT is being imparted by BARC in addition to training of QRTs of the paramilitary forces and defence CBRN officers.

vi) Emergency preparedness exists at all nuclear and radiation facilities to respond to any on-site or off-site emergency in their areas. A network of 18 units of ERCs has been established by BARC to handle radiological emergencies arising from a transport accident or the movement/ handling of 'orphan sources' or any malevolent act like the explosion of an RDD, RED or IND at any time or anywhere in the country.

vii) The fact that one cannot see, feel or smell the presence of radiation, coupled with a general lack of credible and authentic information to the public at large about radiation and radiation emergencies and the wide publicity given to any nuclear/radiation related incident, has resulted in several erroneous perceptions about nuclear radiation/ technology. Not surprisingly, most people perceive that any small nuclear/radiation related incident will lead to a situation like Hiroshima/Nagasaki or the Chernobyl accident.

To remove such misgivings, the authorities of nuclear fuel cycle facilities in general, and that of nuclear power stations in particular, are actively involved in carrying out regular public awareness programmes for people living in the vicinity of these facilities.

viii) The AERB, the national regulatory authority, has been regulating the nuclear and radiation facilities in the country very effectively and has, over the years, issued a large number of codes, standards and guides.

ix) In the event of the private sector getting involved in the nuclear power programme, it might be required for the regulatory authority to ensure that the necessary knowledge base does exist in the concerned private industry for building and operating the nuclear facility as per the stipulated safety standards of the AERB.

x) In case of a nuclear/radiological emergency, the rescue and relief measures will be highly demanding in terms of availability of adequate trained manpower as well as advanced instruments/equipment. In this case, the nature of relief measures would be different in many ways from those carried out in natural disasters like fire, floods, earthquakes, etc. (where there is very little detrimental effect to the health of the personnel involved in the relief work). In a nuclear emergency/disaster, however, the persons carrying out the relief work are also likely to be exposed to both high doses of radiation and/or high levels of contamination which, if not controlled, may affect their health including their potential to carry out the relief work effectively.

xi) Several major metros and other vulnerable locations will need to have ERCs established in their areas. Local civil defence, police, fire brigade, hospitals and other agencies also need to develop liaison with these ERCs.

xii) Facilities using radioactive sources need to strengthen their physical protection systems along with proper inventory and control procedures of the radiation sources.

xiii) In the current security threat scenario, there is a need for enhancing the security of the sources at radiation facilities and during their transportation, to ensure that they do not go 'out of control' by any deliberate acts of theft and/or sabotage and become a potential radiation hazard to the public.

xiv) In the context of large-scale radiation disasters, the involvement of civil defence personnel and home guards is usually considered highly desirable.

xv) Because of their preoccupation in defending the country from the enemy, the armed forces are normally not always available to respond to a nuclear disaster scenario. However, for any major nuclear accident where the situation is beyond the coping capability of the civil administration, the services of the armed forces may be called for to take over several critical operations related to response (i.e., rescue and relief), rehabilitation (i.e., evacuation and sheltering) and reconstruction activities, including the immediate restoration of essential infrastructures like communication, electrical power, transportation, etc. Civil-military coordination will be developed for such purposes so that specially trained and rehearsed teams of the Army can be inducted to assist the civil administration, as and when called for and are available.

xvi) To start with, the SDMAs, SECs and DDMAs concerned will aim to cover all cities with a population of 20 lakh or more, that may be affected by a major nuclear/ radiological emergency in respect of the preparedness for response to a nuclear/ radiological emergency. This cover will be progressively extended to other cities.

xvii) Presently, there is no network of hospitals in the country which can handle radiation-induced injuries on a large scale. The establishment of such a network is essential for handling nuclear emergencies/disasters. This will also include the establishment of a nationwide capability for utilisation of the services of a large number of RSOs for managing both RDD-related scenarios and large-scale nuclear disasters on priority. There will also be a dedicated and reliable communication facility among hospitals so that, whenever required, they can pool their resources.

xviii) There can always be a possibility of some radioactive sources going 'out of control' in some country and from there, entering into our country inadvertently or deliberately. Such unnoticed entry has the potential of the end products of steel mills being contaminated or, in the worst scenario, the source being used in an RDD. Hence the strengthening of border controls will need to be addressed on priority by MHA.

xix) In an off-site emergency situation in a nuclear facility, emergency response plans envisage the evacuation of the public from the affected zone. This requires well-defined routes and evacuation strategies, taking into account the topology of the site. Problems related to the availability of well-defined routes, transport facilities, food, drinking water, shelters, etc. also need to be addressed by the concerned DDMAs/SDMAs as part of the preparedness/response programme in an all-hazards approach.

xx) In the emerging security threat scenario, there is a possibility of 'orphan' sources (stolen or misplaced sources that may go out of regulatory control of the AERB) falling into the wrong hands and being used for malevolent purposes through an RDD (also called a 'dirty bomb').

At present, there is no mobile monitoring system available with law and order authorities which can warn them of any significant/abnormal rise in background radiation levels in the public domain. The establishment/strengthening of monitoring and detection systems of such sources on priority is considered highly desirable, to detect any unauthorised presence or movement of radioactive material in the public domain.

xxi) With the increasing incidences of terrorists activities and impending threat of RDD, it is imperative that the police, which in all probability will be the first to reach the site of an explosion, should have some simple portable monitoring instruments (at each police station within the areas with radiological threat perception) which will warn them as they approach the radiation source (from, say, a blast of RDD).

xxii) The values of the radiation dose levels at which intervention is required for various actions (like sheltering, iodine prophylaxis, evacuation, etc.) and the action levels that will be needed to control the consumption of contaminated food items in the affected areas are presently not available either for any RDD or nuclear emergency/ disaster and are needed to be generated because these are essential in respect of both (i) the members of the relief and rescue teams and (ii) the public.

xxiii) The lack of public awareness is a major constraint in handling and objectively responding to nuclear and radiological emergencies. Further, presently there is no mechanism for maintaining a knowledge base or case studies in the public domain on the events of previous emergencies and their consequences. As a result, the lessons that should have been learnt from the handling of those emergencies have been lost sight of. To overcome this, sincere and concerted efforts are needed to create awareness amongst the general public with the target audience of school and college students, teachers, technocrats and government officials.

4 Prevention of Nuclear/Radiological Emergencies

4.1 Prevention: The Best Way to Achieve Radiation Safety

A unique feature of the application of nuclear/radiation technology in India, as is the case the world over, is the concept of ensuring safety by incorporating design features to prevent any incident or accident which will lead to a nuclear or radiological emergency. This concept is applied equally to nuclear power plants, nuclear facilities and even in smaller applications like the use of radiation sources in laboratories.

4.2 Prevention of Accidents at Nuclear Plants

4.2.1 Design Philosophy for Accident Prevention

The inherent safety philosophy in design features, adoption of best available manufacturing/fabrication procedures, best operating practices and stringent regulatory measures are practiced to ensure prevention of unlikely accidents in nuclear power plants.

A reactor accident is prevented by the design philosophy of defence-in-depth, where several levels of protection and multiple barriers are provided to prevent the release of radioactive materials, and to ensure that failures or combinations of failures that might lead to radiological consequences are of very low probability.

Defence-in-depth is structured in five levels. Should one level fail, the subsequent level comes into play automatically to retain the safety status. The details of this concept are shown in the table in Appendix 2.

It may be noted that all Indian nuclear power plants have all the five levels of defence incorporated in their plants.

4.2.2 Unique Features in the Design of Nuclear Reactor Systems

To ensure a very high level of reactor safety, the present generation of nuclear reactors in India are designed, as followed worldwide, on the basis of some unique features that ensure the following:

i) **Reliability:** To achieve a high level of reliability of safety and safety-related systems by implementing the principles of diversity, redundancy and independence.

ii) **Adoption of a Fail-Safe Design:** To ensure that the plant comes to a safe shutdown state in the event of any failure of safety related components.

iii) **Resistance to Natural Disasters:** Structures, systems and components necessary to assure capability for shutdown, decay heat removal and confinement of radioactive material are designed to remain functional throughout the plant's life, even in the event of natural disasters like earthquakes, cyclones, floods, etc.

In the light of the impact of the tsunami, as experienced on 26 December 2004 in the Indian Ocean, the location and design aspects of nuclear installations are required to take this natural hazard also into account.

iv) **Seismic Qualification:** The plant is designed for Operating Basis Earthquake (OBE), which is the maximum ground motion that can be reasonably expected to be experienced at the site area once, with an estimated return period of about 100 years.

The design also takes into account another higher level of earthquake called Safe Shutdown Earthquake (SSE), which is the maximum level of ground motion expected to occur once in 10,000 years.

v) **Safety Analysis:** Safety analyses are carried out for postulated initiating events as per the standard design codes and guides of the AERB to demonstrate the safety of a plant.

4.2.3 Safety Considerations for Accident Prevention

Well-established safety criteria are used during siting, designing, construction, commissioning, operations and decommissioning of nuclear plants.

i) **Siting:** The site for a nuclear power plant is selected through a detailed study of the site to ensure the requirements laid down by the AERB in such a manner that its operation has no adverse impact on the environment.

ii) **Design and Construction:** To prevent accidents caused by faulty design, it is ensured that the technologies incorporated are state-of-the-art and proven and the man-machine interface is considered in all stages of designing.

iii) **Commissioning Programme:** The commissioning programme confirms that the installation, as constructed, is consistent with design and safety requirements. Operating procedures are validated as part of the commissioning programme.

iv) **Operation:** During operation, it is ensured that the plant is always operated within the safe boundaries as identified by safety analyses. Further, all the important functions, viz., operations, inspection, testing, maintenance and support functions are conducted by a sufficient number of properly trained and authorised personnel in accordance with the approved procedures.

v) **ALARA Principle:** During all the stages of the life of a nuclear plant, starting from design to decommissioning, radiation exposure to both the occupational workers as well as members of the public are kept As Low As Reasonably Achievable (ALARA).

vi) **Management:** The managing authority assigns the highest priority to safety standards and ensures that safety policies are implemented with a clear division of responsibility and a well-defined protocol of communication.

vii) **Decommissioning:** The decommissioning aspect is to be taken into account in such a manner that the radioactive wastes generated during decommissioning are handled with care. It must be ensured that (i) it does not add to excessive exposure of the plant's personnel and members of the public after decommissioning is completed and (ii) even after a long period of time, it does not get into the local environment or get mixed up with the water table.

4.2.4 Safety Approach for Future Reactors

The current nuclear energy systems are designed, constructed and operated to meet stringent safety criteria, as laid down in various national regulatory (AERB) requirements and corresponding industry standards, codes, rules, guides and other documents. The main thrust of this approach is to prevent the occurrence of accidents. Features are to be incorporated in the design and construction of nuclear facilities in the future, based on the best engineering codes and standards available at that point of time.

The safety approach of future reactors will be periodically reviewed, to meet the emerging safety standards to be laid down by the AERB.

4.3 Prevention of 'Criticality' Accidents

'Criticality' control is a risk management issue unique to nuclear fuel cycle facilities and other activities involving high-grade fissile materials. It calls for a detailed safety analysis of the system and incorporation of various technical and administrative measures to prevent a 'criticality' situation under all possible scenarios. To prevent 'criticality' accidents in fuel cycle facilities, licensees must ensure that 'criticality' is prevented through proper design and quality assurance programmes on the following parameters which affect 'criticality', viz., mass, density, geometry, interaction, moderator, poison, reflector, etc.

4.4 Prevention of Accidents during Transportation of Radioactive Materials

As regards the transportation of radioactive materials, there are regulatory guidelines which specify the design of the container as well as the manner in which they should be handled and transported.

The containers used for transportation of high-strength radioactive materials like nuclear spent fuel, are designed to withstand severe shock, fire, drop from a height, etc. These containers are certified by actual tests carried out with a scaled-down model. Additionally, restrictions are imposed on the speed of the transport vehicle along with adequate physical protection by security forces to take care of any threat from misguided elements.

4.5 Prevention of Radiological Emergencies

The user has the primary responsibility for the safe use and control of radioactive materials/radioisotopes. Every industry using radioactive materials/radioisotopes will have an inventory of all radioactive sources and access control to prevent the loss of such sources/nuclear materials. Radiological accidents could take place at locations where radiation or radioactive sources are used, e.g., in industry, medicine, agriculture and research. Accidents could also take place during the transportation of radioactive materials.

The regulatory guidelines require that all the applications conform to the specified safety standards. These, in turn, are covered by the design, fabrication, testing and operation of various equipment as well as standard operating procedures to ensure safety. This also involves strict administrative control and security of the radioactive sources.

4.6 Prevention of Radiological Dispersal Device and Improvised Nuclear Device Incidents

The best available physical protection systems using state-of-the-art surveillance and monitoring systems will be provided at all nuclear/radiological facilities. Similarly, by implementing appropriate safety and security measures, strict accounting procedures and quick detection/identification devices, the plant authorities will strengthen the prevention of (i) illicit trafficking of radioactive sources and Special Nuclear Materials (SNMs) and (ii) their falling into the hands of unlawful elements and/or terrorists. These measures will also prevent a radioactive source from being lost, stolen or abandoned (leading to what is termed an 'orphan source').

The first step to counter RDD is to ensure security for all radioactive sources in the country. In this regard, regulatory requirements regarding the security and safety of radioactive sources should be enforced across the country. This will be backed by measures to prevent the smuggling or illicit trafficking of radioactive materials, especially fissile materials. The controlling of such activities calls for setting up a comprehensive national/international security system, auditing and a detecting and monitoring methodology for such materials. Nuclear materials must have material protection, control and accounting, and should have coverage of vigilance and intelligence.

Highly sensitive detectors/dirty bomb detectors capable of detecting the smuggling of radioactive sources or explosives will be installed by MHA at all entry and exit gates of the various possible routes (airports, sea ports, border crossing areas, etc.) to prevent radiological terrorism. On detection of radioactive materials, these detector systems will generate an alarm on real time basis. All nuclear facilities will also have monitoring systems installed at the entry and exit gates to detect any unauthorised movement of radioactive materials. Police patrolling vehicles will also be provided with portable radiation monitors to detect the presence of unauthorised sources in the public domain.

4.7 Compliance with the Regulatory Framework

So far as man-made disasters are concerned, if proper safety design features and operating procedures are in place, the probability of an accident can be very low. In this regard, the regulatory authority plays a crucial role in the prevention of such emergencies/disasters. Globally, the nuclear industry has given formal recognition to this basic principle by giving utmost importance to the role of the national radiation safety regulator. This has resulted in setting up functionally independent and robust regulatory authorities in many countries, including India, which have nuclear fuel cycle facilities. These independent authorities assign utmost priority to the safe operation of any nuclear or radiation related facility so that radiation exposure of the occupational workers is well below the permissible limits and there is no radiation hazard to the general public. Countries are required to give statutory authority to their regulatory authorities who, in turn, issue formal standards, codes, rules, guides and manuals which follow internationally accepted safety criteria. In India, this role of national radiation safety regulator is performed by the AERB.

To achieve its objectives, the AERB ensures compliance with the various rules applicable for:

i) Radiation protection.

ii) Disposal of radioactive wastes.

iii) Food irradiation.

iv) Work in mines and mills.

By virtue of its stringent regulatory measures implemented through a large team of highly competent professionals, the AERB has succeeded in establishing world-class safety standards in the nuclear plants/facilities in India.

4.8 Highlights

Some of the highlights of this chapter are given below:

i) A reactor accident is prevented by the design philosophy of defence-in-depth, where several levels of protection and multiple barriers are provided to prevent the release of radioactive materials into the environment, and to ensure that failures or combination of failures that might lead to radiological consequences are of very low probability.

ii) The inherent safety philosophy in design features, adoption of best available manufacturing/fabrication procedures, best operating practices and stringent regulatory measures ensure the prevention of unlikely accidents in nuclear power plants.

iii) In the light of the impact of the tsunami as experienced on 26 December 2004 in the Indian Ocean, the location and design aspects of nuclear installations are required to take this natural hazard also into account by DAE and AERB.

iv) Safety analyses are carried out for postulated initiating events as per the standard design codes and guides of the AERB to demonstrate the safety of a nuclear/radiological plant.

v) The nuclear plant is designed for OBE, which is the maximum ground motion that can be reasonably expected to be experienced at the site area once, with an estimated return period of about 100 years. The design also takes into account another higher level of earthquake called SSE, which is the maximum level of ground motion expected to occur once in 10,000 years.

vi) The safety features of nuclear reactors will be periodically reviewed and the emerging safety standards will be laid down by the AERB for incorporation in future reactors.

vii) As regards the transportation of radioactive materials, there are regulatory guidelines which specify the design of the container as well as the manner in which they should be handled and transported.

viii) Highly sensitive detectors/dirty bomb detectors capable of detecting the smuggling of radioactive sources or explosives will be installed by MHA at all entry and exit gates of the various possible routes (airports, sea ports, border crossing areas, etc.) to prevent radiological terrorism. All nuclear facilities will also have monitoring systems installed at the entry and exit gates to detect any unauthorised movement of radioactive materials. Police patrolling vehicles will also be provided with portable radiation monitors to detect the presence of unauthorised radioactive sources in the public domain.

5 Mitigation of Nuclear/Radiological Emergencies

5.1 Mitigation Measures

The main objective of risk reduction is to minimise the risk to human health and the environment, including the ecosystem and the constituent parts thereof (that are identified to be fragile, in the proximity of a nuclear installation/facility), which are to be protected during nuclear/radiological emergencies. This may call for the promotion and support of the development of better and safer alternate technologies.

The accident mitigation measures for a plant are engineered safety features and accident management procedures which are aimed at minimising the impact with the objective of keeping the release of radioactivity into the environment as low as possible.

Defence-in-depth helps to ensure that the three basic safety functions, viz: controlling the power, cooling the fuel and confining the radioactive material, are preserved and that even in case of an emergency, radioactive materials do not reach the public or the environment. The defence-in-depth concept is centred around several levels of protection, including successive barriers, preventing the release of radioactive materials into the environment.

These are explained in graphical and pictorial forms in Figures 5.1 and 5.2, respectively. This concept includes protection of the barriers by averting damage to the installation and to the barriers themselves. It includes further measures to protect the public and the environment from harm, in case these barriers are not fully effective.

5.2 Defence-in-Depth: Salient Features

i) Design, construction and operation.

ii) Control and protection systems and associated surveillance programmes.

iii) Engineered safety features.

iv) Accident management.

v) Off-site emergency preparedness.

5.3 Mitigation of Nuclear and Radiological Emergencies

While the design and operation principles of nuclear power plants ensure that the likelihood of an accident is very small, still such failures are postulated and engineered safety systems for reducing damage and confinement of radioactivity are provided to minimise the impact of these failures.

The measures incorporated in the present generation of nuclear reactors in India include:

5.3.1 Engineered Safety Features

i) Emergency core cooling systems:
To ensure emergency core cooling and thereby limiting core damage in case of an emergency or loss of fuel cooling and,

hence, limiting the release of radioactivity within the containment.

ii) Containment and associated systems: While the inherent safety features, design provisions and safety system mentioned above will reduce the chances of an accident to a very low probability, an added level of safety is provided by the double containment and associated systems. The primary containment of pre-stressed concrete envelopes the reactor and other nuclear systems to act as a barrier to the release of radioactivity during an accident. The secondary containment of reinforced concrete limits the ground release of radioactivity.

5.3.2 Accident Management

The possible accident scenarios are to be identified before the start of a plant's operation. For each identified accident, structured procedures are developed along with its Emergency Operating Procedures (EOPs). These EOPs define the expected progression of an event and guidelines for the plant's management for managing accidents. These EOPs also help in mitigating the impact of such an event.

5.3.3 General Mitigation Features

For nuclear facilities, the inbuilt safety measures, including biological shields, safety systems and interlocks, safety audits combined with operations and administrative safety procedures, mitigate the consequences of accidents.

Periodic regulatory inspections by the AERB and surveillance by plant safety personnel are carried out to ensure that a mitigation mechanism is in place.

5.4 Engineered Safety Features (to Mitigate the Consequences of an Accident) in Nuclear Power Plants

The following are the other engineered safety systems provided in some of India's existing nuclear power plants for mitigating the consequences of an accident:

i) Vapour Suppression System to limit the peak pressure of containment during a loss of coolant accident condition.

ii) Liquid Poison Injection System for long-term sub-criticality of reactors.

iii) Reactor Building Coolers to bring down the primary containment pressure during an accident condition.

iv) Secondary Containment Recirculation System to reduce activity release, using multi-pass filtering by recirculation.

However, such systems are evolutionary in nature and future nuclear power plants are likely to induct the upgraded version of these systems or entirely new ones.

For any unlikely event of release of radioactivity in the public domain or loss of a radioactive source, the emergency response system of DAE can be activated any time through its 24x7 emergency communication system. To ensure their effectiveness, the emergency preparedness plans are rehearsed periodically.

5.5 Highlights

Some of the highlights of this chapter are given below:

i) The design philosophy based on defence-in-depth is centred around several levels of protection, including successive barriers that prevent the release of radioactive material into the environment by ensuring three basic safety functions, viz., controlling the power, cooling the fuel and confining the radioactive materials so that even in case of an emergency, these materials do not reach the public domain or the environment.

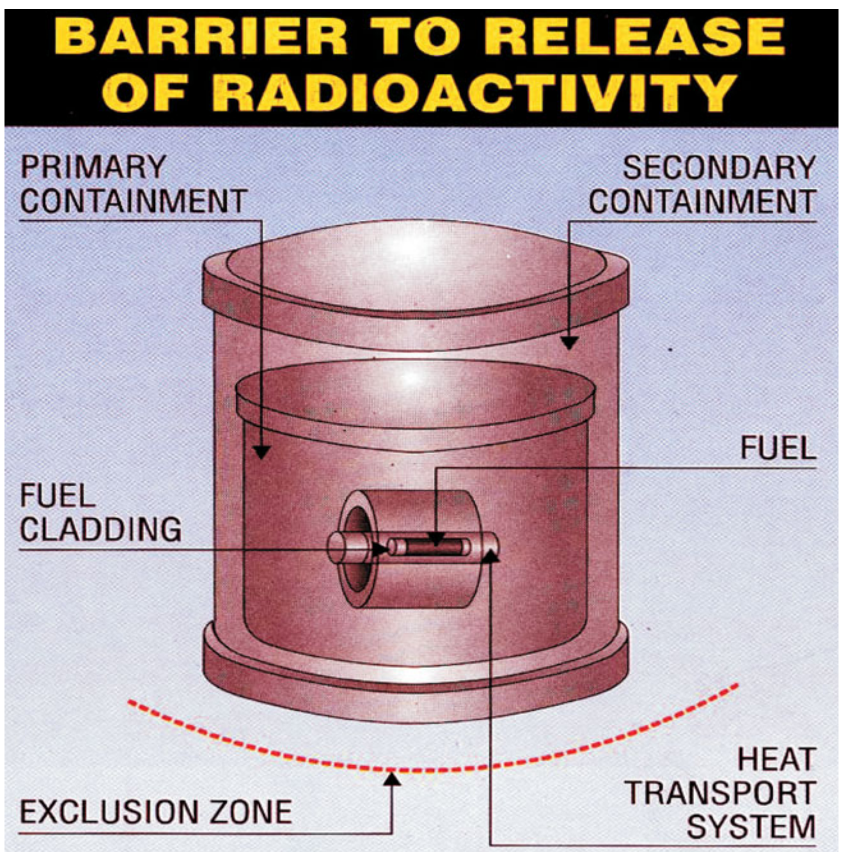
ii) While the design and operation principles of nuclear power plants ensure that the likelihood of an accident is very low, still such failures are postulated and engineered safety systems for reducing the damage and confining the radioactivity are provided to minimise the impact of these failures.

iii) For nuclear facilities, the inbuilt safety measures, including biological shields, safety systems and interlocks, safety audits combined with operations and administrative safety procedures, mitigate the consequences of accidents.

iv) Periodic regulatory inspections by the AERB and surveillance by plant safety personnel are carried out to ensure that a mitigation mechanism is in place. Such systems are evolutionary in nature and future nuclear power plants are likely to induct the upgraded version of these systems or entirely new ones.

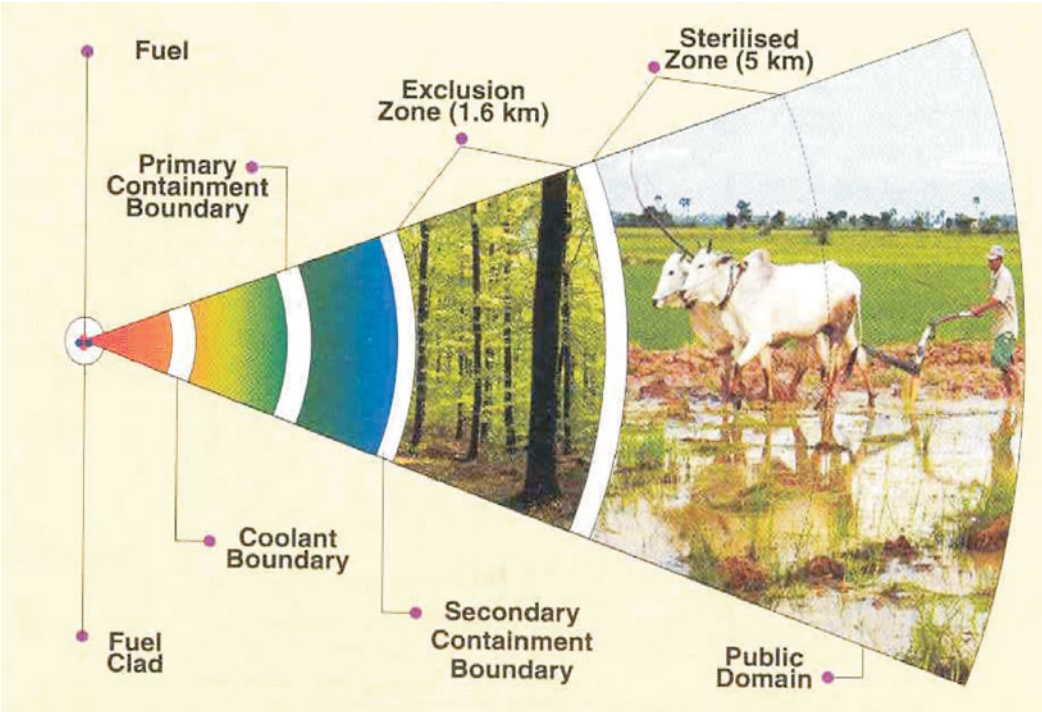
v) For any unlikely event of the release of radioactivity into the public domain or loss of a radioactive source, the emergency response system of DAE can be activated any time through its 24x7 emergency communication system.

Figure 5.1: Barriers to Release of Radioactivity



The graphical presentation of the various barriers to be passed before radioactivity can be released in the public domain are illustrated in the above diagram.

Figure 5.2: Safety Barriers
(not to scale)



The concept of multiple barriers is explained in pictorial form in Figure 5.2. The normal activities of the public continue as usual beyond the sterilised zone without any restrictions.

6 Preparedness for Nuclear/ Radiological Emergencies

6.1 Goals of Emergency Preparedness

The probability of a major accident at nuclear facilities leading to the release of large quantities of radioactivity into the environment is always ensured to be negligibly small. However, even in the event of a major release into the environment, the prompt and effective implementation of countermeasures can reduce the radiological consequences for the public.

The practical goals of nuclear emergency preparedness are:

i) To reduce radiation-induced health effects by preventing, to the extent possible, the occurrence of severe deterministic effects in workers and in the public.

ii) To limit, to the extent practicable, the occurrence of stochastic effects in the population. It should be borne in mind that actions to reduce the risk of stochastic effects beyond a point (e.g., relocation from an area with insignificant levels of dose or contamination) will sometimes do more harm than good. Taking protective action significantly below the generic international guidelines for intervention and actions for protective measures levels could do more harm than good.

The level of preparedness for response will be commensurate with the severity of the nuclear/radiological hazard potential.

6.2 Preparedness for Nuclear/ Radiological Emergencies

The handling of nuclear emergencies requires coordination among different service groups of the nuclear facility. In the event of potential radiological consequences in the public domain, all the authorities at the three levels, i.e., district, state and central, will play a vital role.

6.2.1 Major Responsibilities of Nuclear Power Plant Operators

This includes the arrangements required to promptly classify an emergency, mitigate the emergency, notify and recommend protective actions off the site consistent with international guidelines, protect those on site, obtain off-site assistance, conduct environmental monitoring of the affected area and assist off-site officials in keeping the public informed.

6.2.2 Major Responsibilities of Off-Site Officials

This includes the arrangements required to promptly implement protective actions and countermeasures in the affected area.

6.3 Emergency Preparedness for Nuclear Power Plants

Since the proper implementation of countermeasures can significantly reduce the consequences of an emergency situation, it is mandatory for all nuclear facilities that there must be a comprehensive emergency preparedness plan. Prior to the issuance of a license for the operation of a nuclear facility, the AERB ensures that the facility has the Emergency Response Manuals for the three main types of emergencies, viz., plant, on-site and off-site, and that the plans are in place to handle these types of emergencies. The operators of nuclear facilities must make an assessment of the type and quantum of release of radioactivity under various accident conditions and the extent to which it can spread into the environment.

The response actions within the site boundary of the nuclear facility are the responsibility of the management of the nuclear facility whereas the implementation of the emergency response plan in the public domain (beyond the site boundary) is the responsibility of the concerned district authority. In the event an off-site emergency having the potential for trans-boundary effects, necessary action is taken by DAE in accordance with the country's international obligations.

The operating authorities of nuclear facilities in India already have an emergency response plan in place to be invoked in the event of an emergency, which is tested during periodic exercises as per international practice.

6.3.1 Handling a Plant Emergency

When the radiological consequences of an abnormal situation are expected to remain confined to the plant boundary or a section of the plant, it is described as a plant emergency. Nuclear facilities in the country already have the following provisions for the detection, classification, notification and mitigation of any emergency situation:

i) Emergency operating procedures for the assessment of an emergency condition and its mitigation.

ii) Pre-identification of any facility-specific, abnormal situation for classification of a plant and site emergency.

iii) Facility-specific, approved nuclear emergency response plans specifying the jobs of all the functionaries who have assigned roles during the emergency.

iv) Alerting the plant personnel by sounding the emergency siren and making an emergency announcement.

v) Adequate means for communicating a notification to the emergency response organisations at the facility, the district and state authorities, CMG of DAE and the central government authorities.

vi) Identified assembly locations for plant personnel and casual visitors for their accounting, and assessment of persons trapped in the radiological areas.

vii) Formation of rescue teams and activation of a treatment area and decontamination centre.

viii) Radiation survey around the plant and outside the plant and site boundaries.

ix) Assessment of wind speed, wind direction and the affected sector around the nuclear facility.

x) Whenever required, the nuclear facility is able to mobilise the services of the ambulance and paramedical staff at its site.

xi) Equipment and materials for handling a nuclear emergency are kept at a designated place of the nuclear facility and ERC.

6.3.2 Handling On-Site Emergencies

An accidental release of radioactivity or the potential of release of activity extending beyond the plant, but confined to the site boundary, constitutes a site emergency condition.

In addition to all the provisions applicable in a plant emergency, the following additional provisions are ensured:

i) Extensive radiological survey for an assessment of the radiological conditions within the site boundary of the nuclear facility.

ii) Suitable prophylaxis to be made available at all assembly areas for administration to plant personnel, in case the situation demands.

iii) Identification of temporary shelters within the facility/site for shifting plant personnel, in case required.

iv) Provision of a fleet of vehicles for evacuation of plant personnel from the site to a safer place.

v) Provision of fixed and portable contamination monitors to check contaminated personnel/vehicles leaving the site.

vi) On sensing the potential of release of radioactivity which can transgress into the public domain, the concerned district authorities are alerted to be on standby for emergency operations in the public domain.

vii) Radiological monitoring of the environment in the EPZ (16 km radius around the plant).

6.3.3 Handling Off-Site Emergencies

On recognising the potential for an uncontrolled release of radioactivity into the public domain, the concerned district authorities are alerted to be on standby for emergency response operations.

In addition to all the provisions applicable in plant emergency and site emergency, the following additional provisions are to be ensured for handling a nuclear emergency in the public domain:

i) Pre-identification of plant conditions which can lead to an emergency in the public domain.

ii) An assessment of the radiological status at the site boundary and in the public domain.

An Off-site Emergency Response Plan has already been drawn up by the local administration in consultation with the concerned plant authority. It identifies the role of each response agency in a clear and unambiguous manner. After obtaining concurrence from the AERB, detailed emergency response plans and procedures for handling off-site emergencies are approved by the Chairman, SEC, of the respective state where the nuclear facility is located. Finally, procedures are also in place to carry out drills/exercises to rehearse these plans which, in turn, are periodically reviewed and revised/updated based on the lessons learnt from past exercises.

For handling of an off-site emergency condition in an NPP, there is an off-site emergency committee headed by the district magistrate of the concerned district and supported by the district subcommittee, which include chiefs of all public service departments relevant to emergency management in the district and also the Head of the Site Emergency Committee of the nuclear facility for technical advice. This committee takes decisions pertaining to the handling of a nuclear emergency outside the site boundary and ensures implementation of countermeasures such as sheltering, prophylaxis and evacuation and resettlement, including maintenance of law and order and civil amenities. All the activities pertaining to the handling of an off-site emergency are guided and coordinated from a pre-designated emergency response centre located outside the boundary of the nuclear facility. The information and broadcasting department of the district, in association with an authorised information officer, ensures the smooth flow of information to the media to avoid panic and spreading of rumours.

6.3.4 Raising Specialised Response Teams

Specialised response teams will be raised, specially trained for a nuclear/radiological emergency/disaster and fully equipped at the state as well as central levels. In this context, it is to be noted that four battalions of NDRF are being specially trained by NDMA with assistance from DAE/DRDO (for detecting and monitoring radiation, for their own protection during response actions, decontamination and triage operation, etc.) to provide specialised response during a nuclear/radiological emergency/disaster.

Since the response actions during CBRN disaster scenarios are quite different from those needed for natural and other man-made disasters, CBRN-trained battalions of NDRF (presently located at Greater Noida, Kolkata, Talegaon in Pune and Arakonam in Chennai) must always be available on an emergent basis.

6.3.5 Role of Civil Defence

Civil defence organisations near existing NPPs are provided training on emergency preparedness. Their volunteers also participate in off-site emergency exercises. Civil defence is expected to play a significant role in future nuclear emergency/disaster scenarios arising from facilities other than NPPs. Civil defence personnel are normally trained in handling natural calamities. Therefore, selected civil defence personnel will be trained extensively in the subjects of radiation, radioactivity, radiation protection, use of monitoring instruments, use of protective gear, shielding, decontamination, waste disposal, etc.

A revamping of the civil defence set-up has been proposed in which it will be made district-centric in order to cover all the districts of the country in two phases. In the first phase, 241 multi-hazard districts will be covered. Of these, 37 districts which are cyclone prone already have civil defence set-ups in their major towns.

In the meanwhile, the civil defence set-up already existing in the country will be immediately utilised to train the community for disaster response in the concerned districts of the towns already activated. The Director General of Civil Defence in each state will work out training modules for DM covering awareness generation, first aid and rescue drills. Selected civil defence personnel will be trained for CBRN emergencies and will be closely involved in assisting all the response agencies. Other civil defence personnel will support response agencies for the management of CBRN emergencies. The National Institute of Disaster Management (NIDM) will prepare a comprehensive training module simultaneously and circulate it, which will be incorporated in the ongoing training programme.

The civil defence authorities will work out their overall mechanism for responding to various disasters and take the assistance of DAE/DRDO as well as CBRN-trained NDRF staff in training and equipping their personnel with regard to handling radiation emergencies/disasters.

6.3.5.1 Instruments, Equipment and Protective Gear for Response Teams

The standard list of instruments, equipment and protective gear necessary for the various response teams will be drawn up in consultation with DAE, with full technical specifications (the list will be updated periodically) and procured by the concerned SDMAs and DDMAs in advance for the response action.

These will be procured for the specialised response teams, medical teams, and civil defence personnel.

An adequate stock of specified clothing will be procured for use by the affected people.

An illustrative list of the instruments, equipment and protective gear for specialised response teams is given in Appendix 3.

6.3.6 Role of the Armed Forces

While the central and state governments must aim to develop suitable response capabilities to meet the perceived nuclear emergency/disaster threat scenario; such response efforts might require to be augmented by the armed forces. To ensure optimum synergy, it is imperative that there is proper interaction between the civil authorities and the armed forces during all stages of planning, preparedness and response.

While NDMA and MHA have co-opted suitable members from the Ministry of Defence in all the committees, similar action must be taken by the state governments and district authorities at their respective locations. The armed forces will also gear up their nuclear disaster preparedness so that they can be inducted in the event of nuclear disasters.

6.3.7 Training of Stakeholders, Periodic Exercises and Mock Drills

Training plays an important role in the proper implementation of various emergency response activities. It focuses on roles and responsibilities, resource identification, use of equipment, understanding the effects of radiation on human beings, animals and the environment. The required emergency preparedness is maintained by organising various training courses for on-site and off-site personnel at regular intervals. Appropriate training is imparted to employees of the facility at all levels at regular intervals to familiarise them with the required actions during an emergency. Similar training courses are organised round the year for various public authorities and state government officials in view of the routine turnovers.

The adequacy of emergency response arrangements at a nuclear facility is evaluated through the audit and review of plans, procedures and infrastructure. The ability to carry out the required emergency actions is assessed, in general, through audit and reviews of past performance. However, a primary evaluation of the same is based on the feedback of designated observers for the periodic mock exercises. The preparation, conduct and evaluation of these exercises shall involve the coordination of all functionaries within the facility, the district authorities and the CMG of DAE.

These drills for plant, on-site, and off-site emergencies will preferably be conducted quarterly, annually and once in two years, respectively; however, the frequency of the actual exercise will depend on the type of nuclear facility.

The nuclear facility will have proper media management to minimise possible negative impacts of the exercise on the public psyche.

The evaluation of an exercise will identify areas of emergency plans and preparedness that may need to be improved or enhanced. It will be the responsibility of the nuclear facility and the district authority to review the evaluation report and ensure implementation of the corrective measures recommended by the evaluators.

A large number of organisations/agencies have to be fully integrated by SDMAs, SECs, and DDMAs with assistance from DAE, DRDO, NIDM, and NDMA into the nuclear/radiological emergency programmes at the district and state levels. These organisations/agencies include (i) CBRN-specialised teams of the four battalions of NDRF; fire and emergency services personnel and the police force as the first responders along with medicos, paramedics, (including the staff from rural/primary health centres); Non-Governmental Organisations (NGOs), Community Based Organisations (CBOs); the civil defence staff and home guards; (ii) designated specialists from the hospitals of DAE units; elected officials; public information officers and academicians as resource personnel to educate the public; and teachers and students from schools, colleges and universities.

The procedures and actions for the various response agencies will be evolved and regularly rehearsed so as to use their services as and when required. SOPs will need to be laid down for first responders, who will also be trained and empowered to carry out their assigned tasks.

As already discussed, the revamping of structures and their functioning in nuclear/radiological emergencies have to be properly defined for the civil defence staff.

Training would have to be imparted by specified trainers to other stakeholders from the district, state and central authorities. In the process of their being trained to handle other types of natural and man-made disasters, they will also be sensitised on the special aspects of nuclear/radiological emergencies (while highlighting some common features like sheltering, evacuation, etc.).

The training of all the stakeholders will include information on:

i) Radiation sources and nuclear/radiological accidents.

ii) Health and safety aspects of radiation emergency and the effect on human beings.

iii) Possible scenarios of nuclear/radiological emergencies.

iv) Preparedness of the facilities' operators and other stakeholders to cope with such emergency scenarios.

v) Relevant technical information for appropriate integration into risk assessment and associated decision making.

vi) Information pertaining to the provisions of liability, insurance, relief and compensation.

vii) Dissemination of the training materials in local languages by making full use of, inter alia, the print and audio visual media.

viii) Testing the training programmes for quality assurance through regular mock-drills/exercises.

The training will be as interactive as possible using various tools like videos, CD-ROMs, satellite broadcast, web casts, etc., and the process of training should be continuous with periodic refresher courses.

6.3.8 Periodic Review of Emergency Response Plans/Conduct of Exercises

The AERB ensures that the emergency response plans are periodically updated and revised and the feedback from various exercises and drills are used to continuously improve the emergency preparedness and response capabilities of the nuclear facility and local administration, wherever required.

While it is understandable that off-site emergency exercises have to be planned and conducted with prior notice to all so as to avoid panic in the public domain, however, plant and site emergency exercises which involve only the operating personnel, are conducted without any declaration to the plant's employees.

Similarly, radiological emergency exercises are also to be planned and conducted at major cities to evaluate/check the coordination among the various response agencies.

6.3.9 Strengthening the Infrastructure (to Ensure Safety and Effective Emergency Response)

6.3.9.1 Strengthening the Network of Emergency Response Centres

In addition to the ERCs (presently 18 in number) established by BARC, it is essential that additional ERCs with the necessary trained personnel and equipped with appropriate radiation detection instruments and PPG are set up in all the major cities and other vulnerable locations.

The police being the automatic first responders, these additional ERCs will be located at the District Police Control Rooms (DPCRs)/District Police Lines (DPLs). Immediately on the occurrence of any major/near major explosion, personnel from the nearest ERC will move in a police vehicle along with radiation detection devices and PPG for inspecting the site in the normal course and as part of SOP. On detection of any enhanced level of radiation whatsoever, they will immediately report the same to the DDMA from where the necessary instructions for handling of such emergency will originate. The response actions will, inter alia, include calling experts from the nearest DAE/DRDO establishment or from any of the other ERCs set up by BARC. If any NDRF battalion or Army formation is located nearby, their assistance will also be immediately requested for, if required. The responsibility of setting up these additional ERCs will be that of the state government's and will be from the existing manpower in their police force. The financial resources for these will be made available by the centre. NDMA will organise provisioning of the entire financial requirements for preparation of such emergencies as part of a mitigation project.

The establishment of these additional ERCs, including the procurement of the necessary monitoring instruments and PPG and training of the first responders from the police force will be completed within a period of three years at the outer limit.

ERCs will be set up at all levels (i.e., state capitals and major cities) with the necessary manpower, instruments and equipment. Depending upon the location and assigned functions, these ERCs will also be maintained in a ready state to quickly respond to any nuclear/radiological emergency.

Since emergency situations require reliable communication systems for command and control, the communication equipment in the

ERCs will be planned considering this requirement. Dedicated communication facilities will be established between ERCs and the district authorities.

An ERC will have a mobile monitoring van equipped with radiation detection systems and protective gear (for ERTs) to assess the radiological impact. Assessment of the radiological status at the site of the emergency is very important and necessary in order to protect rescue workers and medical personnel.

6.3.9.2 Strengthening Radiation Detection/ Monitoring Instruments and Protective Gear

In case of any nuclear/radiological emergency, the first need is the availability of instruments for detecting and monitoring the radiation. An inventory of radiation monitoring instruments and protective gear will be built up by all the SDMAs and DDMAs in consultation with DAE. Various categories of first responders will be trained in their use to build up the confidence in them to handle a nuclear/ radiological emergency scenario in the desired manner.

6.3.9.3 Strengthening Real Time Monitoring Systems

A network of simple environmental monitors, the IERMON has been established by BARC. These monitors work on a 24 x 7 basis and large number of these are being installed at select locations countrywide. These monitors can transmit the monitored environmental dose rate data to the nodal ERC at BARC either through a telephone or GSM modem. The display panel in BARC can identify any area where the radiation level becomes abnormally high and generates a warning signal about an impending radiation emergency in that area.

However, all major cities and other vulnerable areas are presently not covered by this network, and this will be taken up on priority by the state governments and assisted by DAE and MHA. NEC will monitor the timely implementation of the network.

6.3.10 Strengthening the Response Infrastructure

The infrastructure pertaining to communication, transport and sheltering are common to all disaster response mechanisms. While the need for strengthening these infrastructures is discussed later in this section, it should be understood that the investment in such infrastructures would improve the effectiveness of all types of response mechanisms at the district level.

6.3.10.1 Communication

All nuclear facilities will have a reliable, efficient and dedicated communication network that is essential for ensuring a coordinated and efficient emergency response. Such a network (based on HF, wireless, Polnet and satellite links) is utilised for communication within the facility with ERCs of nuclear facilities, medical facilities, district authorities, the CMG of DAE, NCMC and NEC for sharing of information on priority issues and actions, among all functionaries who have a role in handling the emergency on a priority basis. Periodic functional checks of the communication links is ensured by the nuclear facility. The planned last-mile coverage to the community will provide the facility to pass the communication in simple regional languages. The essential communication systems will be Electro-Magnetic Pulse (EMP) hardened. A reliable and dedicated NDCN is planned to be established by NDMA as part of its mitigation programme.

The specific requirements of a nuclear emergency communication system include:

i) Civil defence communication (siren/ signals) to communicate stay-in and evacuation warnings in the event of an off-site emergency or a large-scale nuclear disaster is to be ensured for all major target sites and will be periodically tested. The public will also be made aware of the nature of the signals and their implications.

ii) Reliable and diverse communication systems will be ensured for communication among national, state and district headquarters through Emergency Operations Centres (EOCs) as envisaged in the NDCN of NDMA.

iii) All possible communication channels will be explored, including ham radio operators, as per the vulnerability profile of the state/district.

iv) SOPs will be laid down for effective communication during a nuclear emergency/disaster.

v) Mock drills will be periodically carried out to test the communication links.

vi) A nodal officer (District Information Officer) will be identified for briefing the media.

6.3.10.2 Network of Roads and Transport Systems

SDMAs and DDMAs will assess the transport needs for evacuation, including those for the emergency response personnel. Identifying and ensuring the availability of access routes and transportation vehicles for evacuation of the affected population are to be ensured as part of the preparedness programme in an all-hazards approach, in consultation with all the stakeholders including DAE. This may require identification and improvement of roads, in addition to carrying out regular repairs of the existing ones, to ensure that the mechanism is in place to mobilise the required number of transport vehicles.

6.3.10.3 Shelters

Some places like schools, colleges, community centres, marriage halls, religious places, etc., can be easily converted into shelters in the event of a radiological/nuclear emergency without too much investment. Such shelters have been identified with details like accommodation, capacity, etc., in existing emergency preparedness plans for all NPPs. But it is important that these places are identified in advance for vulnerable cities, and the community informed.

SDMAs, SECs, DDMAs, with the guidance of DAE, will assess the number of shelters required during a nuclear/radiation emergency and make plans to make them available.

The state governments concerned will review the details of available shelters and take the initiative to augment these with such additional arrangements as will be needed to cater for the assessed number of people in an emergency. DRDO has developed a variety of shelters which could be considered as an additional resource for large-scale sheltering of people.

6.3.10.4 Alternate Sources of Food, Water and Hygiene Facilities

At NPPs, the district food supply officer is responsible for making arrangements for supplying uncontaminated food to the residents in shelters as part of the emergency preparedness plans of existing NPPs. Similar arrangements need to be worked out by state governments along with the district administration, to ensure availability of alternate sources of food, water and hygiene facilities for the effected community in other radiological emergencies. Normally, the available sources of food and water have to be discarded in the event of their contamination to a level that does not allow their continued consumption/usage.

6.4 Preparedness for Radiological Emergencies

It is the responsibility of every user of nuclear/radioisotope materials to know and comply with all the applicable regulations and safety procedures related to the utilisation of such materials in order to minimise the risk of an accident. All radiation facilities using radioactive materials are required to prepare emergency response plans for the envisaged scenarios resulting in contamination, external exposure and loss of source.

Any unusual event relating to the loss of source or excessive exposure to a person or contamination will be informed to AERB and CMG, and the nearest ERC. The user industry/facility, along with experts/professionals from DAE units/AERB, will promptly provide expert services in radiation protection to assist the local officials and first responders in mitigating an emergency from a radioactive source or for searching and sealing of the lost source.

6.4.1 Strengthening Radiation Monitoring and Detection Systems in the Public Domain

It is desirable to have a mechanism to continuously monitor background radiation levels in the public domain by SDMAs with assistance from MHA and in consultation with DAE which will help in detecting and locating orphan sources. Such a mechanism will be implemented in all major cities that are hubs of important business activities or other important installations which could be potential targets for such threats.

In this context, it may be noted that BARC and DRDO have developed a vehicle monitoring system that can check any inadvertent movement of any radioactive source or material in a moving vehicle.

6.4.2 Enhancing Security Systems at Border Controls and Facilities Handling Radioactive Sources

6.4.2.1 Strengthening Border Controls

In order to detect unauthorised/illicit trafficking, sensitive portal radiation monitors and other radiation detection devices are to be installed by MHA in consultation with the DAE and AERB at border entry points, sea ports and airports. As a second level of defence, such monitoring facilities will also be installed at all the big metal scrap dealers to rule out the possible presence of radioactive material.

6.4.2.2 Enhancing Security at Radiation Facilities and during Transportation of Radioactive Materials

To enhance security at facilities handling radioactive materials and during the transportation of such sources, the AERB has laid down its requirement/guidelines for the security of the sources during handling and transportation. These guidelines will be strictly adhered to by the users of the radiation sources. Wherever required, physical protection measures will also need to be implemented/strengthened.

6.5 Preparedness for 'Criticality' Accidents

In case of a 'criticality' accident at a nuclear fuel cycle facility, the rate of release of radiation is very high and takes place in a time period as short as a millisecond (which may continue to last over a much longer period, if not controlled immediately). A very high radiation field produced during 'criticality' makes a normal radiation detection system (e.g., gamma or neutron area monitors) ineffective. Therefore 'criticality monitors' are to be installed at appropriate locations in the concerned nuclear facilities to sense the release of bursts of neutrons and gamma rays from the 'criticality' reactions.

As with radiological safety, assessment through the technique of hazard analysis is one method of identifying potential 'criticality' hazards. For 'criticality' control, however, it is assessor training which provides the most important input to fault identification due to the fact that the assessor needs to be aware of all the factors which have the potential to result in an inadvertent 'criticality'.

6.6 Preparedness for Transport Accidents

The AERB has already published its requirement/guidelines for the security of sources during handling and transportation. These guidelines must be strictly adhered to by users of the radiation sources.

6.7 Preparedness for Handling a Radiological Dispersal Device

In an RDD, the radioactive material is either placed inside or mixed with a highly explosive device which, on detonation, vaporises and spreads the radioactive material, leading to contamination of the surrounding area. The spreading of this airborne radioactivity and its radiological impact depends on the size, nature and quantity of radioactive material used and the dispersal of the released material. To cope with such an emergency, the tasks to be undertaken by SDMAs, SECs and DDMAs, in consultation DAE, DRDO and AERB and with assistance from MHA, involve, inter alia, preparedness in the following main areas, viz.:

i) The affected persons and area will have to be monitored for contamination levels. The first responders have to be suitably equipped to measure the radiation levels and have the necessary kit to protect themselves. There will also be a need to monitor a large number of persons after an RDD explosion and handle large amounts of radioactive wastes arising out of change of clothing, showering or washing.

ii) A list of the agencies to be contacted by the public in case of a suspected presence of radioactivity will be made available to all citizens.

iii) Expertise has to be developed for remotely defusing unexploded RDDs and other methods of reducing exposure of the experts need to be planned and worked out.

6.8 Medical Preparedness

6.8.1 Strategy for Medical Management

Medical preparedness is an essential component of nuclear disaster/radiological emergency/disaster preparedness. Though emergency/disaster management encompasses all hazards, a multi-disciplinary approach to nuclear emergency/disaster requires additional focus on protection, detection, decontamination, de-corporation and restitution of the immune system. Medical facilities such as specialised ambulances, specialised CBRN hospitals and radiation injury treatment centres also need to be augmented to take care of mass casualties due to radiation burns and injuries.

It is also necessary to network medical professionals, train them in the management of radiation injuries, maintain an up-to-date database of such expertise and develop a mechanism to tap this expertise in the event of an emergency. This requires a concerted approach by all concerned, viz., NDMA, SDMA, DDMA, MHA, DAE, Ministry of Health and Family Welfare (MoH&FW) and state as well as district health authorities.

The scale of arrangements required depends upon the type of scenario, ranging from radiation accident in a nuclear facility, use of 'dirty bombs' by terrorists or a full-fledged nuclear war. The specific requirements for the possible scenario at the site, during evacuation, at the hospital and the administrative actions required, are discussed in the succeeding sections.

6.8.2 Institutional and Operational Framework

At the national level, MoH&FW will work in close coordination with NDMA, SDMA, MHA, DAE and Ministry of Defence (MoD) to foresee the preparedness in specific areas.

MoH&FW and the concerned state health department will have an emergency support plan in place to mobilise additional human and material resources. The state governments will also have a contingency plan in place to mobilise additional men and material through the networking of hospitals. The extent of mobilisation will depend on the nature of the event and rapid assessment.

The health sector will have EOCs at the national, state and district levels to have effective communication with all the stakeholders.

6.8.3 Pre-Hospital Preparedness

For a large-scale nuclear disaster, an emergency preparedness plan will be drawn up by the concerned district administration. Medical preparedness will also be an important component of such a plan. The medical preparedness plans at the incident site and at the hospital will be integrated to have effective coordination. The chief medical officer of the district will be responsible for all medical matters. For managing the medical aspects of incidents at nuclear facilities or to manage incidents of radiological terrorism, the guidelines are given below.

6.8.3.1 Network of Medical Facilities and Medical Professionals

The existing medical facilities and medical professionals in the country are highly inadequate to handle large-scale radiation injury cases. These are to be augmented by MoH&FW in consultation with DAE at the primary, secondary as well as tertiary levels in addition to their proper networking to cope with the need of a large-scale nuclear emergency.

6.8.3.2 Network of Radiological Safety Officers

The certified RSOs who are available at various radiation facilities where significant quantities of radioactive sources are used, will also be used as a potential resource of qualified professionals by local law and order agencies to handle any radiation-related event in the public domain (like suspected presence of a radioactive source, an RDD explosion, etc.).

To enable this, it is necessary that a database of RSOs be prepared/maintained and made available at the DDMA, SDMA and national levels by the AERB.

6.8.3.3 Quick Reaction Medical Teams (QRMTs)/ Medical First Responders (MFRs)

The district health authorities will constitute quick reaction medical teams for pre-hospital care. The team consisting of RSOs, medical doctors, nurses and paramedical staff would be equipped with monitoring instruments/ equipment, protective gear, decontamination agents and other material. Critical care vans with resuscitation and life support systems will be part of QRMTs/MFRs.

The specialised search and rescue teams of NDRF/State Disaster Response Force (SDRF)/ District Disaster Response Force (DDRF) will facilitate the task of QRMTs/MFRs to provide the necessary assistance.

The names, contact numbers, addresses, etc., of the team members will be available with the district authorities to mobilise the teams at short notice.

All the QRMTs/MFRs will be trained on personal protection, evaluation of radiation exposure, decontamination and on-field radiation injury management.

The provision of mobile hospitals needs to be planned for managing casualties at the site.

The QRMT/MFR teams will form part of the regular mock-drill/ simulation exercise/tabletop exercise conducted by DDMAs.

6.8.3.4 Mobile Radiological Laboratory

There will be at least one mobile radiological laboratory unit in each district and at least two units in each metropolis to support the detection, protection and decontamination procedures. Presently, a few mobile radiological laboratories are available with DAE and DRDO.

6.8.4 Hospital Preparedness

The hospital preparedness plan will be based on an 'all hazards' plan, of which the nuclear/ radiation emergency response will be one component. Nuclear or radiological emergencies would require building up of capacities for radiation injury management. A major accident in a nuclear facility would result in the exposure of large number of occupational workers and people in the surrounding areas. The situation arising out of a 'dirty bomb' attack using conventional explosive devices may result in blast injuries, burns and some radioactive contamination. The number of cases may vary according to the intensity of the explosion and population density at the site. It is expected that an adversary or a terrorist will be targeting metropolises or sensitive installations. The number of casualties is not expected to be large in a 'dirty bomb' attack, but on the other hand a few lakhs may be affected in the aftermath of a nuclear attack.

Designated hospitals require specialised Radiation Injuries Treatment Centres (RITCs) to manage nuclear/radiological emergencies. These RITCs will have a burns ward, blood bank, Bone Marrow Transplant (BMT) and stem cell harvesting facilities, etc. Further details for medical preparedness are given in Appendix 4.

The identified hospitals in the off-site plan of nuclear facilities will also be networked into this pool of designated hospitals for managing radiation injuries. The identified hospitals at the secondary (district) level will require strengthening in order to develop specialised capacities such as decontamination centre, facility for safe disposal of contaminated waste, detection, protection and de-corporation and managing patients exposed to radiation and primary trauma care. The tertiary (state and national level) institutions identified in vulnerable areas would have, in addition, facilities such as RITC, BMT and stem cell harvesting, genetic lab, molecular lab, immunology lab and arrangements to treat mass casualties arising from nuclear war/major accidents in the nuclear facilities. The scale of arrangements will differ with respect to the preparedness at the secondary and tertiary levels, depending upon the extent of severity.

6.8.5 Hospital Logistics

The 'all hazards' DM plan of designated hospitals will cater to specialised requirements for the treatment of radiation injuries. Following are some of the aspects that will require attention:

i) The logistical requirement may actually be much higher than what could have been planned for natural disasters or even mass casualties arising out of conventional weapons. In a worst-case scenario, this will require large quantities of IV fluids, plasma expanders, antibiotics, vaccines, etc. The indigenous manufacturers of drugs/vaccines would be surveyed by the central/state health authorities and their capacity for production as well as optimal lead time to produce any augmented requirement will be assessed. The supply system will be geared up to provide for increased demands for certain types of medical supplies and equipment such as whole blood, blood components, burn kits, dressings, individual protective clothing, dosimeters, etc.

ii) Each vulnerable state will stockpile specialised medical stores consisting of Amifostine and other radio-protectors, decontamination agents, de-corporation agents [DiethyleneTriamine-Penta Acetate (DTPA), Prussian Blue, etc.], Potassium Iodide/Iodate, growth factors, colony stimulating factors and other radiation recovery agents. While on the subject, it may be noted that two main de-corporation agents, viz. DTPA and Prussian Blue, are presently required to be imported. The Food and Drug administration authorities, including Drug Controllers in the state and central governments will expedite permissions for fast procurement of these essential de-corporation agents.

iii) The hospitals will establish an effective communication network that is essential for a coordinated and efficient incident response.

6.8.6 Training of Medical Staff

The medical and paramedical staff of the identified district hospital, radiation injury treatment centre and mobile units will be given appropriate training for working in a radiation environment.

6.8.7 Psycho-Social Care and Mental Health

i) The central and state governments will identify nodal agencies for providing psycho-social care. The identified institutions will form teams for giving psycho-social relief, mental health needs, depressive or aggressive psychosis.

ii) Volunteers from the community will be trained in counselling those amenable to such therapy. Efforts will be made to station counselling teams trained from the local community, in the temporary shelters for continuous care.

6.8.8 Extended Mortuary

Any large-scale emergency/disaster is expected to result in a large number of fatalities. This would necessitate the establishment of mortuary facilities to accommodate dead bodies. This will take into account the fact that in the event of a large-scale nuclear emergency/ disaster, there would be the possibility of a large number of dead bodies being contaminated. The Medical Management Guidelines document for CBRN disasters elaborates further on these requirements.

6.8.9 Research and Development

The development of biomarkers of radiation response, molecular biological techniques for mass screening, radio-protectors, isotope-specific chelating agents, etc., are the immediate requirements on which basic and applied research will be focused.

A model CBRN research and treatment centre will be established by MoH&FW in one of the major hospitals, with sufficient number of beds to take care of any type of nuclear emergency/disaster. This facility will also be created in advanced tertiary care hospitals. The facility may be replicated subsequently in at least four geographically well separated locations near the high-risk areas/zones.

DAE and state governments will also be encouraged to develop such CBRN centres for knowledge management, R&D, medical management and teaching and training.

6.9 Emergency/Disaster Management for Metros and Important Cities

All the major metros and certain other bigger cities can be considered vulnerable from a nuclear emergency/disaster point of view. A list of monitoring instruments and other equipment required for this purpose can be worked out with the help of DAE. The training of first responders at these places should be taken up immediately. The civil defence set-up of these cities will also be activated. Detailed operational plans followed by SOPs will be prepared for all these locations.

To prepare all these units to cope with a nuclear emergency/disaster, huge resources, both in terms of manpower and equipment will be needed.

To start with, an effort will be made to cover all cities with a population of 20 lakh or more in the first phase by the SDMAs/SECs and DDMAs concerned, in consultation with DAE/DRDO. The satellite towns around the target cities will also be considered as available resources by preparing them to provide the necessary assistance in the event of any nuclear/ radiological disaster. This is most important for the metros in the country. The coverage will be progressively extended to include cities with population of approximately 10 lakh or more after three years and on completion of the first phase.

Emergency exercises will be conducted at all such places to test the preparedness of first responders as well as the community. However, such exercises, purely for handling of a nuclear emergency, may create panic in the public and may send wrong signals to various agencies. The exercise for nuclear emergency will, therefore, be carried out as part of the overall emergency exercise (conducted to get prepared to face various types of natural and man-made calamities).

6.10 Intervention and Action Levels

The radiation dose level over an area, a few kilometers in radius (where people might have survived the nuclear attack), may be very high as the area may become highly contaminated. Due to the presence of radioactive dust, there may be very serious inhalation hazards in the area in addition to very high levels of radiation dose. Under these conditions, carrying out rescue and relief work may be highly demanding, both for the first responders as well members of the NDRF teams. In carrying out the rescue and relief operations, they may be exposed to, without the availability of the intervention level, to very high levels of both radiation dose and contamination which will impair their capacity to continue the rescue and relief work.

It is, therefore, essential that advance information is available about the intervention levels at which the responders will be asked to carry out the rescue and relief operations. These levels are equally important for both the public (from the point of avertable exposure to radiation) as well as for the members of relief and rescue teams (from the point of avertable overdose). Below the intervention level, no deterministic effect of radiation is expected in the public.

Similarly, in case of a nuclear attack, it is possible that large quantities of food and water available in the area will be highly contaminated. To control the consumption of contaminated food items in the affected area or for arranging the supply of fresh food from outside the effected area, it is important to know the action levels for food and water consumption in the area.

Presently, the values of neither the intervention nor action levels are available. In fact, these values are not available even in the case of an explosion of an RDD where the intensity and magnitude of the event will be much lower compared to that of a nuclear explosion.

The concerned expert agencies are examining this matter together with NDMA and the required intervention and action levels are likely to be established shortly.

6.11 Availability of a GIS-Based Emergency Preparedness and Response System

It is necessary to develop a GIS-based emergency preparedness and response system as a national programme. Digital maps of the affected areas/cities/regions in the country at an appropriate scale will be integrated with GIS-based data for effective response systems for all emergencies. Such tools should also be developed for monitoring the movement of radioactive plumes to provide the necessary inputs to decision makers for taking decisions on the evacuation of affected localities and sheltering.

6.12 Financial Provisions

The DM authority at the national, state and district levels must cater for planned and unplanned budgets for capacity building, training and mock-drills that are necessary to cope with nuclear/radiological emergencies. Sufficient funds must be allocated for detection, protection, radiation survey vans, decontamination, resuscitation equipment, ambulances/heli-ambulances, helicopters, casualty bags, mobile decontamination tents, specialised centres for treatment of radiation injuries, etc. Finances will be arranged for creating shelters and for the supply of clean water, fresh food and medicines, where required.

Adequate funds will be earmarked for the development/upgradation of a large number of emergency response centres with sufficient number of monitoring systems and protective gear, training of emergency response teams and first responders, etc. States/UTs will be adequately assisted by NDMA and the Planning Commission in this matter.

6.13 Action Points

Some of the action points of this chapter are given below:

i) It is desirable to have a mechanism to continuously monitor background radiation levels in the public domain by SDMAs, with assistance from MHA and in consultation with DAE, which will help in detecting and locating the orphan sources. Such a mechanism should be put in place in all major cities that are hubs of important business activities or other important installations which could be potential targets for such threats.

ii) In order to detect unauthorised/illicit trafficking, sensitive portable radiation monitors and other radiation detection devices are to be installed by MHA in consultation with the DAE and AERB at border entry points, sea ports and airports. As a second level of defence, such monitoring facilities should also be installed at all big metal scrap dealers to rule out the possible presence of radioactive material.

iii) 'Criticality monitors' are to be installed at appropriate locations in the concerned nuclear facilities to sense the release of burst of neutrons and gamma rays from the 'criticality' reactions.

iv) The AERB has already published its requirements/guidelines for the security of sources during their handling and transportation. These guidelines must be strictly adhered to by the users of the radiation sources.

v) To cope with RDD emergencies, the tasks to be undertaken by SDMAs, SECs and DDMAs, in consultation DAE, DRDO and AERB and with assistance from MHA, involve, inter alia, preparedness in the following main areas, viz.:

a. Affected persons and areas will have to be monitored for contamination levels.

b. The first responders have to be suitably equipped to measure the radiation levels and also be equipped with the necessary kit to protect themselves.

c. There will also be the need to monitor a large number of persons after an RDD explosion and handle large amounts of radioactive wastes arising out of change of clothing, showering or washing.

d. A list of the agencies to be contacted by the public in case of a suspected presence of radioactive material will be made available to all citizens.

e. Expertise is also to be developed for remotely defusing unexploded RDDs and methods to reduce the exposure of experts need to be planned and worked out.

vi) A concerted approach by all concerned, viz., NDMA, SDMA, DDMA, MHA, DAE, MoH&FW and state as well as district health authorities, is necessary to network medical professionals, train them in the management of radiation injuries, maintain an up-to-date database of such expertise and develop a mechanism to tap this expertise in the event of an emergency. To enable this, it is necessary that a database of RSOs be prepared/maintained and made available to DDMAs, SDMAs and agencies at the national level by the AERB.

vii) At the national level, MoH&FW will work in close coordination with NDMA, SDMA, MHA, DAE and MoD to foresee medical preparedness in specific areas.

viii) The existing medical facilities and medical professionals are highly inadequate to handle large-scale radiation injury cases in the country. These are to be augmented by MoH&FW in consultation with DAE at the primary, secondary and tertiary levels, in addition to their proper networking to cope with the needs of a large-scale nuclear emergency.

ix) The district health authorities will constitute QRMTs for pre-hospital care. The team consisting of RSOs, medical doctors, nurses and paramedical staff would be equipped with monitoring instruments/equipment, protective gear, decontamination agents and other material. Critical care vans with resuscitation and life support systems will be part of QRMTs/MFRs. The QRMT/MFR teams will form part of the regular mock-drill/simulation exercise/tabletop exercise conducted by DDMAs.

x) There will be at least one mobile radiological laboratory unit in each district and at least two units in each metropolis to support detection, protection and decontamination procedures. Presently, only a few mobile radiological laboratories are available with DAE and DRDO.

xi) The hospital preparedness plan will be based on an 'all hazards' plan, of which the nuclear/radiation emergency response will be one component. Nuclear or radiological emergencies would require building capacities for radiation injury management. A major accident in a nuclear facility would result in the exposure of a large number of occupational workers and people in the surrounding areas. The situation arising out of a 'dirty bomb' attack using conventional explosive devices may result in blast injuries, burns and some radioactive contamination.

xii) Designated hospitals require specialised RITCs to manage nuclear/radiological emergencies. These RITCs will have a burns ward, blood bank, BMT and stem cell harvesting facilities, etc. Further details for medical preparedness are given in Appendix 4.

The identified hospitals in the off-site plan of nuclear facilities will also be networked into this pool of designated hospitals for managing radiation injuries. The identified hospitals at the secondary (district) level will require strengthening in order to develop specialised capacities such as a decontamination centre, the facility for safe disposal of contaminated wastes, detection, protection and de-corporation and managing patients exposed to radiation and primary trauma care. The tertiary (state and national level) institutions identified in vulnerable areas would have, in addition, facilities such as RITC, BMT and stem cell harvesting facilities, genetic lab, molecular lab, immunology lab and facilities to treat mass casualties arising from nuclear war/major accidents in the nuclear facilities. The scale of arrangements will differ with respect to preparedness at the secondary and tertiary levels, depending upon the extent of severity.

xiii) A model CBRN research and treatment centre will be established by MoH&FW in consultation with DAE in one of the major hospitals, with sufficient number of beds to take care of any type of nuclear emergency/disaster. This facility will also be created in advanced tertiary care hospitals. The facility may be replicated subsequently in at least four geographically well-separated locations near the high-risk areas/zones.

xiv) An effort will be made in the first phase to cover all the cities with a population of 20 lakh or more by the concerned SDMAs/SECs and DDMAs in consultation with DAE/DRDO for monitoring and training of first responders to respond to a nuclear/radiological emergency. The satellite towns around the target cities will also be taken as available resources by preparing them to provide the necessary assistance in the event of any nuclear/radiological disaster. This is most important for the metros in the country. The coverage will be progressively extended to include cities with a population of approximately 10 lakh or more after three years and on completion of the first phase.

Adequate funds will be earmarked for the development/upgradation of a large number of emergency response centres with a sufficient number of monitoring systems and protective gear, training of emergency response teams and first responders, etc. States/UTs will be adequately assisted by NDMA and the Planning Commission in this matter.

xv) The concerned expert agencies of DAE and AERB are required to examine and make available shortly, the required intervention and action levels.

xvi) SDMAs, SECs and DDMAs, with guidance from DAE, will assess the number of shelters required during a nuclear/ radiation emergency and draw up plans to make them available.

xvii) SDMAs and DDMAs will assess the transport needs for evacuation, including those for the emergency response personnel, as part of the preparedness programme in an 'all-hazards' approach, in consultation with all the stakeholders, including DAE.

xviii) The specific requirements of a nuclear emergency communication system include the following:

a. A reliable and diverse communication system will be ensured for communication among national, state and district headquarters through EOCs as envisaged in the NDCN of NDMA. However, it will be the responsibility of SDMAs/DDMAs, with the assistance of nuclear facility operators and DAE, to ensure last mile connectivity to NDCN.

b. Civil defence communication (siren/ signals) to communicate stay-in and evacuation warnings in the event of an off-site emergency or a large-scale nuclear disaster is to be ensured for all major target sites and will be periodically tested. The public will also be made aware of the nature of the signals and their implications.

c. SOPs will be laid down for effective communication during a nuclear emergency/disaster and a nodal officer (District Information Officer) will be identified for briefing the media. Mock drills will be periodically carried out to test the communication links.

xix) In addition to the ERCs (presently 18 in number) established by BARC, it is essential that additional ERCs, with the necessary trained personnel equipped with appropriate radiation detection instruments and PPG are set up in all major cities and other vulnerable locations, to cope with nuclear/ radiological emergencies within a period of three years at the outer limit. The responsibility of setting up of these additional ERCs will be that of the state governments from their own existing manpower in the police. The financial resources for these will be made available by the centre. NDMA will organise provisioning of the entire financial requirements for the preparation for such emergencies as part of a mitigation project.

An ERC will have a mobile monitoring van equipped with radiation detection systems and protective gear (for ERTs) to carry out an assessment of the radiological impact. Assessment of the radiological status at the site of the emergency is very important so that rescue workers and medical personnel can be protected.

xx) In case of any nuclear/radiological emergency, the first need is the availability of instruments for radiation detection and monitoring. An inventory of radiation monitoring instruments and protective gear will be built up by all SDMAs and DDMAs in consultation with DAE. Various categories of first responders will be trained in their use to build up confidence in them to handle a nuclear/radiological emergency scenario in the desired way.

The evaluation of an exercise will identify areas of emergency plans and preparedness that may need to be improved or enhanced. It will be the responsibility of the nuclear facility and the district authority to review the evaluation report and to ensure implementation of the corrective measures recommended by the evaluators.

xxi) While the central and state governments must aim to develop suitable response capabilities to meet the perceived nuclear emergency/disaster threat scenario, such response efforts might require to be augmented by the armed forces. To ensure optimum synergy, it is imperative that proper interaction between the civil authorities and armed forces is carried out during all stages of planning, preparedness and response.

xxii) Specialised response teams will be raised, specially trained for nuclear/radiological emergencies/disasters and fully equipped at the state (by SDMAs/SECs/DDMAs) and central levels (by MHA). Four battalions of NDRF are being specially trained by NDMA with assistance from DAE/DRDO to provide specialised first response during a nuclear/radiological emergency/ disaster. The first responders group will be extended to include fire and emergency services personnel, the police force and the civil defence staff.

xxiii) Since response actions during CBRN disaster scenarios are quite different from those needed for natural and other man-made disasters, CBRN-trained battalions of NDRF (presently located at Greater Noida, Kolkata, Talegaon in Pune and Arakonam in Chennai) must always be available on an emergent basis.

7 Capacity Development for Nuclear/Radiological Emergencies

7.1 Capacity Development

The major strategies with regard to capacity development and building of technical support systems are to:

i) Bridge the existing gap in capacities between current needs and current means.

ii) Increase the capacity at all levels to cope with the enhanced demand for handling nuclear accidents.

iii) Establish/strengthen partnership and liaison among the industrial and hospital clusters handling radiation sources. Encourage technical cooperation among them for management of nuclear emergencies.

iv) Encourage stakeholders (like academia, research institutes, medical facilities) to develop and promote programmes on nuclear safety and undertake R&D work that will assist in capacity development.

v) Promote coordination and access to information on capacity development for the management of nuclear accidents in a transparent way.

vi) Facilitate adequate financial, technical, and infrastructural support for capacity building through sharing of experience and technical cooperation.

The important tasks involved in capacity development in terms of augmentation and upgradation of various response forces and infrastructure have already been covered in Chapter 6 which deals with preparedness. The measures needed to upgrade human resources at various levels of stakeholders in general, and the community, in particular are dealt with in this chapter.

7.2 Education, Knowledge Management, Awareness Generation and Training of Stakeholders

For the success of nuclear/radiological emergency management, the most important factor is the confidence level in the community at large to cope with such an event. Education, awareness generation and knowledge management of information related to nuclear/radiological emergencies have an important role to play in this context.

Once a community becomes familiar with the beneficial aspects of nuclear energy and the capability of nuclear facility operators in India to handle the hazards, their anxiety and fear towards the nuclear energy programme, in general, and nuclear accidents, in particular, will reduce considerably. Education on nuclear emergency/disaster management is essential for both the community as well as for stakeholders.

7.2.1 Education and Knowledge Management

The strategic approach with regard to education, information dissemination and training of nuclear emergencies will be to ensure that:

i) All undue apprehension or panic in the public mind regarding a peaceful nuclear power/radiological programme is allayed completely.

ii) Knowledge and information on radiation/ radioactive substances and nuclear emergency management is adequate and widely disseminated across the country.

iii) The occupational workers and response forces can perform their duties efficiently during nuclear/radiological emergencies.

Education and upgradation of the knowledge base on nuclear/radiological emergency/disaster management is, therefore, essential for all stakeholders, starting from the community to the government agencies at various levels.

7.2.1.1 Student Community and Administrative Personnel

Disaster awareness in the community can be spread effectively through the student community by including relevant topics in the syllabi of the science streams, pertaining to nuclear/radiological emergencies/disasters such as radiation, effects of radiation on biological systems and the environment, reduction of exposure through the principles of time, distance and shielding, etc. This can be done at the school as well as college levels.

The Ministry of Human Resource Development (MHRD), with the active support of MHA, will ensure that the student community is imparted proper education on the relevant topics by schools/colleges. The teachers will be specially trained for this purpose, through the Central Board of Secondary Education (CBSE) and State Secondary Education Boards.

Similarly, the syllabi of the basic courses in Lal Bahadur Shastri National Academy of Administration (LBSNAA), state Administrative Training Institutes (ATIs), academies of the armed forces, paramilitary forces, police service, and MBA programmes should also include similar topics with added emphasis on the management of nuclear/radiological emergencies/disasters.

The institutional training will be imparted by the NIDM with guidance from DAE and NDMA. Education being an area of keen interest to the private organisations in our country, public-private partnerships would be effective in this programme.

Such educational programmes will help establish the necessary knowledge base at the preliminary level in the public domain.

7.2.1.2 Community Education

Despite the initiatives taken at various levels to allay apprehensions about radiation and the nuclear energy programme, presently the public perception of the possible adverse affect of any nuclear/radiological accident is far detached from the ground reality. It is necessary to address this issue through an effective community education programme where preliminary information on nuclear/radiological emergencies will be disseminated. Such information must by authentic, accurate, need based, and easy to understand. The agency entrusted with this task must enjoy credibility and acceptability in the community in order to win its confidence.

The responsibility for community education will rest with the nuclear installations, industries using radioisotopes, user hospitals of radioisotopes, institutions involved in radiation research, and disaster management authorities at the district and state levels, including NIDM and NDMA.

The literature used for dissemination of information should be prepared in vernacular languages and reviewed and updated periodically, by a group to be established by MHRD in consultation with the Core Group on Nuclear Disaster Management set up by the NDMA.

As a matter of strategy, information relating to expected community response in case of nuclear emergencies/disasters can also be shared with the community through health camps, etc., for better effectiveness. Hospital authorities can play a major role in community education regarding the effects on health due to radiation exposure as they enjoy greater credibility in the community.

7.2.1.3 Education of Professional Personnel

The availability of professional expertise is a crucial factor for the successful dissemination, monitoring and sustainable implementation of the nuclear emergency/disaster management action plans at various levels (including government agencies).

The nuclear DM framework also imposes additional responsibility on the professionals to improve their skills and expertise to stay tuned to best practices the world over for safer nuclear energy/radiation applications, so as to contribute to capacity building. DAE will get actively involved in this programme and guide this effort.

7.3 Enhancing Public Awareness

Most nuclear facilities conduct a number of public awareness generation programmes, though limited to around the facility to make the public aware of various preparedness/ response plans of the facility operators. This is done so that the public get the proper perspective and confidence and do not panic in the event of any nuclear emergency.

With the increasing use of nuclear and radiation technologies for societal benefit, conscious efforts will be made to enhance public awareness on the benefits as well as hazards of nuclear/radiological technology and nuclear/radiological emergencies/disasters, including the measures taken to ensure safety at nuclear facilities. The fact that 'alarm bells' start ringing in the field of nuclear science and technology much earlier in comparison to other technologies will be stressed. The awareness programme will also educate the public on the simple measures they can take to protect themselves in the event of their encountering any radiation emergency scenario.

Awareness programmes will be conducted in the form of symposia, workshops, interactive sessions, exhibitions, etc., using printed material like pamphlets, brochures, etc., which are also to be made available in vernacular languages, so as to reach the maximum number of people in the country. Use will also be made of all forms of media i.e., print, audiovisual and electronic in an appropriate way. The target groups for these programmes will be school and college students, teachers, government officials and technocrats. To start with, the people living in and around nuclear facilities and major metros will be the chosen groups for promoting awareness generation programmes on radiation emergency scenarios.

7.3.1 Community Participation

The best way to win the confidence of the community for handling nuclear/radiological emergencies/disasters is to involve them in the various stages of nuclear emergency management activities right from the planning stages of the DDMAs, SDMAs, and local bodies through:

i) Community education, awareness generation, and training.

ii) Participation in off-site emergency exercises.

iii) Sharing of the results of community response in off-site emergency exercises;

iv) Analysis and necessary upgradation of response programmes.

7.4 Training of Stakeholders

7.4.1 Training of First Responders

Various first responder groups like the NDRF, fire services, police, civil defence, state disaster response forces, medical teams, etc., will be trained extensively in nuclear emergency/disaster management through regular courses conducted by trained personnel of the NDRF with assistance from DAE, DRDO, and NDMA. There will be regular refresher courses to keep them up to date with the new developments in the field of nuclear safety and security.

7.4.2 Training of Administrative Personnel

With assistance from DAE, NIDM at the national level and ATIs at the state level will organise training of administrative personnel from all central ministries/departments and state governments in various aspects of the management of nuclear emergencies/disasters, including its preparedness and response requirements.

The training will be elaborate and explain how a nuclear emergency is conceptually different from a conventional emergency because of the likelihood of high radiation levels and contamination in the affected area. First responders will also be trained on how to take care of their own radiation safety by wearing Personal Protective Gear (PPG) while they are involved in monitoring, decontamination, triage, etc.

7.5 Documentation

The basic idea of such documentation work is to channelise efforts that serve the purpose of 'learning lessons from past experience' and also for carrying forward the necessary improvements in existing as well as future nuclear facilities in the country. With the necessary support from DAE, NIDM will prepare films, manuals and other documents necessary to spread authentic, accurate, and easy to understand information on various safety aspects of nuclear facilities, nuclear emergency preparedness/response on the part of nuclear facility operators, and the role of various stakeholders during any nuclear emergency, etc. Special importance will be given to the history of nuclear/radiological emergencies/disasters in the world and past records of nuclear incidents/emergencies, if any, in India. Such documents must also include the following information:

i) Limits of radiation exposure that have been set at a fraction of what can cause any significant harm to activate emergency procedures. This important aspect will be included in the information given to the community to instill greater confidence in them.

ii) Information about the existence of a specially trained and equipped NDRF to handle any CBRN emergency will be shared with the community.

7.6 Participation of Electronic and Print Media

The electronic and print media have a strong network throughout the nation with a powerful audiovisual impact on the viewer. It is an important tool which can be used for enhancing community awareness and imparting education through well designed and tested audio/visuals, interviews of experts, printed leaflets related to prevention/preparedness aspects of nuclear/radiological emergencies, and dos and don'ts to spread awareness and confidence without creating any panic in the community. Nationwide training will be organised by the concerned facility operator of DAE for media personnel on a regular basis to remove their misconceptions.

The nuclear facilities will have dedicated and well informed men for media management to minimise the possible negative impacts of off-site emergency exercises on the public psyche, if any.

To maintain uniformity in approach in case of an emergency at an NPP, all information to the media will be routed through the district information officer.

7.7 Strengthening the Institutional Framework (for Regulatory and Response Mechanisms)

7.7.1 Regulatory and Enforcement Issues

Since the number of radiation applications in medicine, industry, agriculture and research will significantly increase in the coming years, AERB will consider establishing regional regulatory centres/authorities to handle the increased volume of regulatory work by decentralising and delegating the regulatory powers to these regional centres. This process needs to be accelerated to ensure better regulatory enforcement at the state level.

Further, while the regulations are largely comprehensive, the AERB will continue to review its codes and standards in the light of emerging new technologies and develop additional codes wherever required.

7.7.2 Formalising the Coordination Mechanism with Public Authorities

The emergency response authorities at the state and district levels have to be sufficiently empowered to respond to radiation/nuclear emergencies. The linkages between them and the nearest ERC of DAE have to be formalised and tested through periodic exercises. This mechanism will be strengthened, based on feedback from exercises.

For community participation programmes to be successful, nuclear facility operators will involve NDRF, civil defence, fire services, home guards, NGOs and youth organisations like National Cadet Corps (NCC), Nehru Yuva Kendra Sangathan (NYKS) and National Service Scheme (NSS), as part of their emergency management programme.

7.8 Public-Private Partnership and Corporate Social Responsibility

In addition to their support for education, the corporate sector has shown commendable willingness to support disaster response in recent years. They will be encouraged to pay more attention towards preparation and rehearsal of both 'on-site' and 'off-site' plans in partnership with the local authorities. Some of the other areas in which public-private partnership contribution/collaboration would be fruitful are communication, mobile hospitals, heli-ambulances, roads and transportation facilities, fire services, DM education, addition of radiation care units in hospitals to treat radiation injuries, establishment of secondary and tertiary level hospitals for treatment of radiation injuries, resuscitation activities, medical institutes for studies on radiation effects, environmental protection, evacuation, shelters, etc. The facility operators, NDMA and the SDMAs will network with corporate associations to further strengthen and formalise their role in the DM process so that they can make a greater contribution in providing radiation safety to the community.

7.9 Launching Research and Development Initiatives and Development of Instruments and Equipment

There is an urgent need to initiate some R&D efforts by DAE/DRDO in the areas of radiation biology, in the light of newer findings of how radiation affects the basic biomass in the human body. This would help provide essential inputs for the easy diagnosis of radiation related injuries/diseases and also help assessment of the impact of radiation emergencies.

R&D initiatives are also needed to develop advanced monitoring instruments, and radiation measuring devices incorporated in simple gadgets like watches, mobile phones, pens, etc., and also for better protection gear. This will also include development of suitable 'radio-protectors' that can be made easily available to the masses.

Other areas of R&D efforts will include development of improvised shielding materials that may be used by the public to protect themselves from radiation in the event of nuclear emergencies/disasters; mobile, lightweight and quick-to-assemble shelters for radiation protection; and more efficient decontamination agents.

Further research is warranted to understand the mechanisms of radiation injury, radiation carcinogenesis, and biological effects of radiation. This is required for developing safety standards for newer treatment protocols for cancer patients and also for ascertaining the radiation exposure limits for occupational workers and members of the public.

7.10 Action Points

Some of the action points of this chapter are given below:

i) MHRD, with the active support of MHA, will ensure that the student community, being the most effective segment of the society, is imparted education and training on relevant topics of nuclear/ radiological emergencies/disasters by the schools/colleges, whose teachers are to be specially trained for this purpose, by the CBSE and State Secondary Education Boards.

ii) The responsibility for awareness generation, education and training of the community will rest with DDMAs and SDMAs including the local bodies along with the nuclear installations, industries using radioisotopes, user hospitals of radioisotopes, institutions involved in radiation research and DM authorities at the district and state levels, including NIDM and NDMA.

   For community participation programmes to be successful, nuclear facility operators will involve the NDRF, civil defence, fire services, home guards, NGOs, and youth organisations like NCC, NYKS and NSS, as part of their emergency management programme.

iii) Various first responder groups like the NDRF, fire service personnel, police force, civil defence personnel, state disaster response forces, medical teams, etc., will be trained extensively on nuclear emergency/disaster management through the regular courses conducted by CBRN trained personnel of the NDRF with assistance from DAE, DRDO, and NDMA. There will be regular refresher courses to keep them up to date with new developments in the field of nuclear safety and security.

iv) With assistance from DAE and DRDO, NIDM at the national level and ATIs at the state level would organise training of administrative personnel from all central ministries/departments and state governments in various aspects of the management of nuclear emergencies/ disasters, including its preparedness and response requirements.

v) The nuclear facilities will have dedicated and well informed men for media management to maintain uniformity in approach in case of an emergency at an NPP. All information to the media will be routed through the district information officer.

vi) Since the number of radiation applications in medicine, industry, agriculture, and research will significantly increase in the coming years, AERB will consider establishing regional regulatory centres/authorities to handle the increased volume of regulatory work by decentralising and delegating regulatory powers to these regional centres. This process needs to be accelerated to ensure better regulatory enforcement at the state level.

vii) While the regulations are largely comprehensive, the AERB will continue to review its codes and standards in the light of emerging new technologies and develop additional codes, wherever required.

viii) The facility operators, NDMA, and the SDMAs will network with corporate bodies to strengthen and formalise their role in the DM process so that they can make a greater contribution in planning and preparation to handle an off-site emergency. Some of the other areas in which public-private partnership contribution/collaboration would be fruitful are communication, mobile hospitals, heli-ambulances, roads and transportation facilities, fire services, DM education, addition of radiation care units in hospitals to treat radiation injuries, establishment of secondary and tertiary level hospitals for treatment of radiation injuries, resuscitation activities, medical institutes for studies on radiation effects, environmental protection, evacuation, shelters, etc.

ix) There is an urgent need to initiate some R&D efforts by DAE/DRDO in the areas of radiation biology, in the light of newer findings of how radiation affects the basic biomass in the human body.

R&D initiatives are also needed to develop advanced monitoring instruments, radiation measuring devices in simple gadgets like watches, mobile phones, pens, etc., including better protection gear.

Further research is warranted to understand the mechanisms of radiation injury, radiation carcinogenesis and biological effects of radiation which is required for developing safety standards for newer treatment protocols for cancer patients and also for ascertaining the radiation exposure limits for occupational workers and members of the public.

8 Response to Nuclear/Radiological Emergencies

8.1 Objectives of Response to Nuclear / Radiological Emergencies

The response to nuclear/radiological emergencies has its own objectives and principles, such as mitigation of accidents at source; prevention of deterministic health effects in individuals; providing first aid and treatment of injuries; reducing the probability of stochastic effects in the population; reduction of psychological impact on the population; and protection of the environment and property, all within the constraints of available resources.

For off-site nuclear emergencies at all nuclear power plants/facilities, the district collector of the affected area will take charge as the incident commander. The collector himself will be responsible for this task and will not delegate responsibility to anyone lower.

Similarly, for radiological emergencies at metros/big cities, the state authorities will nominate in advance an incident commander, specifically for handling radiological emergencies, if any, wherein more than one district are involved and this task will not be then delegated to any other authority.

8.2 Concept of Operation: Integrated Incident Command System

The concept of operation envisages an integrated Incident Command System (ICS), in which a single incident commander is responsible for coordinating the response of all concerned organisations. As the severity of the emergency increases, the responsibility will pass from the lower level to higher level in a graded manner. The incident commander directs the response from the incident command post located near the emergency site. Once the response operation is established, a Public Information Centre (PIC) will be set up to give information to the public in a simple language, the description of the possible risks, the action being taken at various response levels, and the actions that are to be taken by the public to reduce risk to their life, livelihood and property.

8.3 Response Organisation

The planning and preparedness for response to a radiological emergency will be integrated with the planning for response to all types of conventional emergencies like fires, floods, earthquakes, tsunami, etc., and involve local and national agencies for the purpose. The preparation for response to all these hazards should be structured into a coherent and interlocking system. At the top level, there will be a national emergency plan for an integrated response to any combination of hazards, and a national nuclear/radiation emergency plan will be prepared by the NEC with technical support from DAE which will be a subset of the national emergency plan. This plan will describe the concept of operations, roles and responsibilities of all the responding organisations and their interrelationships. The next level will comprise of plans developed by the state governments, district collectors and facility operators. The final level will work out the SOPs for handling emergencies.

NEC will ensure that the functions and responsibilities of the nuclear facility operators and response organisations are clearly defined and understood by all stakeholders. The MHA and the NEC will also determine the actions that need to be performed by each organisation during an emergency and whether it has the necessary resources and capabilities needed for the purpose. The advice of NCMC will also be sought in this matter.

8.4 Graded Response to Nuclear/ Radiological Emergencies

Depending on the severity of the nuclear/ radiological conditions and consequences, starting from the plant to the trans-boundary emergency, the required response through a well-informed, well-rehearsed, and well-equipped force should be mobilised with minimum possible delay. In this context, the International Nuclear Event Scale (INES) evolved by IAEA and how it is to be used, are shown in Annexure 2. Based on the guidelines made by NDMA, NEC will evolve an overall pattern for developing the response capacity for various emergencies/ disasters, including nuclear. Such a capacity would be developed at the community, district, state and NEC levels. NCMC will have a significant role to play in planning, preparedness, and response to a large scale nuclear emergency/disaster. The national disaster response plans will be developed by NEC in consultation with all stakeholders and guidance of NDMA, and will clearly identify the responsibilities for each level of emergency/ disaster. The NCMC will be kept informed of all developments to enable them to intervene, if required, at some stage. The national plans will be integrated with the state plans for efficient transition from a particular level of emergency/ disaster to the next, if the need arises.

The structure of the capacity (for response) will be developed on a brick system so that the capacity developed at various levels is complementary to one another, thereby increasing the national capacity for relief operations.

To augment the capacities of the states, NDMA is developing the response capabilities of four NDRF battalions which are being trained to provide specialised response, under CBRN scenarios. In addition, the armed forces will also develop response capabilities for which separate funds will be allocated, thereby ensuring availability of adequate resources throughout the country. While locating such resources, in addition to the vulnerability profile of the region for disasters, it will be ensured that the resources are not duplicated among different holding agencies but uniformly located throughout the country. Similarly, the utilisation of the relief stores need not necessarily be sequential. Efforts will be made to ensure that whenever a need arises, stores are provided at the earliest and, therefore, the proximity of the stores to the affected area will be the vital factor.

8.5 Emergencies at Nuclear Facilities

The response to a nuclear/radiological emergency has many elements in common with a response to natural disasters/other man-made accidents. Some common response elements include:

i) Activation of a response.

ii) Mitigation of the impact of the accident.

iii) Activation of command and control.

iv) Mobilisation of emergency facilities and equipment.

v) Emergency assessment.

vi) Protective measures.

vii) Public information.

viii) Life-saving and medical care.

ix) Coordination among the various agencies involved in the response action.

Although specialists are involved in responding to each type of emergency, many of the organisations and personnel involved are common for all types of disasters, e.g., NDRF, medical, civil defence, police, fire brigade, local authorities, ministries, etc.

Based on the regulatory guidelines for nuclear emergency preparedness, the concerned nuclear facilities have their own detailed emergency response plans and procedures for handling plant- and site-level emergencies. All emergency response plans and procedures are periodically reviewed and updated.

8.5.1 Plant Emergency

The response action for a plant-level emergency includes identification of the emergency, declaration of plant emergency, intimation to employees and management, assembly of workers in assembly areas, radiological surveys inside and outside the reactor building, distribution of prophylaxis if required and rescue operation if needed.

8.5.2 Site Emergency

The response action for site-level emergency includes identification of the situation, declaration of site emergency when conditions so demand and intimation to persons at the site as well as off-site emergency response officials (district collector, etc.), to be on standby. Based on the radiological conditions, countermeasures such as sheltering, prophylaxis, or evacuation of persons at the site are carried out as a response to the emergency conditions.

8.5.3 Off-Site Emergency

The response action for an off-site level emergency includes identification of the gravity of the situation, declaration of an off-site emergency by the off-site emergency director (district collector) when conditions so require and communication to the emergency control centre at the corporate office, state government and the CMG, DAE. Immediate, further actions include the deployment of various emergency response teams in the affected sector(s); initiation of countermeasures (such as sheltering and prophylaxis) of different grades based on the reports of the emergency monitoring teams from off-site areas, specifically from the affected sector (more sectors may be affected due to change in wind direction during the release); evacuation of the public from the rallying post to predetermined areas, if evacuation is planned, etc. The off-site emergency director activates systems of the state machinery to meet the necessary requirements of the public in the camp till the people are in a position to go back to their homes after the affected areas are cleared and declared safe.

8.5.4 Trans-Boundary Emergency

In accordance with international commitments, information will be provided to the concerned authorities/agencies in the event of trans-boundary effects of a major incident.

In the event of the competent authority in the country receiving information about an incident elsewhere, which might have the potential of radiological impact within India, the National Nuclear/Radiological Emergency Plan would be activated.

8.5.5 Continuous Radiation Monitoring

For a nuclear accident involving atmospheric release, ambient dose rate measurements of cloud shine, ground shine, or directly from the source, several monitoring teams are required to determine nature and magnitude of the hazard to the population by defining the extent of the plume and deposition from the plume. Arrangements should also exist for replacement of monitoring and sampling teams to limit the radiation exposures of these teams.

8.5.6 Emergency Response Committees

All nuclear facilities have their emergency response committees comprising experts from within the facility, which is headed by the head of the facility who is also identified to handle the nuclear emergency. This committee ensures mitigation of the consequences of the emergency situation, notification and communication to district authorities (DDMA) and CMG of DAE.

8.5.7 Response Actions during a Nuclear/ Radiological Emergency Situation

Following are the response actions to be taken in case of nuclear/radiological emergencies. Depending on the type and magnitude of the emergency, some or all of these actions are to be initiated at the appropriate time.

i) Recognise the existence of an abnormal situation.

ii) Identify and characterise the source and its origin.

iii) Initiate a quick and reliable monitoring methodology to detect the onset of an accident/emergency condition and assess its magnitude.

iv) Communicate the situation to fire fighting and medical services, police, civil defence, transport, and other agencies.

v) Rapid and continuous assessment, and future projections, of the emergency situation as it develops.

vi) Estimate the dose via the relevant pathways.

vii) Determine the areas where countermeasures are required.

viii) Support decision making on protective measures for the population and the environment.

ix) Predict the development of a contamination situation and of the consequences of protective measures in time and space.

x) If required, distribute iodine tablets at the earliest (iodine prophylaxis).

xi) Respond quickly to the situation and mobilise resources at short notice.

xii) Initiate countermeasures at the earliest (for relief and rescue operations on the basis of actual radiation dose levels prevailing in different zones).

xiii) Ensure that all concerned ministries/ departments of the Government of India, state governments and district administrations are aware of the precise measures to be taken by them as the situation develops and also that the actions taken by the various agencies are well coordinated.

xiv) Send prior information (in respect of dos and don'ts) to those likely to be affected by the accident/emergency. These include:

a. Evacuation/temporary relocation of the affected population, if required.

b. Withdrawal and substitution of supplies of food and drinking water (based on actual measurement of contamination found in food and drinking water).

c. Animal husbandry and agriculture department personnel to ensure radiological protection following a nuclear emergency.

d. Initiation of the recovery phase at an appropriate time.

8.5.7.1 Notification, Activation and Request for Assistance

In this context, it is required that the arrangements and processes for notification, activation and deployment of national response resources in case of any notification by IAEA or of any transnational nuclear emergency, are developed and implemented.

8.5.7.2 Protective Actions

In the event of a nuclear emergency, protective actions and countermeasures are to be taken promptly in order to be effective. This includes identification and isolation of the affected area, sheltering, evacuation, prophylaxis, protection of food supplies and control on the international trade of goods and products. For countermeasures to be effective, Operational Intervention Levels (OILs) and Action Levels (ALs) will be developed in advance, for both nuclear and radiological emergencies. The actions should be balanced and commensurate with the level of severity and should not create unnecessary anxiety and panic among the people.

8.5.7.3 Media and Public Relations

Arrangements are in place at NPPs for providing useful, timely, correct, consistent, and appropriate information to the public in the event of a nuclear or radiological emergency. Answers to questions, description of the risk and appropriate actions being taken up by the authorities and the actions to be taken by the public to reduce the risk are given in simple language.

A nodal officer is identified for the media and periodic press releases. The arrangements for coordinating information from the national level with that from the local administration and the operator are also available to ensure that information provided to the public through the media is timely, consistent and effective.

8.6 Response to 'Criticality' Accidents

The radiological risk from a criticality accident is dominated by the external dose from neutron and gamma radiations. In some cases it may also lead to airborne alpha activity. Special types of monitors should be used to measure neutron and alpha doses while the gamma dose can be measured using teletectors or other high range instruments.

A criticality cannot produce sufficient fission products to result in a release of significant airborne activity. However, the thermal energy (heat) from a criticality may be sufficient to result in the release of radioactive or other hazardous materials already existing in the vicinity of the criticality area (e.g., in process streams).

Off-site doses from a partial criticality accident are not expected to warrant urgent protective measures beyond 0.5–1.0 km.

Response to a criticality accident in a UF6 conversion plant will be either through removal of the reflecting layers of equipment or draining off the excess mass from the system to a standby storage bay.

8.7 Accidents during Transportation of Radioactive Materials

Radioactive materials are transported in a variety of packages. These can be transported as unsealed or sealed sources. Regulatory requirements clearly prescribe the type of packaging to be chosen for the transportation of radioactive material. The strength of the source may vary from micro-curies to millions of curies (spent fuel from an NPP).

The CMG of DAE is the nodal agency which is activated in case of any accident during the transportation of radioactive material.

The driver of the vehicle, or the person in charge of the convoy, will carry a Transport Emergency Card (TREMCARD) issued by the concerned regulatory authority that will have the details about handling of any accident that may occur during transportation.

8.8 Response to a Radiological Dispersal Device Emergency

While an RDD may not release enough radiation to cause fatalities or cause severe illnesses, the main threat of an RDD is from the direct effect of an explosion rather than that from radiation exposure. Depending on the scenario, an RDD explosion could create fear and panic and may contaminate personnel and property. The extent of local contamination would depend on the amount and type of explosive and the radioactive material used, the means of dispersal and weather conditions, and the decontamination of the affected area may involve considerable time and expense.

An early assessment of the possible radiological impact of an RDD would help in reducing unwarranted fears of the public and also help the first responders to act more efficiently in protecting the victims of blast injuries. It is to be ensured that the teams of emergency responders are well equipped with radiation detection equipment. Even if radioactive contamination is suspected/ detected, life-saving rescues and emergency first aid for serious injuries are to be undertaken immediately by the responders.

For a suspected RDD incident, an initial inner-cordoned area (safety perimeter) of 400m is recommended. This will be extended based on actual radiological monitoring, beyond the initial area, to a place where the actual dose rate is 100 μGy/hr at 1m height from the ground. Initial safe distances in radiological emergencies and suggested initial response actions are explained in the succeeding sections.

8.8.1 Initial Response Actions

In the light of the above, the first responders equipped with personal dosimeter; portable dose rate meter which is able to measure alpha, beta and gamma radiations; PPG; full body-covering suit; impermeable mask or preferably Self-Contained Breathing Apparatus (SCBA); and water supply hose (because water is the best option to decontaminate wounds, personnel, clothing, buildings, etc.) will perform the response actions once they reach the radiological incident/accident site. Broadly, these actions involve mobilising and operating incident command; overseeing victims triage; cordoning the site, and managing and controlling the perimeter; providing notification and activation of special teams; providing traffic and access control; providing protection to at-risk and special population; providing resources support and requests for assistance; providing public works coordination; providing direction and control of critical infrastructure mitigation; and providing public information, outreach, and communication activities. However, these steps are given as guidance for first responders to respond to radiological incidents/accidents and actual action will depend upon the ground realities at the scene of incidence/accident.

8.8.2 First Responders' Response

It is important to remember that only the essential activities mentioned below are carried out in the proximity of the incident site prior to the arrival of, or consultation with qualified radiological health professionals:

i) Contact the Emergency Management Agency as soon as possible.

ii) Seal off the inner zone of 400m radius from the blast point as 'no entry area' except for emergency measures.

iii) Wear personal dosimeter and protective clothing, if available. Fire fighters are generally equipped with respiratory protection gear that provides effective protection against inhalation hazards. However, other first responders should use common radiation survey instruments, which can detect significant external exposure hazards but cannot detect inhalation hazards. Take all precautionary measures to prevent spread of contamination to outside the affected area. Wearing of a wrist watch type personal dosimeter with alarm facility would be one of the best options for the situation.

iv) Restrict entry to the area of the incident.

a. Keep the public as far away as possible from the incident scene and any associated debris. Appropriate security exercise should be done for crowd control, casualty flow and traffic control.

b. Remove non-essential personnel and members of the public from the incident area. If contamination is suspected, keep all the persons in a separate area until the radiological assessor arrives or, if possible, monitor them and decontaminate as necessary. Provide respiratory protection (if airborne contamination is suspected) and avoid inadvertent ingestion.

c. Establish and supervise an access and contamination control point as near as possible to the safety perimeter, (upwind, inside the security perimeter) where the ambient dose rate is close to background. If for any reason the radiation level at the contamination control point increases to above 10 μSv/h, move the contamination control point to another upwind location within the security perimeter where the level is close to background, or at least sufficiently low to allow suitable detection limits.

d. Position in the upwind direction of the incident especially where fire is present.

e. The area downwind of the fire, especially if smoke and ash are involved, will be cleared of people, even if they are residents.

v) Perform life-saving rescue and emergency first aid for seriously injured without waiting for radiation monitoring, even if radioactive contamination is suspected.

a. Remove injured persons as far away as practical from the incident scene, especially in case of fire.

b. If medical attention is needed, assist in arrangements for medical assistance.

c. The medical personnel will be informed that radioactive contamination might exist on the victims and/or their clothing.

vi) If there is a fire or danger of fire, summon assistance from the nearest fire department. Fire personnel will be cautioned that radioactive materials may be present.

vii) Keep to an absolute minimum, any contact with radioactive material and suspected contaminated material.

a. If work connected with rescue or fire fighting must be done at the incident site itself, handle the debris resulting from the incident by mechanical means to avoid contact with the body/clothing.

b. Clothing and tools used at the scene will be disposed off as radioactive material.

c. Do not attempt to move or clean up any material involved.

viii) Detain all persons to:

a. Identify all those who may have been exposed to a possible release of radioactive material.

b. Identify those involved with the incident or potentially contaminated by the incident at the scene, except those requiring emergency medical evacuation.

ix) All individuals will be monitored and decontaminated, if necessary, and cleared after further medical treatment and discharged.

x) Record names, addresses, destinations, and telephone numbers of those individuals who cannot be persuaded to stay at the incident scene.

xi) Prohibit eating, drinking and smoking in the incident area;

xii) Use a handy evaluation tool when demonstrating countermeasures.

xiii) The initial safe distances suggested in Radiological Emergencies (IAEA 2006) are given in Table 8.1.

8.8.3 Suggested Radius of Inner Cordoned Area (Safety Perimeters) for Radiological Emergencies (IAEA-EPR-FIRST RESPONDERS 2006)

The suggested safety perimeters for various cases of radiological emergency are as indicated in Table 8.1.

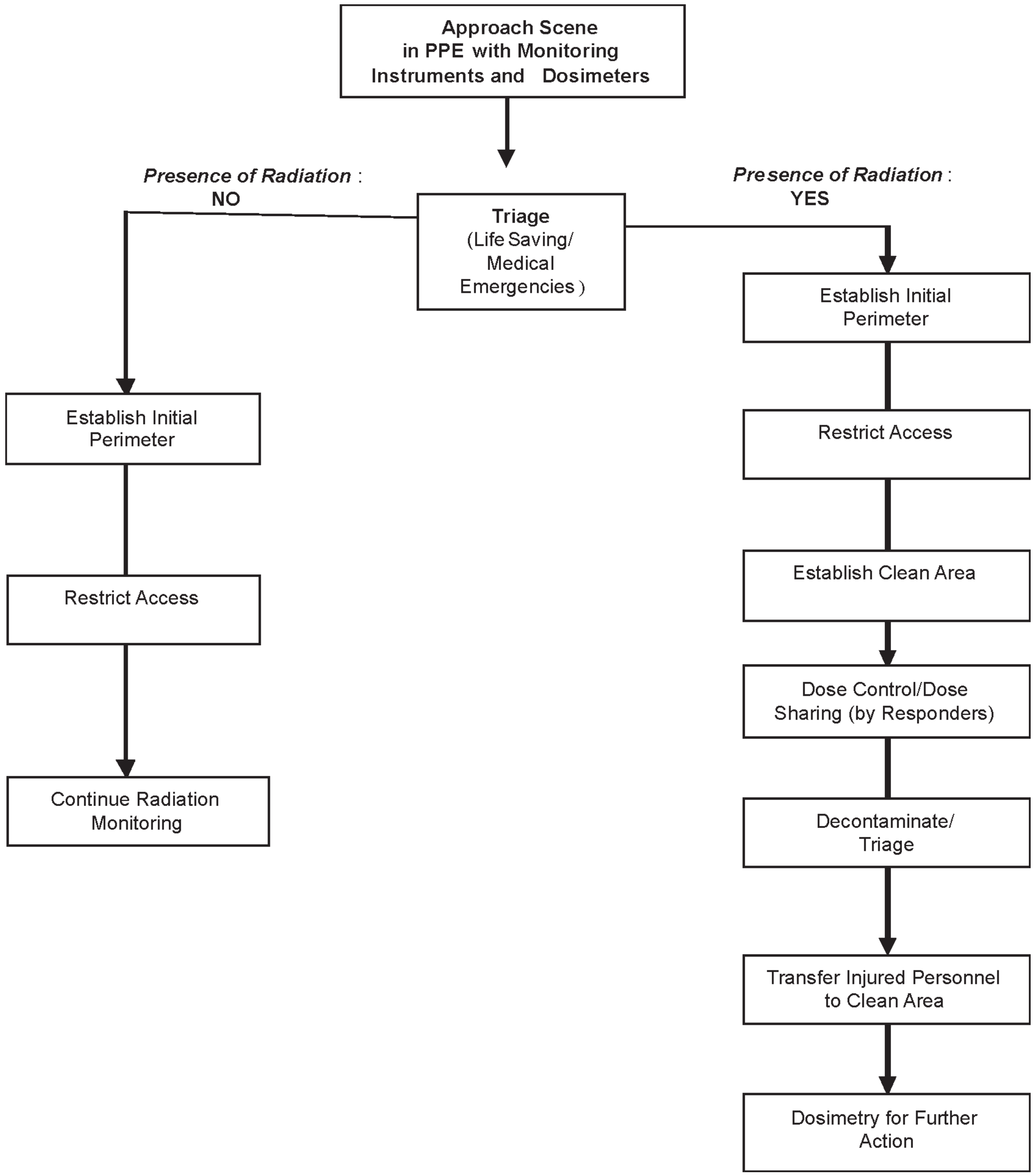
Table 8.1: Suggested Radius of Inner Cordoned Area

(Safety Perimeter)

for Radiological Emergencies (IAEA-EPR-FIRST RESPONDERS 2006)

Situation	Initial Inner Cordoned Area (Safety Perimeter)
Initial Determination (Radiological Emergency in Open Area)	
Unshielded or damaged potentially dangerous source	30m around
Major spill from a potentially dangerous source	100m around
Fire, explosion or fumes involving a potentially dangerous source	300m radius
Suspected bomb (potential RDD), exploded or unexploded	**400m radius or more to protect against an explosion**
Initial Determination (Radiological Emergency 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 materials throughout the building (e.g. , through the ventilation system)	**Entire building and appropriate outside distance as indicated above**
Expansion Based on Radiological Monitoring	
Ambient dose rate of 100 μSv/h	Wherever these levels are measured

8.8.4 Flow Chart for First Responder Response



Perform Other Actions

i) All persons in the open area within 0.1 km to 0.5 km (called 'inner cordoned area') should also be evacuated. Persons inside sheltered buildings in this area may need to be evacuated based on the detailed radiation monitoring. Re-entry to this area will be allowed only after clearance from the authorities.

ii) The zone within 0.5 km to 5 km is to be subjected to periodic radiation monitoring to detect any possible cross contamination. Though evacuation is not envisaged for this zone, inhabitants staying in this zone will be given the required advice so as to prevent the spread of contamination into their area.

iii) For distances greater than 5 km, no special measures are required to be taken though detailed radiation monitoring is to be carried out to confirm that contamination has not spread to the area.

iv) After an RDD explosion, there may be a need to monitor large number of people for radiation exposure and to handle a large volume of radioactive waste arising out of change of clothing, showering or washing the exposed areas of the skin (which will lead to removal of dangerous levels of contamination and prevent the spread of radioactivity).

8.8.5 Advice to the Local Public following a Radiological Dispersal Device Explosion

The public living in approximately twice the radius of the inner cordoned area are advised the following:

i) If present in the inner zone, to get monitored at the earliest.

ii) Avoid inadvertent ingestion.

iii) Move away from the immediate area, at least several tens of metres from the explosion site and get inside a closed building. This will reduce exposure to both radiation and radioactive airborne dust.

iv) Not to eat food until certified free from contamination.

v) Avoid any smoke/dust.

vi) Turn on local radio/TV channels for advice from emergency response centres/health authorities.

vii) Remove contaminated clothes and place these in a sealed plastic bag;

viii) Take a shower to wash off dust and dirt. This will reduce total radiation exposure.

ix) If radioactive material was released, local news broadcasts will advise people where to report for radiation monitoring and for blood and other tests to determine whether they were in fact exposed and steps to be taken to protect their health.

8.9 Response to Loss or Theft of Radioisotopes/Radioactive Material

In case of loss or theft of a radioactive source, the matter needs to be reported to the police, CMG and AERB immediately. It is the user's responsibility to maintain an inventory of all sources at all times. The user may seek assistance from a competent authority for tracing the lost/misplaced source. The possible location of the missing source could generally be metal scrap dealers. Immediate notification may facilitate tracing of the source. Theft of sources should be dealt jointly by law and order enforcement agencies and radiation protection experts.

Search for sources need to be done by experienced persons with the use of sensitive radiation monitoring instruments. For recovering the source, assessment for contamination and external radiation exposures will be made prior to taking control of the source and transporting it for safe disposal. Fire service personnel need to wear personal protective gear such as masks, aprons, gloves and gum boots and will be guided by radiation protection officers for instituting appropriate radiation protection procedures in case of unsealed/destroyed sources.

8.10 Large-Scale Nuclear Disaster

While the response to various nuclear/ radiological emergency scenarios will largely follow the general response guidelines of a decentralised response system with most resources being available at the local district/ state level (as adopted to cope with natural disasters), there is also a need for the nation to have the capability for responding to a large-scale nuclear disaster arising from a nuclear weapon explosion (in line with the response for any large natural calamity) involving the elements of rescue, medical care, transportation, evacuation, providing food and shelter, etc.

The scale and magnitude of such a disaster will be enormous. Further, there will be the additional factors of large-scale radiation exposure and contamination which are to be factored in the response mechanism. In such a special case, response actions will be implemented following a top–down approach (as done in the case of major natural calamities) and the immediate aim will be to mobilise all national resources and direct them to the affected area. This will be handled by the NCMC assisted by the NEC, DAE and National Technical Research Organisation (NTRO).

The optimal manner in which such a response system can be put in place is by ensuring that generic response agencies acting as first responders, NDRF, fire service personnel, civil defence, medical, transport, civil supplies, civil engineering departments, etc., have the radiation emergency response component as part of their response system to ensure large-scale national capability in this regard. In addition, four battalions of NDRF will be trained to provide special response under such scenarios.

The assessment of the early phase of such a large-scale event and the availability of intervention level and action level would play a crucial role for response by the CBRN teams of NDRF.

Building up the national capability to cope with the situation in the aftermath of a nuclear attack would require large-scale orientation, continuous training of personnel, drawing up of SOPs, conduct of exercise/drills, reliable communications and effective coordination mechanisms. Such actions are initiated as a long-term programme with the necessary assistance from various units of DAE and involvement of various ministries at the national as well as state government levels with a target to develop the necessary capacity.

Response actions and SOPs to be followed in the aftermath of a nuclear attack are already available in a separate classified document with MHA. In such a scenario, NCMC will provide necessary guidance to MHA, NEC and other agencies at central and state government levels, as is being done in case of all other major calamities.

8.10.1 Deployment of Armed Forces

As spelt out earlier, while the central and state governments will aim to develop suitable response capability to meet the perceived nuclear emergencies/disasters threat scenario, such response effort might require to be augmented by the armed forces, whenever needed. However, the resources of the armed forces will be deployed, commensurate with the assessment of the situation.

The procedure for demand of assistance from the armed forces will be on the same lines as for aid to civil authorities in case of natural calamities. As regards the command and control aspects, the armed forces will only be in ‘support’ of the civil administration, as their availability cannot be guaranteed all along due to some possible contingencies.

In specific scenarios, where the primacy of the armed forces in handling of the situation may be so warranted, the decision will be taken by the appropriate authorities at that particular moment.

8.11 Emergency Medical Response

Timely and effective medical response is a crucial component in reducing morbidity and mortality and alleviating the fear and suffering of an affected population. Activation of the response will be based on a trigger mechanism initiated by the respective authorities.

The roles are distinct at the central, state and district levels and depend on the scenario and the coping ability of the district/state. Some of the medical support actions to be taken during nuclear/radiological emergencies are discussed in the succeeding sections.

8.11.1 Iodine Prophylaxis

The thyroid gland is the most vulnerable organ in the body that is likely to be damaged by radiation. If exposure to radioiodine is anticipated, like in the case of radioactive releases following a major reactor accident, administration of 130 mg of Potassium Iodide (KI) or 170 mg of Potassium Iodate (KIO3) will prevent the uptake of radioactive Iodine. For high-risk individuals, this will protect the thyroid gland from the effects of radiation.

8.11.2 Casualty Decontamination

Identified hospitals will establish a decontamination station near the entrance, isolated from patients and visitors. Standard procedures will be followed for decontamination.

For such purpose, the hospitals concerned will deploy QRMTs/MFRs consisting of physicians, triage officer, RSO, nurses and paramedical staff.

8.11.3 Triage and Evacuation

i) Maps clearly indicating the entry and exit routes for ambulances and walk-in patients will be laid down.

ii) The reception area will be expanded to accommodate a large number of expected patients with trauma and burns.

iii) The hospital functionaries will be trained in triage.

8.11.4 Sanitation at Temporary Shelters/ Camps

Hospital authorities will also develop plans for creating a temporary hospital capacity to accommodate a large number of casualties.

In nuclear emergencies/disasters, the situation will be worse. The population density in shelters/camps meant for a trans-located population will be very high. Many persons in shelters will have varying degrees of sickness due to radiation exposure, secondary infections, shortage of power, water and medicines. The sanitary and public health facilities will be in total disarray resulting in repeated outbreaks of waterborne and vector-borne diseases. Temporary shelters housing the trans-located population, even those in case of natural disasters, call for good hygiene practices for maintaining proper sanitation. Accordingly, this particular aspect has to be assigned due care in the planning of temporary shelters.

8.11.5 Medical Response following Accidents in a Nuclear Facility and Radiological Emergencies

The major medical actions to be activated for different categories of nuclear/radiological emergencies will include the following actions:

i) The first responders will do a rapid assessment of the radiation levels and subsequent action will be based on this assessment.

ii) MoH&FW and the concerned state health department will activate their respective emergency support action plans to mobilise additional human and material resources. All communication channels and networks prepared for such purpose will be activated.

iii) For incidents in a nuclear facility, the on-site and off-site emergency response plans may be activated.

iv) When required, the district hospital will deploy their QRMTs/MFRs. Based on the need, the SDMA will requisition and deploy QRMTs/MFRs of neighbouring districts. They will assist the specialised teams of the NDRF and SDRF in providing necessary decontamination, triage, administration of de-corporating agents at the site, basic and advanced life-support and transportation to the identified hospitals.

v) The mobile radiological laboratory unit will facilitate radiation monitoring and decontamination.

vi) If the incident is beyond the handling capacity of the state, help from the central government will be sought. National resources will be pressed into service through NEC (NDMA) and NCMC.

vii) Patients will be put through necessary triage.

viii) The identified hospitals in the off-site emergency plan of nuclear facilities or in the vulnerable cities will be the focal point for managing the affected victims. They will activate their DM plan. The identified command structure will take command and control of the operations of the hospital. All individuals will be decontaminated before treatment. However, critical patients may not wait for decontamination and may have to be provided treatment.

a. If required, the availability of beds will be augmented by discharging sub-acute and chronic patients. If the hospital gets overcrowded, the decontaminated patients would be shifted to nearby hospitals, including private hospitals.

b. Those in need of specialised treatment will be shifted to the radiation injury treatment centres.

c. Local police will be deployed for casualty flow, crowd control, and traffic control.

d. The hospital will establish information facilitation centres to inform the public about the status of patients.

e. Contaminated articles will be disposed of following the guidelines of hospital waste management rules.

8.11.6 Medical Response during Nuclear and Radiological Emergencies and Large-Scale Nuclear Disasters

A rapid assessment of the initial phase would determine the extent of damage and need for evacuation. The guidelines to be followed for an effective response will include:

i) All health facilities in the safe zones, including those in the nearest satellite towns, will be activated. NCMC/NEC will pool all medical resources including those from MoD, MoH&FW, Ministry of Railways, Employees' State Insurance (ESI), Indian Red Cross and the private sectors for managing mass casualties. Additional provisions for managing casualties will be made through mobile hospitals.

ii) The local authorities will arrange makeshift hospitals and shelters to accommodate large numbers of casualties. Schools, colleges, community buildings, religious places, etc., will be converted into makeshift hospitals.

iii) People affected with acute haemopoietic, gastrointestinal, coetaneous and CNS syndrome, which requires specialised care would be shifted to the nearest Radiation Injury Treatment Centre.

iv) Blood and blood components will be mobilised from all available sources by MoH&FW, Red Cross, the armed forces and central and state blood banks.

v) Large quantities of IV fluids, plasma expanders, antibiotics, vaccines, burn kits, dressings, PPG etc., will be mobilised from pre-identified indigenous manufacturers.

vi) Specialised medical stores such as Amifostine and other radio-protectors, de-corporation agents (DTPA, Prussian blue), Potassium Iodide, growth factors, colony stimulating factors and other radiation recovery agents will be mobilised.

vii) Civil Defence, Red Cross, NCC, Scouts and Guides and other NGOs and the community would play a major role in providing emergency services.

viii) The civic authorities will make arrangements for dead body identification and management.

ix) The community will be kept informed of the 'dos and don'ts'.

x) Public health surveillance will be augmented to detect any contamination in food and water.

8.12 Protection of International Trade and Commerce Interests

It is important to note that the threat as reported in the media or as perceived by the international community can be as important as the real threat. Consequently, measures will be taken immediately to ensure international standards for trades during, as well as, after a nuclear/radiological emergency.

8.13 Infrastructure Requirements

The infrastructural elements that are essential for providing adequate response capability are discussed below. In the DAE facilities, response capabilities do exist, but these will be periodically reviewed for their effectiveness and strengthened whenever required. Non-DAE facilities have yet to create many of these capabilities.

i) Authority

This is required to avoid delay in notifying an off-site emergency. The person at the site will be authorised and be automatically responsible to promptly classify the emergency and notify the authority outside the plant/facility perimeter. AERB will work to remove this deficiency.

ii) Coordination of Emergency Response

The response to a radiological emergency must be implemented with clear division of responsibilities and clear lines of communication among the various organisations involved, in order to avoid delay and confusion. Any simultaneous implementation of uncoordinated plans (e.g., security plan and emergency plan) will be avoided.

iii) Procedures and Training

At times there are delays in initially recognising or comprehending the severity of the event or to initiate the proper response to an on-site or off-site emergency because of lack of procedures that do not clearly identify the criteria on which to determine the severity of the event and to decide the response actions due to lack of training. Therefore, all efforts are to be made to develop procedures to handle an emergency and also to train the people thoroughly.

iv) Logistic Support and Facilities

Sometimes equipment and facilities are not available during the emergency because of improper planning and preparedness, e.g., breakdown of the public telephone system, (landline and mobile) or due to incompatibility of communication equipment used by the authorised personnel at the various response organisations.

v) Training, Drills and Exercises

In order to ensure timely response action and to see that the efforts are not diluted in spite of the best planning, it is essential that all first responders and other responding agencies are kept in a condition of full readiness through various training programmes, drills and exercises conducted under various simulated scenarios.

vi) Quality Assurance Programme

Emergency responses are required to be maintained at an adequate state of readiness in order to avoid a situation where the required equipment/facilities are not available, or inadequate, either due to lack of procurement in advance or due to lack of maintaining at the proper place in properly calibrated/functional conditions. This can be achieved by periodically applying quality assurance checks.

8.14 Action Points

Some of the action points of this chapter are given below:

i) For off-site nuclear emergencies at all nuclear power plants/facilities, the district collector of the affected area will take charge as the incident commander. The collector himself will be responsible for this task and will not delegate responsibility to anyone lower.

ii) Similarly, for radiological emergencies at metros/big cities, the state authorities will nominate in advance an incident commander specifically for handling radiological emergencies, if any, and this task will not be then delegated to anyone lower.

iii) NEC will ensure that the functions and responsibilities of the nuclear facility operators and response organisations are clearly defined and understood by all stakeholders. The MHA and the NEC will also determine the actions that need to be performed by each organisation during an emergency and whether it has the necessary resources and capabilities needed for the purpose. The advice of NCMC will also be sought in this matter.

iv) Based on the guidelines of NDMA, NEC will evolve an overall pattern for development of the response capacity to be built up for various emergencies/ disasters, including nuclear ones. Such a capacity will be developed at the community, district, state and NEC levels. NCMC will have a significant role to play in planning, preparedness, and response to a large-scale nuclear emergency/ disaster. The national disaster response plans will be developed by NEC in consultation with all stakeholders and guidance of NDMA. The national plan will clearly identify the responsibilities for each level of nuclear emergency/disaster. The NCMC will be kept informed of all developments to enable them to intervene, if required, at any stage. The national plans will be integrated with the state plans for efficient transition from a particular level of emergency/disaster to the next, if the need arises.

v) The structure of the capacity (for response) will be developed on a brick system so that the capacity developed at various levels is complementary to one another, thereby increasing the national capacity for relief operations.

vi) Based on the regulatory guidelines for nuclear emergency preparedness, the concerned nuclear facilities have their own detailed emergency response plans and procedures for handling plant- and site-level emergencies. All emergency response plans and procedures are periodically reviewed and updated.

vii) In the event of the competent authority in the country receiving information about an incident elsewhere, which might have the potential of radiological impact within India, the National Nuclear/Radiological Emergency Plan would be activated.

In accordance with international commitments, information will be provided to the concerned authorities/ agencies in the event of trans-boundary effects of a major incident.

viii) All nuclear facilities have their emergency response committees comprising experts from within the facility, which is headed by the head of the facility who is also identified to handle the nuclear emergency. This committee ensures mitigation of the consequences of the emergency situation, notification and communication to district authorities (DDMA) and CMG of DAE.

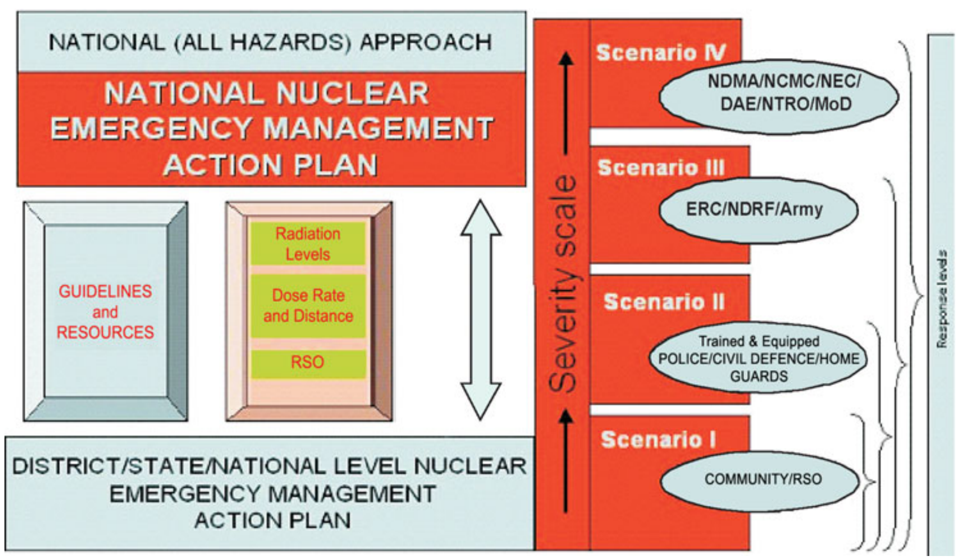
ix) The driver of the vehicle carrying radioactive material, or the person in charge of the convoy, will carry a TREMCARD issued by the concerned regulatory authority that will have the details about handling of any accident that may occur during transportation. The CMG of DAE is the nodal agency which is activated in case of any accident during the transportation of radioactive material.

9 Implementation of the Guidelines

9.1 Community Based Holistic Approach for Implementation

The national guidelines have been formulated to ensure that, when implemented at various levels, by way of action plans to be developed through an extensive consultative approach involving all the stakeholders, the occurrence of nuclear/radiological accidents leading to risks to human health, life and the environment are minimised.

Figure 9.1: Conceptual Framework of Implementation of NDMG-NRE



The overall strategy of nuclear emergency management is to prepare a working module in which a district plan is a subset of the state-level plan which, in turn, is a subset of the national-level plan.

In order to optimise the use of resources, it is advisable to adopt an 'all hazards' approach at the national level with a separate group of specialists to advice on various issues in handling a nuclear/radiological emergency.

Like a conventional DM plan, a nuclear/radiological emergency plan is implemented by following a bottom-up approach (from the district to the state and the central government authorities). However, for the management of a nuclear disaster, where the loss of life and property will be of much higher magnitude, a top-down approach is to be adopted (which is normally adopted during war, major calamities, or international crises).

Since all emergencies are initially local in nature, the implementation of DM programmes through a holistic approach begins at the community level. While individuals are responsible for the safety, preparedness and well-being of themselves and their families, the community, along with its private sector and volunteer organisation partners like NGOs and CBOs will be involved in a proactive manner to develop and implement the DM programme tailored to the local needs. The community based approach will, in addition to ensuring a sense of ownership and clear understanding of the mutual responsibility, build confidence and generate self-help capacities particularly with respect to vulnerable and marginalised groups like women, the elderly and physically challenged people. In many cases, the response capability of the community (i.e., fire, police, medical, civil defence, public works, etc.) will be sufficient to deal with routine incidents. Therefore, the community is the key player as well as the major beneficiary of the DM process on a sustainable basis.

However, to cope with the increasing severity of the nuclear emergency, the district, state and central authorities will reinforce the system as depicted schematically in Figure 9.1.

In this context, specialists with expertise in the relevant fields must be associated with the formulation, development, implementation, and monitoring of these plans as per the spirit of the *National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies* (NDMG-NRE). Professionals, particularly nuclear scientists and engineers, and district, state and central government planners are, therefore, to be closely involved in the disaster risk management initiatives at all levels and for all tasks relevant to their expertise.

9.2 Implementation of the National Guidelines at Macro and Micro Levels

For the success of a nuclear emergency management programme, it is essential that a proper institutional framework is established and implementation of a DM plan is made mandatory at all levels of administration. It should ensure a harmonious partnership among all stakeholders/ agencies, with a sense of ownership and clear understanding of their respective roles.

The National Disaster Management Act, 2005 proposes the creation of an institutional set-up at four levels of administration, viz., central, state, district and local for handling any type of disaster in the country, to support, interact, coordinate and complement each other at all levels (instead of working in isolation at any level) of operation starting from the national to the local level.

The main stakeholders in a nuclear emergency response are the Ministries of Home, Defence, Transport, Health and Family Welfare and the relevant central and state departments such as the DAE (nodal department for nuclear crisis management), AERB, DRDO, NTRO, Agriculture, Environment and Forest; scientific and technical institutions involved in R&D; academic institutions, professional bodies, corporate sector; and NGOs and the communities. Institutionalisation of the programmes and activities at the ministerial/ departmental levels, increased inter-ministerial and inter-agencies communications and networking, rationalisation and augmentation of the existing regulatory framework and infrastructure are considered vital for ensuring a seamless and harmonious functioning of all the stakeholders.

The preparation of an action plan at the macro level will be carried out by NEC with technical assistance from DAE that will be approved by the NDMA. The National Action Plan thus prepared will detail out work areas, activities, targets and time-frames positively within the next six months. The time-frame for various authorities will have to be reasonably short, as we must aim to be ready in all respects within the time-frame indicated subsequently. The action plan prepared will also specify the various indicators of progress so as to enable monitoring and review.

The National Plan will include, inter alia, the following:

i) Measures for the prevention of nuclear and radiological emergencies, and mitigation of their effects (leading to avoidable morbidity and mortality).

ii) Measures for the integration of mitigation programmes into the development plans.

iii) Measures for preparedness and capacity building to effectively respond to any threatening nuclear emergency/disaster situation.

iv) Roles and responsibilities of different ministries and departments of the Government of India, the nodal ministry, industry, the community and NGOs, in respect of measures specified in the clauses cited above.

On the basis of the detailed national plan, all the concerned central ministries/ departments, in turn, will make their own DM plans which are to be approved by the NDMA. The time-frame for preparation of the action plans for line ministries will be one year from the date of release of the Guidelines. And the same for the state level authorities will be within a year and a half from the release of the Guidelines.

These plans of the line ministries/ departments will include, inter alia, the following:

i) Issue of guidelines to respective stakeholders for implementation of the National Plan;

ii) Periodic review of the progress of implementation of the action plans;

iii) Implementation of the action plans as per the specified time-frames and taking corrective actions, wherever needed.

iv) Dissemination of the status of progress and issuance of further guidelines on implementation of the action plans to stakeholders.

v) Reporting the progress on implementation of the National Plan to the nodal ministry and NDMA.

At the micro level, with the help of specialists from DAE and in consultation with the district/ local authorities, the states/UTs will make their own detailed implementation plan. This plan will be based on the policies and guidelines issued by NDMA and the same will be implemented within a year and a half from the date of release of the Guidelines.

Recognising the enormity and crucial nature of nuclear and radiological emergency/disaster management, the SDMAs are required to identify and enlist officers with total responsibility of issues related to nuclear/radiological disaster management as a necessary first step towards ensuring effective implementation of the Guidelines.

To sustain an integrated approach to nuclear/radiological emergency/disaster management, the NEC will set up a mechanism for implementing the national plan on an inter-ministerial basis, so that the interests of all central ministries/departments concerned and other stakeholders at the states/UTs and district levels are represented and all substantive issues are not only addressed to, but the efforts of all the stakeholders are also fully converged. Overall guidance and assistance of NCMC will be sought wherever needed.

9.3 Financial Arrangements for Implementation

After any disaster, the central and state governments provide funds for immediate relief and rehabilitation to address the immediate needs of the affected population in terms of food, water, shelter, medicine, etc. However, this relief-centric approach is neither adequate for the recovery and reconstruction of the affected areas/environment (leaving aside the tragedy of avoidable loss of life), nor does it make the country's development sustainable. Accordingly, the focus of the governments in DM needs to be shifted to pre- disaster scenarios in a proactive manner by providing sufficient funds for prevention, mitigation, preparedness and capacity building tasks (without compromising the needs for the post-disaster activities, because in the event of major disasters/calamities, the basic responsibility of undertaking the rescue, relief and rehabilitation measures is that of the concerned state government, whose efforts are to be supplemented by the central government).

For the effective implementation of the National Guidelines, it is extremely important that the various plans at different levels of administration for DM of nuclear/radiological emergencies/disasters are mainstreamed into the developmental process and the necessary allocation of funds are obtained from the concerned ministries/departments of central and state governments with assistance of the planning commission. Appropriate strategies will be worked out to ensure that the necessary funds are available and the flow of funds is organised on a priority basis for the various pre-disaster activities that have been identified in the DM plans, based on an all-hazard approach, to be mutually complementary, without any duplication.

Experience shows that effective results are achieved by undertaking prevention/mitigation/ preparedness projects in a mission mode and in consultation with local bodies. A similar approach will be employed for nuclear DM at all levels.

Along with the SDMAs, the DDMAs will consult the local bodies and panchayati raj institutions on nuclear disaster risk mitigation proposals and ensure the allocation of the necessary funds.

In addition to the financial support from the central/state governments, efforts will also be made to augment the financial resources from other sources:

i) Wherever necessary and feasible, the central ministries/departments and Urban Local Bodies (ULB) in the states will initiate discussions with the corporate sector to support disaster-specific risk reduction or capacity development programmes as a part of Public-Private Partnership (PPP) and Corporate Social Responsibility (CSR).

ii) All the preparatory measures, including the equipment for additional ERCs, will be procured as part of a mitigation project to be undertaken by the NDMA in concert with all the stakeholders. The provisioning of funds for this project will be organised by the NDMA.

iii) For equipping the SDRFs for CBRN capabilities, 10 per cent of the funds from the Calamity Relief Funds (CRFs) can be used towards this requirement.

iv) Operational level training of the SDRFs will be carried out by the NDRF battalions, at the NDRF battalion locations.

v) For specialised training, the vacancies will be allotted at the NDRF training institutions by the NDMA. Financial provisioning for this will be done by the NDMA.

9.4 Time Frame and Implementing Agencies for Implementation of NDMG-NRE Guidelines

Implementation of the Guidelines will begin with the formulation of an action plan and an enabling phase to build the necessary capacity, taking into consideration all the existing elements such as legislation, emergency plans, stakeholder initiatives, gaps, priorities, needs, and circumstances. The action plan will indicate detailed work areas and activities/targets with suggested time-frames and suitable indicators of progress including monitoring mechanisms along with the authorities engaged in implementation of the Guidelines.

The major recommendations of NDMG-NRE can be broadly realised in three phases, namely—Short-term Plan (0–3 years), Medium-term Plan (0–5 years) and Long-term Plan (0–8 years). The broad areas of activities to be covered during each of these three phases along with the concerned implementing agencies are highlighted in the following paragraphs.

9.4.1 Short-Term Plan (0–3 Years)

The experience gained in the initial phase of implementation is of immense value, to be utilised not only to make mid-course corrections but also to make long-term policy and guidelines after comprehensive review of the effectiveness of actions undertaken in the short-term plan. The broad time-frame to achieve the objectives of the short-term plan of NDMG-NRE is end December 2010 and includes, inter alia, the following:

Objectives	Implementing Agencies
Prevention	DAE,AERB
• Intelligence Mechanisms	MHA, RAW, MoD
• Surveillance at Vulnerable Locations	MHA
• Detection of Unusual Events	MHA, DAE
• Early Warning System	DAE, NTRO, IMD
Regulation and Enforcement	AERB
Risk Reduction Framework	DAE, AERB
Preparedness	DAE, MoH&FW, DRDO, NTRO, SDMAs, DDMAs, NEC
Capacity Development	
• Education and Awareness Generation	MHRD, NDMA, NIDM, DAE
• Training and Community Participation	NDMA, NIDM, SDMA, DDMA
• Knowledge Management	DAE, DRDO
• Critical Infrastructure (ERCs, Communication etc.)	DAE, NDMA, SDMA, DDMA

Response and Recovery	MHA, DAE, NDMA, DRDO, MoH&FW, SDMA, DDMA
Medical Preparedness • Hospital Disaster Management Plans • Emergency Medical Response • Upgradation and Networking of Medical Facilities • Training and Networking of Medical Professionals • Creation of QRMTs/MFRs • Medical Response for Management of Acute as well as Delayed Radiation Effects • Psychosocial Care	DAE, DRDO, MoH&FW, MoD, Ministry of Railways, State/UT Health Departments
R&D for Development of Advanced Sensors, Biomarkers, etc.	DAE, DRDO, MoH&FW

9.4.2 Medium-Term Plan (0– 5 Years)

Further Upgradation of Regulation and Enforcement	AERB
Enhancement of Risk Reduction Framework	DAE, AERB
Preparedness with Community Participation	NDMA, SDMA, DDMA
Upgradation of Response Capabilities	MHA, DAE, NDMA, DRDO, MoH&FW, SDMA, DDMA
Enhancement of Capacity Development	MHRD, DAE, NDMA, NIDM, DRDO, SDMA, DDMA

9.4.3 Long-Term Plan (0–8 Years)

Total Regulation and Enforcement	AERB
Complete Risk Reduction	DAE, AERB
Optimum Level of Preparedness	NDMA, SDMA, DDMA
Optimum Response Capability	MHA, DAE, NDMA, DRDO, MoH&FW, SDMA, DDMA
Total Capacity Development in Terms of Community and Infrastructure	MHRD, DAE, NDMA, NIDM, DRDO, SDMA, DDMA

The timelines proposed for the implementation of various activities in the guidelines are considered both important and desirable, especially in case of those non-structural measures for which no clearances are required from central or other agencies. Precise schedules for structural measures will, however, be evolved in the nuclear and radiological management plans that will follow at the central ministries/state levels duly taking into account the availability of financial, technical and managerial resources. In case of compelling circumstances warranting a change, consultation with NDMA will be undertaken, well in advance, for any adjustment, on a case to case basis.

9.5 Interim Arrangements till the Formulation and Approval of the Action Plan

To start with, the existing DM plans at various levels will be further revamped/strengthened to address nuclear/radiological hazards. The Guidelines will form the basis for the concerned ministries and departments to evolve policies, programmes and activities. Appropriate allocation of financial and other resources, including dedicated manpower and targeted capacity building, will be the key to the success of the implementation of these Guidelines. Periodic training, tabletop exercises, simulations, mock-drills, etc., will further enhance and ensure effective implementation.

9.6 Role of Various Ministries/ Departments during Nuclear and Radiological Emergencies and Large-Scale Nuclear Disasters

In the event of nuclear and radiological emergencies and during a large-scale nuclear disaster, several ministries/departments would be involved in the response plans. The following sections discuss the broad outline of the roles expected of them.

9.6.1 Ministry of Home Affairs

Being the nodal ministry, MHA will coordinate with the various response agencies in the event of any major nuclear/radiological emergency/disaster in the public domain. The different agencies in the MHA which have a role to play are the civil defence apparatus which includes the National Civil Defence College (NCDC), the Directorate General of Civil Defence (DGCD), the Central Para Military Forces (CPMFs) and the additional ERCs. Tasks involved are the establishment of additional ERCs, ERTs and fire services capability throughout the country. In addition, it has to build shelters/camps with provision of food, water, fuel, medicine, sanitation facilities, etc.

9.6.2 State Governments

The state governments include the Home Department, District Administration, the State Public Works Department (SPWD), the State Electricity Board (SEB), the Food and Civil Supplies Department (F&CSD), and SDRF which are the main agencies who will actually respond to any major emergency at the operational level. Among other things, the tasks of the state government include setting up of state- and district-level Emergency Command Centres (ECCs) and ERTs, procuring the necessary radiation monitoring instruments/equipment along with PPG and maintaining comprehensive GIS (covering all infrastructure like roads, villages, shelters, medical facilities, food provisions, transport facilities, etc.). In addition, it has to upgrade and augment its services and devise mechanisms to restore power, make available fuel, enhance medical preparedness (that includes networking RSOs, medical professionals and hospitals), dissemination of information through the media, establishment of decontamination centres, making arrangements to handle large number of fatalities and disposal of carcasses, etc.

Another important task of the state government is to establish an effective coordination mechanism with all the other agencies such as MHA, DAE, fire and emergency services, civil defence, etc. (both within the state as well as with neighbouring states).

9.6.3 Department of Atomic Energy

The DAE has been identified as the nodal technical agency to provide the necessary inputs to handle the nuclear/ radiological aspects of any large-scale emergency/disaster. The existing response system, with the assistance of DAE, can cope with most of the minor emergencies or even an off-site emergency at any DAE facility in the country.

As the nodal technical agency, DAE has to closely coordinate with other agencies like MoD/ DRDO, Department of Space (DoS)/National Remote Sensing Agency (NRSA), Department of Science and Technology (DST)/India Meteorological Department (IMD), NTRO/ARC in providing the services of radiation experts for capacity building in the area of radiation measurement and protection at the national level.

By training the required number of trainers, DAE will facilitate training of CPMFs, civil defence personnel and fire service personnel in the basics of radiation measurement and protection and emergency response.

9.6.4 Ministry of Health and Family Welfare

As in any other major national emergency, MoH&FW has the role of overseeing all aspects relating to medical and health care, including identification of hospitals, building up their infrastructure to handle large numbers of radiation patients, provision and stocking of appropriate medicines. It should also maintain a national database of medical professionals who are conversant with treatment of radiation injuries and of RSOs so that their services can be tapped even for smaller emergencies. Another important task is to arrange comprehensive training programmes for medical professionals in the treatment of radiation injuries.

9.6.5 Other Ministries

The NRSA and the IMD have key roles to play in the event of a major nuclear emergency in assisting DAE experts in the evaluation of the magnitude of the event, monitoring any large-scale fallout and keeping track of the same, and providing their assessments to national- and state-level authorities for taking appropriate response measures.

Services of the Indian Railways and Ministry of Civil Aviation will be sought, particularly for transportation of the emergency response teams (along with their equipment and other resources), including the affected people.

The Ministry of Urban Development (MUD) and the Central Public Works Department (CPWD) will be involved in the construction of various emergency command centres and shelters, and in the restoration of communication links and other urban infrastructure when required.

The Ministry of Petroleum and Natural Gas (MPNG) will have to make arrangements for storing the necessary Petroleum, Oil and Lubricants (POL) reserves and ensure their availability at all locations across the country during an emergency.

9.7 Action Points

Some of the action points of this chapter are given below:

i) In order to optimise the use of resources, it is advisable to adopt an 'all hazards' approach at the national level with a separate group of specialists to advise on various issues in nuclear/radiological emergency.

ii) Like a conventional DM plan, a nuclear/radiological emergency plan is implemented by following a bottom-up approach (from the district to the state and the central government authorities). However, for the management of a nuclear disaster, where the loss of life and property will be of much higher magnitude, a top-down approach is to be adopted (which is normally adopted during war, major calamities or international crises).

iii) To cope with the increasing severity of the nuclear emergency, the district, state and central authorities will reinforce the system in a mutually complementary fashion without duplication, as depicted schematically in Figure 9.1.

iv) Specialists/professionals (particularly nuclear scientists and engineers) with expertise in the relevant fields must be associated with the formulation, development, implementation and monitoring of these plans as per the spirit of the *National Disaster Management Guidelines: Management of Nuclear and Radiological Emergencies* along with the district, state and central government authorities.

v) The preparation of an action plan at macro level will be carried out by NEC, with technical assistance from DAE that will be approved by the NDMA. The National Action Plan thus prepared will detail out work areas, activities, targets and time-frames positively within next six months. The time-frame for various authorities will have to be reasonably short, as we must aim to be ready in all respects within the time-frame indicated subsequently. The action plan prepared will also specify the various indicators of progress so as to enable monitoring and review.

vi) On the basis of the detailed national plan, all the concerned central ministries/departments, in turn, will make their own DM plans which are to be approved by the NDMA. The time-frame for preparation of the action plans for line ministries will be one year from the date of release of the National Guidelines. And the same for the state level authorities will be within a year and a half from the date of release of the National Guidelines.

vii) At the micro level, with the help of specialists from DAE and in consultation with the district/local authorities, the states/UTs will make their own detailed implementation plan. This plan will be based on the policies and guidelines issued by NDMA and the same will be implemented within a year and a half from the date of release of the National Guidelines.

viii) Recognising the enormity and crucial nature of nuclear and radiological emergency/disaster management, the SDMAs are required to identify and enlist officers with total responsibility of issues related to nuclear/radiological DM as a necessary first step towards ensuring effective implementation of the Guidelines.

ix) For the effective implementation of the Guidelines, it is extremely important that the various plans at different levels of administration for DM of nuclear/radiological emergencies/disasters are mainstreamed into the developmental process and the necessary allocation of funds are obtained from the concerned ministries/departments of central and state government with assistance of the planning commission. Appropriate strategies will be worked out to ensure that the necessary funds are available and the flow of funds is organised on priority basis for the various pre-disaster activities that have been identified in the DM plans, based on an all-hazard approach, to be mutually complementary, without any duplication.

Along with the SDMAs, the DDMAs will consult the local bodies and panchayati raj institutions on nuclear/radiological disaster risk mitigation proposals and ensure the allocation of the necessary funds.

In addition to the financial supports from central/state governments, efforts to be made for augmentation of financial resources from other sources viz., (a) wherever necessary and feasible, the Central Ministries/Departments and ULBs in the states will initiate discussions with the corporate sector to support disaster-specific risk reduction or capacity development programmes as a part of PPP and CSR; (b) all the preparatory measures, including the equipment for additional ERCs, will be procured as part of a mitigation project to be under taken by the NDMA in concert with all the stakeholders. The provisioning of funds for this project will be organised by the NDMA; (c) for equipping of the SDRFs for CBRN capabilities, 10 per cent of the funds from the CRFs can be used towards this requirement; (d) operational level training of the SDRFs will be carried out by the NDRF battalions, at the NDRF battalion locations; and (e) for specialised training, the vacancies will be allotted at the NDRF training institutions by the NDMA. Financial provisioning for this will be done by the NDMA.

10 Summary of Action Points

10.1 Introduction

In order to control the impact of nuclear and radiological emergencies (in the event of failure to prevent such emergencies, in-spite of the best possible structural and non-structural measures outlined in these Guidelines), the Guidelines are to be implemented at various levels of administrations involving all the stakeholders. In this context, several technical and administrative recommendations have been made which are to be implemented by the concerned stakeholders for building disaster resilience in the society through a holistic approach to DM. In order to optimise the use of resources, it is advisable to adopt an 'all hazards' approach in handling a nuclear/radiological emergency at various levels of administration with separate groups of nuclear specialists to advice on various issues. For the ease of reference to the stakeholders for their compliance, some of the major recommendations are consolidated hereunder (along with the indices of their locations in the text of the national guidelines). However, all the recommendations made in the various chapters of the guidelines will be complied with, by the concerned authorities.

10.2 Preparation of Disaster Management Plans and Financial Arrangements

i) The national guidelines are to be implemented by preparing appropriate DM plans at all levels of administration. The NCMC/NEC, with technical support from DAE (the nodal technical agency for nuclear/radiological emergency/disaster), will prepare the detailed national plan for nuclear emergency in consultation with various stakeholders within the next six months (Section 2.4, Section 9.2).

ii) On the basis of the detailed national plan, all the central ministries/departments will make their own DM plans, which are to be approved by the NDMA, within one year from the date of release of the guidelines. Similarly, all the states/UTs will make their DM plans in consultation with the district authorities within year and a half from the date of release of the Guidelines (Section 2.4, Section 9.2).

iii) Specialists in nuclear science and technology are to be inducted at all levels of administration in the formulation of the plans and their effective monitoring during implementation, covering all the activities of disaster continuum (Section 9.1).

iv) The plans for DM of nuclear/radiological emergencies/disasters from all levels of administration must be mainstreamed, by the respective authorities, in the development programme of the country by seeking allocation of funds from the Planning Commission as well as the concerned ministry, wherever required (Section 9.3).

v) The collectors/magistrates of the districts will prepare detailed off-site emergency preparedness and response plans with the help of the nuclear plant authorities in their districts (Section 3.3).

vi) The DM authorities at the national, state and district levels must cater for their planned and unplanned budget for the various activities in the pre-, during and post-event scenarios of a nuclear/ radiological emergency disaster. Adequate funds will be allotted by the concerned ministries in the central and state governments to cope with the requirements for such activities, in consultation with the Planning Commission. Efforts are to be made for augmentation of central/state government resources from other sources (Section 9.3).

10.3 Responsibilities of Certain Key Stakeholders

i) Recognising the enormity and crucial nature of nuclear and radiological emergency/disaster management, the SDMAs are required to identify and enlist officers with total responsibility of issues related to nuclear/radiological disaster management as a necessary first step towards ensuring effective implementation of the Guidelines (Section 9.2).

ii) The collector/magistrate of the district affected by nuclear emergency from nuclear power plant/facility will be in-charge of the off-site emergency programme and he/she will not delegate his/her responsibility to any one else at the lower level for handling an emergency. For radiological emergencies in the metros/big cities, wherein more than one district is involved, the state authorities will nominate an incident commander (Section 8.2).

iii) Since a lot of effort has gone into their special training, the CBRN trained NDRF personnel must always be made available on emergent basis by NDMA at the affected site (Section 6.3.4).

iv) The coordination mechanism of public authorities with DAE in general and that of its ERCs and CMG in particular will be strengthened significantly by establishing formal linkages with state/district administration through the initiatives of SDMAs/DDMAs. This will also include the linkage with the neighbouring NDRF battalion (Section 3.10.2).

v) The nuclear facilities will have dedicated and well informed personnel for media management. All information to the media will be routed through the respective district information officers (Section 6.3.7, Section 6.3.10).

10.4 Capacity Development

i) A reliable and dedicated communication system, with adequate redundancy and diversity, will be established through the National Disaster Communication Network of NDMA which will provide the last-mile connectivity to the disaster affected site. However, it will be the primary responsibility of the nuclear plant/facility operators and the SDMAs/ DDMAs concerned to ensure proper and adequate last-mile connectivity during all the phases of a nuclear emergency (Section 3.11.5, Section 6.3.10.1).

ii) Specialised response teams will be raised, specially trained for nuclear/radiological emergency/disaster and fully equipped at the state (by the SDMAs/SECs/DDMAs) as well as at the central levels (by MHA). Four battalions of NDRF are being specially trained by NDMA with assistance from DAE/DRDO/Army to provide specialised first response during a nuclear/radiological emergency/disaster. The first responders group will be extended to include the fire and emergency services personnel, the police force and the civil defence staff (Section 6.3.4, Section 6.3.5).

iii) A large number of ERCs rendering specialised services during nuclear/radiological emergencies will be established to cover all the metros and the other vulnerable areas in the country by both DAE as well as state governments (Section 3.5.2, Section 3.11.1, Section 3.17).

iv) In addition to the ERCs established by BARC, it is essential that additional ERCs, with the necessary trained personnel equipped with appropriate radiation detection instruments, PPG and a mobile monitoring van, are set up in all major cities and other vulnerable locations. Police being the automatic first responders, the responsibility of setting up these additional ERCs will be that of the state governments within their own existing manpower and financial resources (Section 6.3.9.1).

To start with, efforts should be made to cover all the metro cities and other vulnerable areas with populations of 20 lakh or more for establishment of additional ERCs and training of first responders (Section 6.9).

v) The roads and transport network will be strengthened by SDMAs/DDMAs of the various state governments/UTs for effective and quick response (Section 3.11.6, Section 6.3.10.2).

The possible places of shelters in large metros and vulnerable areas are to be identified by the various state governments/UTs, with assistance from DAE/DRDO, for the people to be evacuated in the event of any nuclear/radiological emergency (Section 3.11.7, Section 6.3.10.3).

vi) Being the nodal ministry, MHA will be responsible for the establishment of additional ERCs, ERTs, fire services capability for response to nuclear/radiological emergency throughout the country. In addition, it has to build shelters/camps with provision of food, water, fuel, medicine, sanitation facilities, etc. (Section 9.6.1).

vii) Additional IERMON systems for strengthening real time surveillance and early warning systems are to be installed for radiation monitoring in various metros and vulnerable areas by the state governments in consultation with DAE and MHA (Section 6.3.9.3).

viii) Sufficient inventory of radiation monitoring instruments and protective gear will be built-up by all the SDMAs and DDMAs in order to ensure availability of these basic needs for response to nuclear/radiological emergency (Section 6.3.9.2).

SDMAs and DDMAs will keep ready, in advance, all the instruments and protective gear needed by the response teams for nuclear/radiological emergency (Section 6.3.51).

ix) Monitors at entry/exit points of the country will be installed by MHA to prevent illicit trafficking of radioactive materials and the security staff stationed at such points should be properly trained to prevent the smuggling/illegal trafficking of the radioactive materials. Similarly, there is a need to enhance the security of radioactive sources at radiation facilities and during their transportation by the concerned facility operator (Section 3.12, Section 4.6).

x) MoH&FW will take action for setting up of at least one mobile radiological laboratory unit in each district and at least two such units in each metropolis to support detection, protection, and decontamination procedures in consultation with DAE and DRDO (Section 6.8.3.4).

xi) The 'Intervention Levels' of radiation dose for various actions by the members of rescue and relief teams and the 'Action Levels' to control the consumption of contaminated food items in the effected areas are needed to be generated by the experts from DAE and AERB (Section 3.10.3, Section 6.10).

xii) Education and awareness generation programmes for the community will be conducted throughout the country to allay their apprehensions about the nuclear energy programme and nuclear emergencies by the nuclear/radiological facility operators, NIDM and SDMAs/ DDMAs with assistance from MHRD, MHA, DAE, and DRDO (Sections 7.2-7.3).

xiii) With the number of radiation applications increasing considerably in the fields of medicine, industry, agriculture, and research, AERB will consider establishing regional regulatory centres/authorities to handle the increased volume of regulatory work (Section 7.7.1).

xiv) The country will be prepared by NEC/ MHA/NCMC, in consultation with DAE/ AERB/NTRO, for a quick and effective response to the worst case scenario of a nuclear attack, even though such a scenario is quite unlikely but has always a remote possibility (Section 2.2.6, Section 8.4, Section 8.10).

10.5 Medical Preparedness

The hospital preparedness plan will be based on an 'all hazards' plan, of which the nuclear/ radiation emergency response will be one component. At the national level, the MoH&FW will work in close coordination with NDMA, SDMA, MHA, DAE, and MoD to foresee the medical preparedness for nuclear/radiological emergency in the country.

i) Existing medical facilities and medical professionals are highly inadequate to handle large scale radiation injury cases. Establishment/upgradation of primary, secondary, and tertiary care hospitals which can handle sufficient number of people affected during a nuclear emergency will be taken up by MoH&FW with the help of DAE on a priority basis (Section 6.8.3.1).

ii) A concerted approach by all concerned, viz., NDMA, SDMA, DDMA, MHA, DAE, MoH&FW, and state as well as district health authorities, is necessary to network medical professionals, training them in the management of radiation injuries, maintaining an up-to-date database of such expertise and developing mechanism to tap this expertise in the event of an emergency. To enable this, it is necessary that a database of RSOs be prepared/ maintained and made available at the DDMA, SDMA and national levels by the AERB.

iii) A model CBRN research and treatment centre will be established by MoH&FW in one of the major tertiary care hospitals in the country, with sufficient number of beds to take care of any type of nuclear emergency/disaster. The facility will be replicated subsequently in at least four geographically well separated locations near the high-risk areas (Section 6.8.8).

10.6 Training of First Responders, Mock Drills and Emergency Exercises

i) Training of the various first responders and the administrative personnel involved in DM at various levels of administration will be imparted at regular intervals by the CBRN trained NDRF trainers and NIDM with assistance from DAE, DRDO and NDMA (Section 7.4, Section 7.5).

ii) To cope with radiological emergencies, mock-drills and emergency preparedness exercises will be conducted by SDMAs/ DDMAs, (with assistance from DAE, DRDO, NDMA, and MHA), on a regular basis in the public domain. Keeping in mind that such mock-drills may create panic in the public, this should be conducted either as part of other emergency preparedness exercises or carried out at appropriate places. The QRMT/MFR team will form part of the regular mock-drill/simulation exercise/ table top exercise conducted by DDMA (Section 6.9).

iii) Training programmes for medical professionals for treatment of radiation injuries, formation of QRMTs/ MFRs along with maintaining sufficient stock of essential medicines and database for experienced medical professionals will be taken up by MoH&FW on a priority basis (Section 3.11.8, Section 6.8.3.3, Section 9.6.4).

Appendices and Annexures

Appendix 1

Apprehensions about Nuclear Radiation and Nuclear Energy

Human beings all over the world have always been exposed to many natural disasters like earthquake, cyclone, flood, tsunami, epidemic, etc., where lakhs of people have lost their lives, along with huge loss of livelihood and property. Similarly, there are large number of deaths as well as heavy loss of property every year due to man-made accidents/disasters like road, train and plane accidents, or huge fires at residential, office as well as industrial complexes. Accidents in the coal mines and industries (like the tragic accident at Bhopal, India in 1984) are glaring examples of man-made disasters resulting in massive losses of life and property. However, the public in the society have taken all such disasters in their stride as inevitable, partly because these are not fears of unknown that have become integral parts of their life and partly due to the fact that the benefits derived from such sources of man-made accidents far outweigh the negative aspects of the same.

On the other hand, there have been a total of about 150 fatalities (a number which is comparatively insignificant, though not desirable) over the last five decades from radiation related accidents worldwide, due to adaptation of the best engineering practices and strict compliance to the highest standards of safety regulations. In spite of this, the public perception about the consequences of even a small incidence of nuclear emergency is far from the ground reality, primarily because people invariably link even a minor nuclear emergency with, erroneously though, the sad memories of Hiroshima and Nagasaki in Japan, the memories that have been further aggravated by the wide publicity given to the accidents at Three Mile Island, USA (even though, there was no loss of life or significant release of radioactivity in the public domain from this accident) and Chernobyl at Ukraine (which was essentially due to faulty design of the reactor and violation of safety regulations by the operating personnel that led to 31 deaths along with a number of children in the nearby areas being affected by thyroid cancer, and about 1.25 lakh people being required to be relocated from their original habitats). Due to lack of awareness, education and authentic and accurate information, it is extremely difficult for the common people to accept the ground reality that, with the best practices followed in design (with defence-in-depth approach), development, construction and operation of the nuclear power plants of the present generation, chances of a major nuclear accident in a nuclear power plant are extremely remote.

Frankly speaking, one cannot blame the public totally for such a misconception about radiation disasters for reasons more than one: firstly, a radiation disaster is associated with 'fear of unknowns' because one cannot see, feel or smell the presence of radiation; secondly, the benefits derived from nuclear electricity and applications of radioisotopes in the areas of medicine, industry, food preservation etc., have not yet reached a stage where societies across the countries can accept even a small nuclear/radiological emergencies in their life, and finally, because of ignorance and lack of awareness, there is still a mystery shrouding such incidents/emergencies because of which, even minor accidents/abnormal situations in the nuclear facilities are invariably considered to assume the dimension of a Chernobyl like accident.

But the ground reality is that, human beings are continuously exposed to the naturally occurring ionizing radiation all the time since creation of the earth. As per UNSCEAR, the average dose received by a person from natural sources of radiation on our planet is 2.4 mSv/y and there are places like parts of the

Appendix 1 contd.

Kerala coast in India (where people get nearly five times this average dose), Iran (where people get 10-15 times this average dose), and places in China and Brazil (where the natural radiation dose is much higher than the average level). It is interesting to note that, at all the places where the natural background levels are higher, people have been living for generations without any observed ill effects of health. Thus, nuclear radiation is really not something unknown or a mystery; it is the lack of information as well as awareness that have built the shroud of mystery around nuclear radiation. In this context, it may be noted that a single exposure during a chest X-ray or when people travel in an aircraft, the radiation dose received by them is quite significant compared to what they receive on the surface of the earth. Similarly, the ^{40}K content in the fly ash from the coal-fired power plants is a source of radiation.

At this point, one should understand the difference between nuclear radiation and radioactivity. Radiation can be in the form of energetic particles (like alpha, beta and neutron particles) or as packets of energy in the form of electromagnetic waves emitted by a radioactive material (like X-rays, gamma rays). A person, receiving the radiations in particle or wave form does not become radioactive or get contaminated with radioactive material (unless a person receives the radiation of very high energy, when some activation products, that are radioactive, may be formed). On the other hand, when radioactive material becomes air borne and if a person inhales or ingests this radioactive dust, his/her body will be contaminated internally. If the radioactive dust falls on the exposed area of a person's body or on the clothes worn by the person, he/she will be externally contaminated.

While it is true that nuclear radiation, unlike the radiation from sources of heat and light, cannot be perceived by any human sensory organs, a large variety of highly sensitive instruments have been developed by the scientific and technical community to replace the human sensories for easy detection of even very low level of radiation and to exploit the beneficial aspects of nuclear power and radiation technologies. In fact, it is quite feasible to control the level of radiation at a place by adopting the principles of time, distance and shielding. The exposure received by a person from a radiation source is directly proportional to the time of exposure and it reduces inversely with the square of the distance from the source. Further, a person can be shielded from radiation by interposing high density materials (for gamma-rays) or light materials (for neutrons) between the source and the person.

Since it is known that the exposure of radiation beyond a limit can be harmful to human health, International Commission on Radiological Protection [(ICRP) which is a forum of the best known radiation experts in the world] has prescribed the limits within which people can work in the nuclear facilities without any deterministic effects (that can be determined after the exposure) and with very low probability of stochastic effects (that cannot be immediately determined but may have the possibility of getting manifested in the future). After detailed investigations over the decades on the effects of radiation on human beings that were exposed to very high level of radiation at Hiroshima and Nagasaki, the international body ICRP has prescribed the acceptable limits of radiation for the occupational workers (to just 20 mSv/y) in the nuclear facilities and for the public (to 1 mSv/y for exposure from releases from nuclear facilities) which is 20 times less than the limit for the occupational worker. These limits are strictly followed the world over. Based on these limits, the AERB issues its own sets of limits in India that are to be followed.

Further, it may be noted that even if a person receives an acute dose of radiation (of about 500 mSv), there will hardly be any deterministic effect (c.f. the radiation dose for occupational worker is just 20 mSv/y, i.e., 25 times less than this number). In this context it is important to note that persons working in a nuclear facility receive, on an average, an additional dose equal to what is received from the natural background. There are both regulatory and administrative controls in a nuclear industry to ensure that people are not over-exposed. It is the only industry in the world where every individual worker is monitored throughout his/her life (which is extended even after his/her retirement, wherever required).

Appendix 1 contd.

The shroud of mystery and misconception about radiological/nuclear emergency can be removed only through a large scale awareness generation programme in the public domain about the basics of nuclear radiations and radiation emergency on the one hand and how nuclear power and radiation technology can improve, if properly utilised, the quality of life in the society on the other hand. In this context, it must be observed that the people of Japan, the only country in the world which has experienced the worst form of nuclear disaster, have not lagged behind to harness the beneficial aspects of nuclear power and radiation technology in a big way, with 30 per cent of its electricity being generated from nuclear sources. Similarly, France is generating about 78 per cent of its electricity from nuclear power plants. In fact, all the developing countries in the Asian region have ushered in nuclear power and radiation technologies as inevitable options to improve the quality of life in their societies. It is equally important to note that some of the developed countries, who are strong opponents of nuclear power, have accepted applications of radioisotope/radiation technology in a massive way in the areas of medicine (including sterilisation of medical products), industry, food preservation, etc.

Many of the myths, misgivings and misconceptions, prevalent in the public in general about nuclear radiation and nuclear energy are highlighted below, which should be removed by proper awareness generation programmes (that have been highlighted in the guidelines):

1. **Myth**: All irradiated food products become radioactive and make them unfit for human consumption.

   Reality: The shelf-life of irradiated food products increases because irradiation kills the pathogens while retaining the food value. Food products do not become radioactive due to irradiation.

2. **Myth**: Any reactor accident will lead to a situation like Chernobyl.

   Reality: Because of the best practices followed in design (with defence-in-depth approach), development, construction and operation of the nuclear power plant of the present generation, chances of any nuclear accident leading to a Chernobyl like situation are extremely remote.

3. **Myth**: In a major accident, a nuclear power reactor can explode like an atom bomb.

   Reality: Due to the design philosophy adopted and various built-in safety systems in a nuclear power reactor, the possibility of a major accident in a power reactor is extremely low. Even if it does take place, it cannot explode like a bomb, because of the inherent design features and built-in safety systems that practically eliminates the chances of any radioactivity going to public domain. In this context it is to be noted that there was no exposure to the public in case of the Three Mile Island accident, though the reactor core was damaged extensively. Even in case of Chernobyl, where the core was exposed to the open atmosphere and containment gave way, the reactor did not explode like an atom bomb.

4. **Myth**: The genetic effect is observed in the offspring of all those who are exposed to radiation during their occupation.

   Reality: No genetic effect has been observed in the children of the occupational workers who are exposed to radiation within the permissible limits year after year during their occupation. There is no conclusive evidence of any genetic effect, even in those persons who belong to the reproductive age group, and were exposed to high doses to radiation in accidents or during medical treatment.

Appendix 2

Levels of Defence-In-Depth

Levels	Objectives	Essential means	Category
Level 1	Prevention of abnormal operations and failures	Conservative and high quality in ❑ design ❑ construction ❑ operation	**PREVENTION**
Level 2	Control of abnormal operations and detection of failures	❑ Control systems ❑ Protection systems ❑ Associated surveillance programme	
Level 3	Control of accidents	❑ Engineered safety features	**MITIGATION**
Level 4	Control of severe plant condition (accident progression) and mitigation of consequences	❑ Procedures for accident management • Complementary measures • Accident management	
Level 5	Mitigation of radiological consequences 'on release of radioactive material'	❑ Off-site emergency response	**EMERGENCY PREPAREDNESS**

Appendix 3

List of Instruments and Equipment, and Protective Gear for Specialised Response Teams

S.No.	Equipment and Instruments
1	Ambulance with radiation monitoring and decontamination facility
2	Portable gamma ray spectrometer for isotope detection
3	Requirement for aerial survey monitoring: (a) Aerial monitoring system (b) Monitors, protective equipment, PC/laptop, etc.
4	Environmental Radiation Monitor with Navigational Aid (ERMNA) with monitoring vehicle
5	Alpha, beta and gamma counting setup
6	Digital dosimeter
7	GPS for monitoring van
8	T.L. dosimeter
9	Portable contamination monitor
10	CBRN suit with respirator, rubber clothes, gloves and gum boots
11	Dust mask
12	Comfo respirator
13	Decontamination kit including monitoring facility
14	Potassium Iodide/Potassium Iodate tablets
15	Operational manuals for all equipment training and guidance literature
16	Protective coverall, cotton gloves, caps, socks and shoes
17	Electric generator
18	Torch
19	Binoculars
20	Miscellaneous sampling kits: (a) Charcoal papers and cartridges (for iodine sampling/protection) (b) Plastic sheets (for packing of contaminated material) (c) Spare batteries

Appendix 3 contd.

21	Micro R Survey meter
22	Mini Rad meter
23	GM Survey meter
24	Teletector
25	Portable Alpha Contamination monitor
26	First aid kits
27	Radiation tags/symbols
28	PA system
29	Battery operated air sampler with filter paper
30	Cordoning tape
31	Tongs (2 ft) and lead flask of 1” thickness and 5” diameter
32	Breathing apparatus set with spare cylinders

Appendix 4

Medical Preparedness

Creation of Decontamination Room

The earmarked hospital must have a decontamination room with the appropriate equipment and materials. A decontamination room will have a lightweight, durable, impermeable, washable and reusable fiberglass tabletop backboard with flexible drain hose, locking straps, spray nozzle and wall mounting bracket. Two 100-litre waste collection containers must also be available. All nuclear casualties will first be brought to the decontamination room.

Nuclear Ward fitted with Dust-Filter

The radiation injury treatment ward must be fitted with nuclear filtration units to provide purified air with positive pressure so that contaminated air can never enter from outside. Filtration units are suitable for pressurisation inside the ward and control of air flow.

Radioactive Bio-Waste Disposal Facilities

A delay tank is to be constructed to handle waste from the contaminated patients at a place where there is no movement of the public. Only authorised workers are to be allowed to control the flow of effluents from the tank to the main sewerage. The tank has to be leak proof, corrosion free and should have smooth inner surfaces. The outlet of the sewerage tank has to be much higher to avoid any backflow. For a period of one month, the effluent waste may be allowed to flow into only one tank using a set of valves provided on the pipelines leading to tanks from the radiation ward. When this is full, the inlet to this tank should be closed and the effluent should be allowed to flow into the second tank. During the collection period, the radioactivity in the first tank will undergo decay so that it can be conveniently disposed of, when discharge limits are achieved. The activity level at the time of discharge into the sewer shall conform to the regulatory requirements.

Radio Bio-Dosimetry Laboratory having Facilities like Fluorescence InSitu Hybridization (FISH) to Study Chromosomal Aberration

Radio bio-dosimetery includes lymphocyte estimations along with the other formed elements of the blood. Chromosomal study is an important tool for radiation bio-dosimetry. Chromosome exchanges resulting in unstable aberration such as dicentrics, rings, acentric fragments and other asymmetrical rearrangements may be measured using the technique of Fluorescence In Situ Hybridization (FISH) which is currently the essay of choice for definitive bio-dosimetry. Measurements of radiation-induced apoptosis in human lymphocytes are also considered the most sensitive reproducible bio-dosimeter. Counting the frequency or number of micro nuclei in the cytoplasm of irradiated cells, electron spin resonance detection of free radical formation in tooth enamel and measurement of serum bio chemical markers such as amylase, Inter Leukine-6, cholesterol and apolipoprotein levels have also been considered as potential techniques for determining the radiation dose received.

Haematology Laboratory with Cell Separator for Granulocyte Concentrate

Blood and bone marrow are most sensitive organs in the body affected by radiation. Following radiation exposures, neutropaenia will occur suppressing the immunity of the casualty leading to infection. To

Appendix 4 contd.

combat the problem, Granulocyte concentrates is very useful; therefore, a haematology laboratory with cell separator for Granulocyte concentrates is an essential requirement for the management of radiation injuries.

Genetic Laboratory

Genetic damage is one of the long-term adverse effects of radiation. Genetic studies must be carried out in a properly equipped genetic laboratory for proper monitoring, surveillance and counselling of victims.

Molecular Laboratory

Radiation injury damages DNAs, therefore a molecular laboratory needs to be established in radiation injury treatment centres for DNA and other molecular studies.

Immunology Laboratory

Immuno-suppression is the major damage caused by radiation injuries. Proper immunological studies will help for the restitution of the immune system and bone marrow transfusion. Immunology laboratories will facilitate studies of cell mediated and humeral immunity.

Bone Marrow Bank, Bone Marrow Transfusion and Stem Cell Harvesting Facilities

For restitution of the immune system, bone marrow transfusion is very important. However, there are problems of getting a donor, HLA compatibility and host versus graft reaction which may lead to rejection of the bone marrow. Stem cell harvesting and transfusion will avoid the above problems. These problems can also be avoided through the availability of a bone marrow bank where the bone marrow of high radiation exposure risk personnel can be stored under cryo-preservation and the same can be replenished at the time of requirement. Therefore, stem cell harvesting facilitates and a bone marrow bank needs to be created for a RITC.

Specialised medical stores consisting of Amifostine and other radio protectors, de-corporation agents [like DiethyleneTriamine-PentaAcetate (DTPA) and Prussian Blue], Potassium Iodide, growth factors, colony stimulating factors, and other radiation recovery agents will be in place.

In addition to the usual drugs mentioned above, medical stores need to cater to the treatment of radiation injuries. Amifostine significantly decreases radiation toxicity in patients receiving radiotherapy for cancer, when 200 mg/m2 is given intravenously 15–30 minutes prior to each radiation fraction. De-corporation agents (DTPA, Prussian Blue) eliminates radio nuclides entering the body, thus reducing internal contamination. The de-corporation agents act as diluting, blocking, mobilising and chelating agents. De-corporation should be initiated as soon as is practical. Gastric lavage, emetics, purgatives, laxatives and enemas can also be used to eliminate radioactive material from the body. Prior administration of Potassium Iodide prevents damage to thyroid from radiation. Growth factors, colony stimulating factors and other radiation recovery agents are very useful for restitution of the immune system.

Annexure 1

Applications of Radioactive Materials and Related Concerns

Radioactive sources may contain one of the dozens of radionuclides, and their activities can range from ~10^5 to 10^{17} Bq. The half-lives of typical isotopes can range from a few days to thousands of years. Some of the commonly used radioisotopes are given in Table 1. Radioisotopes are widely used in various commercial applications where these are not subject to the stringent level of security measures, as compared to fissile materials, and hence could be more easily accessible to the terrorists. A few important applications of these isotopes are given below along with an introduction to the nuclear reactors where these radioisotopes are produced:

1. Nuclear Power Reactor and Research Reactor

   The most important application of nuclear energy is the generation of electric power in special types of reactors made for this purpose. Power is generated using the principle of nuclear fission. Normally, natural or enriched uranium is used as fuel in these reactors. Plutonium or a mixture of Pu-U (mixed oxide) is also used as fuel in some reactors. In future, Thorium will also be used as fuel in power reactors.

   There is another type of reactor known as research reactor whose main purpose is to produce radioisotopes for industrial, medical and other uses, in addition to research work.

2. Industrial and Other Applications

   One of the important applications of radioisotopes is in the field of industrial radiography, a non-destructive technique, used for testing the integrity, porosity, cracks, etc., of welding joints. Iridium-192 is the γ-source commonly used for this purpose. Cobalt-60 and Cs-137 sources of γ-radiation are used in mining as well as in oil and gas well logging. The most common industrial applications of γ-sources are in level and thickness gauging as well as process control. If these gauges are not removed, when the facility is closed, they can end up in metal recycling facilities.

   Americium-241/Be and Californium-252 neutron sources are also used for many applications. The activity of some Am-241/Be neutron sources used in well logging can be as high as several hundreds of GBq per source (usually within the range of 1–800 GBq). Neutron sources are also used in machines at the airports to scan the presence of explosives and other prohibited/restricted materials.

   Radioisotope Thermoelectric Generators (RTGs) use heat generated by the decay of radioactive isotopes to produce electric power. They have no moving parts and can operate for decades without refuelling. They are used as a power supply where frequent maintenance or refueling is expensive or impractical. The largest known RTG used 25PBq of Sr-90 (typically about 2PBq of Sr -90).

   Industrial irradiators containing Co-60 or Cs-137 as γ-Sources are used to sterilise medical products, meat, fresh vegetables, fruits, spices and other foodstuffs. Although physically small (approximately 1 cm x 50 cm), the radioactive sources or ‘pencils’ in irradiators are highly radioactive. Individual cobalt pencils can have an activity of 500 TBq and an irradiator facility may have an array of cobalt pencils totalling up to a few hundred PBq. The highest activity Cesium irradiators may contain as much as 8 PBq of Cs -137.

Annexure 1 contd.

3. Medical Applications

Hospitals and medical facilities are among the largest users of radioactive sources, typically for teletherapy and brachytherapy applications Gamma radiation is extensively used in the treatment of cancer patients. Until the 1950s, the only significant radioactive sources produced were Ra-226 sources that were used for brachytherapy. Most of the old radium sources used in brachytherapy have been replaced by Co-60, Cs-137, and Ir-192. Cobalt-60 is the most common radionuclide used in teletherapy, although some Cs-137 sources are also in use.

4. Applications in Agriculture

Sealed sources of Co-60 from a few TBq to 100 TBq range are used for food preservation and for removing of microorganisms from food products. Unsealed sources of P-32 with a few KBq are used for soil- and plant-uptake studies. By applying the process of mutation, breeding yield per acre of many types of seeds have been increased considerably.

5. Applications in Research and Education

Radioactive sources used in education and research contain a wide variety of radionuclides. During the 1960s, gamma irradiators containing large quantities of Co-60 were used for research purposes. Soil moisture gauges used for agriculture research contain Cs-137 sources and neutron producing Am-241/Be sources. Sealed sources of a few TBq are also used for agricultural research. Unsealed sources of C-14, S-35, H-3, etc., having strength of a few kBq are used in biomedical research.

6. Concern over Possible Malevolent Uses of Radioisotopes

Keeping in mind, the magnitude of the radioactivity of sources of Teletherapy Units (which in itself is a strong deterrent) and the nature of the special tools/skills needed to get access to these sources, the probability of diversion of sources from Teletherapy Units for malevolent purposes is considered very low. The more vulnerable equipment such as radiographic cameras (about 1,100 units of which are presently being used in India) containing 400 GBq to 4,000 GBq of Ir-192 or Co-60 sources have a high risk of loss or theft, given the need to transport these radioisotopes to and from the radiography fields. Owners sometimes lack adequate control over these sources that puts them at the risk of getting lost or stolen. Many a time, commercial users abandon the radioactive sources, once their commercial interests are over. If such radioisotopes fall into the hands of terrorists, they will pose a possible threat because the radioisotopes can be used as an RDD or 'dirty bomb', which would disperse the radioactive material in the public domain, when exploded together with a conventional explosive device. An RDD can cause large-scale panic in the community and the dispersal of radioactivity in the public domain may call for costly and time-consuming decontamination efforts.

Annexure 1 contd.

Table 1: List of Radioactive Sources, their Half-lives and Applications

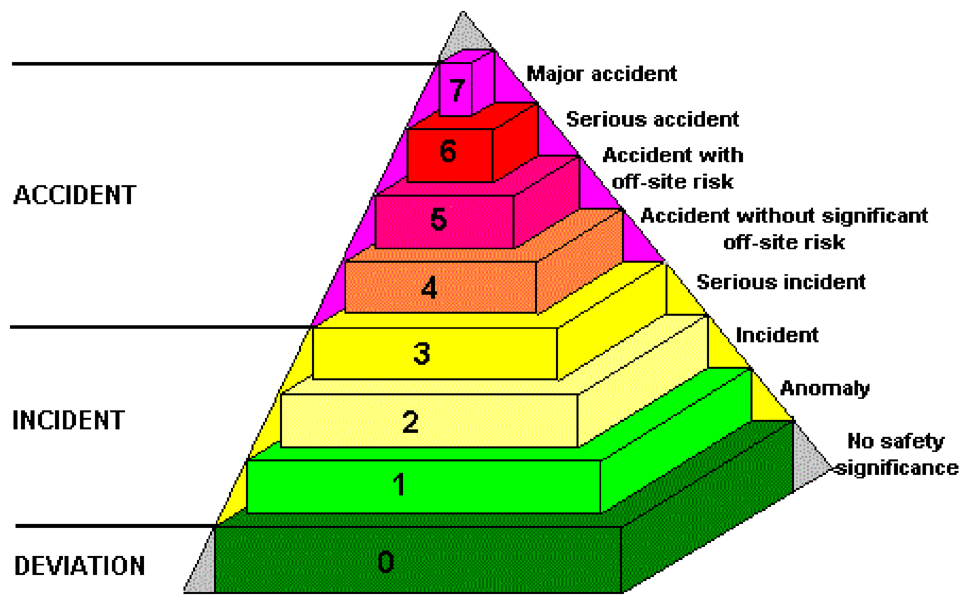
Application	Radionuclide	Half-life
1. Industrial radiography	^{60}Co	5.3 a
	^{192}Ir	74 d
	^{75}Se	120 d
	^{169}Yb	32 d
	^{170}Tm	129 d
2. Irradiators	^{60}Co	5.3 a
	^{137}Cs	30.1a
3. Industrial gauges	^{60}Co	5.3 a
	^{137}Cs	30.1 a
	^{252}Cf	2.6 a
	^{85}Kr	10.7 a
	^{241}Am	432 a
	^{244}Cm	18.1 a
4. Well logging/moisture gauges	^{137}Cs	30.1a
	^{252}Cf	2.6 a
5. RTGs	^{90}Sr	28.6 a
	^{238}Pu	87.8 a
6. Medical (Teletherapy)	^{60}Co	5.3 a
	^{137}Cs	30.1 a
7. Medical (Brachytherapy)	^{60}Co	5.3 a
	^{137}Cs	30.1 a
	^{226}Ra	1600 a
	^{192}Ir	74 d
	^{125}I	60 d
8. Nuclear medicine	^{99m}Tc	6 h
	^{131}I	8 d
9. Pacemakers	^{238}Pu	87.8 a
10. Research	^{241}Am-Be	432 a
	^{239}Pu-Be	24100 a

'a' stands for years, 'd' for days and 'h' for hours

Note: The above list is not exhaustive

Annexure 2

The International Nuclear Event Scale (INES)



General Description of the Scale

The International Nuclear Event Scale (INES) is a means for promptly communicating to the public, in consistent terms, the safety significance of events reported at nuclear installations. By putting events into proper perspective, the Scale can ease common understanding among the nuclear community, the media and the public. It was designed by an international group of experts convened jointly in 1989 by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organisation for Economic Cooperation and Development. The Scale was initially applied for a trial period to classify events at nuclear power plants and then extended and adapted to enable it to be applied to any event associated with radioactive material and/or radiation and to any event occurring during transportation of radioactive materials. It is now operating successfully in over 60 countries.

The INES Information Service, the communication network built up on the request, receives from and disseminates to the INES National Officers of 60 member states, Event Rating forms that provide authoritative information related to nuclear events. Event Rating forms are circulated when events are significant for:

- operational safety (INES level 2 and above)
- public interest (INES level 1 and below)

The communication process has therefore led each participating country to set up a structure which ensures that all events are promptly rated using the INES rating procedure to facilitate communication whenever they have to be reported outside. Events are classified on the Scale at 7 levels; the upper levels (4–7) are termed 'accidents' and the lower levels (1–3), 'incidents'. Events which have no safety significance are classified below the Scale at level 0 and are termed 'deviations'. Events which have no safety relevance

Annexure 2 contd.

are termed 'out of scale'. The basic structure of the Scale is shown below in the form of a matrix with key words. Each level is defined in detail within the *INES User's Manual*. Events are considered in terms of three safety attributes or criteria represented by each of the columns: off-site impact, on-site impact, and defence-in-depth degradation. The second column in the matrix relates to events resulting in off-site releases of radioactivity. Since this is the only consequence having a direct effect on the public, such releases are understandably of particular concern. Thus, the lowest point in this column represents a release giving the critical group an estimated radiation dose numerically equivalent to about one-tenth of the annual dose limit for the public; this is classified as level 3. Such a dose is also typically about one-tenth of the average annual dose received from natural background radiation. The highest level is a major nuclear accident with widespread health and environmental consequences.

The third column considers the on-site impact of the event. This category covers a range from level 2 (contamination and/or overexposure of a worker) to level 5 (severe damage to the reactor core or radiological barriers).

All nuclear facilities are designed so that a succession of safety layers act to prevent major on-site or off-site impact and the extent of the safety layers provided generally will be commensurate with the potential for on- and off-site impact. These safety layers must all fail before substantial off-site or on-site consequences occur. The provision of these safety layers is termed 'defence-in-depth'. The fourth column of the matrix relates to incidents at nuclear installations or during the transportation of radioactive materials in which these defence-in-depth provisions have been degraded. This column spans the incident levels 1–3.

An event which has characteristics represented by more than one criterion is always classified at the highest level, according to any one criterion. Events, which do not reach the threshold of any of the criteria, are rated below the Scale at level 0.

Using the Scale

- The detailed rating procedures are provided in the *INES User's Manual*.
- Although the Scale is designed for prompt use following an event, there will be occasions when a longer time-scale is required to understand and rate the consequences of an event. In these rare circumstances, a provisional rating will be given with confirmation at a later date. It is also possible that as a result of further information, an event may require reclassification.
- The Scale does not replace the criteria already adopted nationally and internationally for the technical analysis and reporting of events to safety authorities
- Although the same Scale is used for all installations, it is physically impossible at some types of installations for events to occur which involve the release to the environment of considerable quantities of radioactive material. For these installations, the upper levels of the Scale would not be applicable. These include research reactors, unirradiated nuclear fuel treatment facilities and waste storage sites.
- It is not appropriate to use the Scale to compare safety performance among countries. Each country has different arrangements for reporting minor events to the public, and it is difficult to ensure precise international consistency in rating events at the boundary between level 0 and level 1. The statistically small number of such events, with variability from year to year, makes it difficult to provide meaningful international comparisons.

Annexure 2 contd.

Examples of Rated Nuclear Events (the following list is not exhaustive)

- The 1986 accident at the Chernobyl nuclear power plant in the Soviet Union (now in Ukraine) had widespread environmental and human health effects. It is thus classified as Level 7.
- The 1957 accident at the Kyshtym reprocessing plant in the Soviet Union (now in Russia) led to a large off-site release. Emergency measures, including evacuation of the population, were taken to limit serious health effects. Based on the off-site impact of this event, it is classified as Level 6.
- The 1957 accident at the air-cooled graphite reactor pile at the Windscale (now Sellafield) facility in the United Kingdom involved an external release of radioactive fission products. Based on the off-site impact, it is classified as Level 5.
- The 1979 accident at Three Mile Island in the United States resulted in a severely damaged reactor core. The off-site release of radioactivity was very limited. The event is classified as Level 5, based on the on-site impact.
- The 1973 accident at the Windscale (now Sellafield) reprocessing plant in the United Kingdom involved a release of radioactive material into a plant operating area as a result of an exothermic reaction in a process vessel. It is classified as Level 4, based on the on-site impact.
- The vast majority of reported events are found to be below Level 3. Although no examples of these events are given here, countries using the Scale may individually wish to provide examples of events at these lower levels.

Annexure 2 contd.

Basic Structure of the Scale

(Criteria given in matrix are broad indicators only)
Detailed definitions are provided in the INES User's Manual

	CRITERIA OR SAFETY ATTRIBUTES		
	OFF-SITE IMPACT	ON-SITE IMPACT	DEFENCE IN DEPTH DEGRADATION
7 MAJOR ACCIDENT	MAJOR RELEASE: WIDESPREAD HEALTH AND ENVIRONMENTAL EFFECTS		
6 SERIOUS ACCIDENT	SIGNIFICANT RELEASE: LIKELY TO REQUIRE FULL IMPLEMENTATION OF PLANNED COUNTERMEASURES		
5 ACCIDENT WITH OFF-SITE RISK	LIMITED RELEASE: LIKELY TO REQUIRE PARTIAL IMPLEMENTATION OF PLANNED COUNTERMEASURES	SEVERE DAMAGE TO REACTOR CORE/RADIOLOGICAL BARRIERS	
4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK	MINOR RELEASE: PUBLIC EXPOSURE OF THE ORDER OF PRESCRIBED LIMITS	SIGNIFICANT DAMAGE TO REACTOR CORE/RADIOLOGICAL BARRIERS/FATAL EXPOSURE OF A WORKER	
3 SERIOUS INCIDENT	VERY SMALL RELEASE: PUBLIC EXPOSURE AT A FRACTION OF PRESCRIBED LIMITS	SEVERE SPREAD OF CONTAMINATION/ACUTE HEALTH EFFECTS TO A WORKER	NEAR ACCIDENT NO SAFETY LAYERS REMAINING
2 INCIDENT		SIGNIFICANT SPREAD OF CONTAMINATION/ OVEREXPOSURE OF A WORKER	INCIDENTS WITH SIGNIFICANT FAILURES IN SAFETY PROVISIONS
1 ANOMALY			ANOMALY BEYOND THE AUTHORIZED OPERATING REGIME
0 DEVIATION	**NO**	**SAFETY**	**SIGNIFICANCE**
OUT OF SCALE EVENT	NO SAFETY RELEVANCE		

Annexure 2 contd.

The International Nuclear Event Scale

For prompt communication of safety significance

LEVEL/ DESCRIPTOR	NATURE OF THE EVENTS	EXAMPLES
ACCIDENTS 7 MAJOR ACCIDENT	• External release of a large fraction of the radioactive material in a large facility (e.g. the core of a power reactor). This would typically involve a mixture of short and long-lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands of terabecquerels of iodine-131). Such a release would result in the possibility of acute health effects; delayed health effects over a wide area, possibly involving more than one country; long-term environmental consequences.	Chernobyl NPP, USSR (now in Ukraine), 1986
6 SERIOUS ACCIDENT	• External release of radioactive material (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131). Such a release would be likely to result in full implementation of countermeasures covered by local emergency plans to limit serious health effects.	Kyshtym Reprocessing Plant, USSR (now in Russia), 1957
5 ACCIDENT WITH OFF-SITE RISK	• External release of radioactive material (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131). Such a release would be likely to result in partial implementation of countermeasures covered by emergency plans to lessen the likelihood of health effects. • Severe damage to the installation. This may involve severe damage to a large fraction of the core of a power reactor, a major criticality accident or a major fire or explosion releasing large quantities of radioactivity within the installation.	Windscale Pile, UK, 1957 Three Mile Island, NPP, USA, 1979
4 ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK	• External release of radioactivity resulting in a dose to the critical group of the order of a few millisieverts.* With such a release the need for off-site protective actions would be generally unlikely except possibly for local food control. • Significant damage to the installation. Such an accident might include damage leading to major on-site recovery problems such as partial core melt in a power reactor and comparable events at non-reactor installations. • Irradiation of one or more workers resulting in an overexposure where a high probability of early death occurs.	Windscale Reprocessing Plant, UK, 1973 Saint-Laurent NPP, France, 1980 Buenos Aires Critical Assembly, Argentina, 1983
INCIDENTS 3 SERIOUS INCIDENT	• External release of radioactivity resulting in a dose to the critical group of the order of tenths of millisievert.* With such a release, off-site protective measures may not be needed. • On-site events resulting in doses to workers sufficient to cause acute health effects and/or an event resulting in a severe spread of contamination for example a few thousand terabecquerels of activity released in a secondary containment where the material can be returned to a satisfactory storage area. • Incidents in which a further failure of safety systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if certain initiators were to occur.	Vandellos NPP, Spain, 1989
2 INCIDENT	• Incidents with significant failure in safety provisions but with sufficient defence in depth remaining to cope with additional failures. These include events where the actual failures would be rated at level 1 but which reveal significant additional organisational inadequacies or safety culture deficiencies. • An event resulting in a dose to a worker exceeding a statutory annual dose limit and/or an event which leads to the presence of significant quantities of radioactivity in the installation in areas not expected by design and which require corrective action.	
1 ANOMALY	• Anomaly beyond the authorised regime but with significant defence in depth remaining. This may be due to equipment failure, human error or procedural inadequacies and may occur in any area covered by the scale, e.g. plant operation, transport of radioactive material, fuel handling, waste storage. Examples include: breaches of technical specifications or transport regulations, incidents without direct safety consequences that reveal inadequacies in the organisational system or safety culture, minor defects in pipework beyond the expectations of the surveillance programme.	
DEVIATIONS 0 BELOW SCALE	• Deviations where operational limits and conditions are not exceeded and which are properly managed in accordance with adequate procedures. Examples include: a single random failure in a redundant system discovered during periodic inspections or tests, a planned reactor trip proceeding normally, spurious initiation of protection systems without significant consequences, leakages within the operational limits, minor spreads of contamination within controlled areas without wider implications for safety culture.	NO SAFETY SIGNIFICANCE

* *The doses are expressed in terms of effective dose equivalent (whole dose body). Those criteria where appropriate can also be expressed in terms of corresponding annual effluent discharge limits authorized by National authorities.*

99-00305/FS-05

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Annexure 3

Effects of a Nuclear Explosion

The effects of a nuclear explosion depend upon the yield and type weapon, height of burst (ground, air, upper atmosphere or water), location of burst (ground zero), time of burst and wind conditions at various heights. The explosion energy is transferred in the surrounding medium in three distinct forms; **blast**, **thermal** and **nuclear radiations**. Broadly, for a 20 kT fission device exploded at a height of 180m or higher above the ground, the distribution of the energy released in the form of blast, thermal and nuclear radiations (both prompt and delayed) are 50%, 35% and 15%, respectively.

Blast Effect

A sudden burst of a large amount of energy causes very high temperature and pressure in the surrounding air, resulting in extremely hot and compressed gases. The hot and compressed air expands and rises rapidly initiating a powerful blast wave or shock wave in other medium like water or earth (in case of underwater or underground explosion), causing widespread destruction of property or rupture of ear drums. This is accompanied by a hurricane type, very strong wind (resulting from the strong negative pressure cycle), causing further damage, including picking up people or vehicles and hurling them into any other object.

Thermal Effect

The extreme high temperature of the air causes intense **flash of light** accompanied by a powerful pulse of heat (thermal) radiation, sufficient to set fire and cause third degree burns up to a distance of few kilometres, depending upon the yield. Finally, it results in a firestorm due to the availability of more and more combustible materials.

Initial Nuclear Radiations

The nuclear explosion is accompanied by an intense pulse of highly penetrating ionising radiations called ‘initial radiation’ that is capable of delivering a lethal radiation dose to the people but in a region which might already be devastated due to the thermal and blast wave. Generally, the initial nuclear radiation refers to the radiations emitted in the initial one minute after the explosion.

Radioactive Fallout

Finally, the residual radioactive substance which might be either in the form of gases or may get attached to the dust particles, sucked up from the earth by the rising fire ball (if it touches the ground, depending upon the height of burst) will come down slowly and will contaminate a very large area-up to several tens or hundreds of kilometers—depending upon yield, height of burst and weather conditions. This fallout pf radioactive material will have its effect on the people and the environment for years to come. The fallout may be greatly reduced, if the explosion occurs in the air at an altitude greater than a height called the ‘optimum height’.

Annexure 3 contd.

Electro-Magnetic Pulse (EMP)

The ionising radiations, while passing through the air, produce a large number of free electrons and residual ions. The concentration of electrons at high altitudes can seriously disturb the propagation of radio waves, thereby disturbing the communication over a large area, depending upon the height of burst. The movement of these electrons (causing electric current) will be affected by the earth's magnetic field causing intense pulses of electromagnetic fields called EMP that is capable of damaging unprotected electronic and electrical systems including communication, command and control centres, power plants, etc., located over a very large area, causing blackouts and disruption in communication, resulting in high economic losses.

Annexure 4

1. Radiation Dose Limits

Presently the nuclear facilities, including those handling radioactive sources, are following the dose limits given by ICRP in its report, *ICRP-60*, in 1991. With minor modifications, these recommendations have been accepted by AERB and are in force in our country since 1991. The dose limits prescribed by ICRP in its report for application in occupational exposure are summarised in Table 1 below:

Table 1
Recommended Dose Limits as Given in *ICRP-60*[1]

Application	Dose Limit Occupational	Public
Effective dose	20 mSv per year averaged over defined period of 5 years [2]	1 mSv in a year
Annual equivalent dose in the i) lens of the eye	150 mSv	15 mSv
ii) skin	500 mSv	50 mSv
iii) hands and feet	500 mSv	-

Note 1: The limits apply to the sum of the relevant doses from external exposure in the specified period and the 50-year committed dose (to age 70 years for children) from intakes in the same period.

Note 2: With the further provision of ICRP that the effective dose shall not exceed 50 mSv in any single year, AERB has put a further restriction in India that the effective dose shall not exceed 30 mSv in any single year. However, all other restrictions of ICRP apply.

2. Effects of Nuclear Radiation

Health Effects

The exposure to large doses of radiation or due to deposition of radioactive material externally or internally within the body may lead to radiation injuries or radiation effects which manifest immediately or during the lifetime of an individual (such individual effects are called somatic effects) or hereditary effects, which may appear in the future generations. Immediate somatic effects could be radiation sickness, death of the individual and early or late expression of damages in radiosensitive organs. Such effects are termed as deterministic effects (Table 2) and include haematopoietic syndrome, gastrointestinal syndrome, Central Nervous System (CNS) syndrome, pneumonitis, cataract, sterility, skin erythema, skin burns, etc. Exposure during pregnancy can result into prenatal death, neonatal death, mental retardation, childhood cancer, etc. Induction of cancer and genetic disorder in the progenies of the exposed are the two main stochastic effects, (which do not have threshold of dose as the case with the deterministic effects).

Annexure 4 contd.

Table 2
Early Effects of Radiation

Dose (Gy)	Effects
Up to 1.5	No short-term effects
1.5–2.5	Nausea and vomiting within 3–6 hours, lasting up to 24 hours. Symptoms reappear 10–14 days after irradiation and last for 4 weeks.
2.5–3.5	Nausea and vomiting within 1–6 hours, lasting for 1–2 days. Symptoms reappear 1–2 weeks after irradiation and last up to 6 weeks. Fatalities: up to 30 %.
3.5–6	Nausea and vomiting within 1–6 hours, lasting for 1–2 days. Symptoms reappear 1–4 weeks after irradiation and last up to 8 weeks. Fatalities: 30–90 % within 2–12 weeks.
6–10	Nausea and vomiting within 15–30 minutes, lasting for 2 days. Fatalities: 90–100 % within 1–6 weeks.
10–25	Nausea and vomiting within 5 –30 minutes; no latent period at higher doses. Fatalities: 100 % within 4–14 days.
>25	Immediate nausea and vomiting. Fatalities: 100 % within a day or two.

Psycho-Social Effects

Radiation exposure in a radiation accident or nuclear explosion can result in numerous psychiatric disorders in exposed individuals, depending upon the type of accident, distance of the patient from the site of accident, psychological characteristics of the patient, time elapsed after the accident, etc. Common post-disaster disorders include anxiety, Acute Organic Brain Syndrome, Post Traumatic Stress Disorder (like flashbacks, nightmares, irritability, dysfunction in normal routine, etc.), depression, numbness, acute burst of fear, panic, or aggression.

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