GUIDE NO. AERB/NRF/SG/NRE-4

GOVERNMENT OF INDIA

AERB SAFETY GUIDE

MEDICAL MANAGEMENT OF PERSONS EXPOSED IN RADIATION ACCIDENTS

ATOMIC ENERGY REGULATORY BOARD

Atomic Energy Regulatory Board

Mumbai-400094

India

December 2025

Orders for this Guide should be addressed to:

Chief Administrative Officer
Atomic Energy Regulatory Board
Niyamak Bhavan
Anushaktinagar
Mumbai-400094
India

FOREWORD

The Atomic Energy Regulatory Board (AERB) was constituted in 1983, to carry out certain regulatory and safety functions envisaged under Section 16, 17 and 23 of the Atomic Energy Act, 1962. AERB has powers to lay down Safety Standards and frame rules and regulations with regard to the regulatory and safety requirements envisaged under the Act. The Atomic Energy (Radiation Protection) Rules, 2004, provides for issue of requirements by the Competent Authority for radiation installations, sealed sources, radiation generating equipment and equipment containing radioactive sources, and transport of radioactive materials.

With a view to ensuring the protection of occupational workers, members of the public and the environment from harmful effects of ionizing radiations, AERB regulatory safety documents establish the requirements and guidances for all stages during the lifetime of nuclear and radiation facilities and transport of radioactive materials. These requirements and guidance are developed such that the radiation exposure of the public and the release of radioactive materials to the environment are controlled; the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source or any other source of radiation is limited, and the consequences of such events if they were to occur are mitigated.

The Regulatory documents apply to nuclear and radiation facilities and activities giving rise to radiation risks due to the use of radiation and radioactive sources, transport of radioactive materials and management of radioactive waste.

The hierarchy of Regulatory Documents is depicted in Fig. 1.

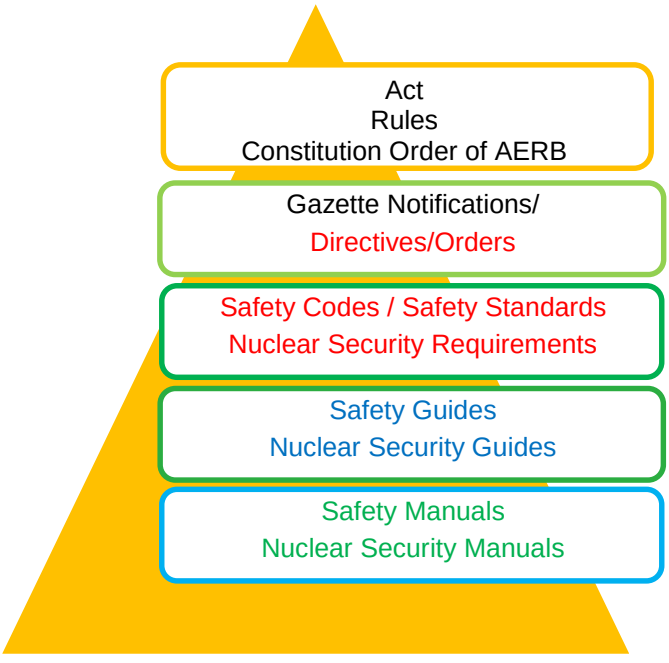


Fig. 1 Hierarchy of Regulatory Documents

Safety Codes establish the objectives and set requirements that shall be fulfilled to provide adequate assurance for safety. Safety Standards provide models and methods, approaches to achieve those requirements specified in the Safety Codes. Safety Guides elaborate various requirements specified in the Safety Codes and furnish approaches for their implementation. Safety Manuals detail instructions/safety aspects relating to a particular application.

Radiation exposure of persons above certain levels can result in radiation injuries and sometimes warrant medical management for reducing the radiological consequences. Adequate planning, appropriate infrastructure, trained multi-disciplinary staff and safety procedures are required in nuclear and radiation facilities to achieve effective medical management of persons exposed in radiation accidents.

The safety code on "Management of Nuclear and Radiological Emergencies, (AERB/NRF/SC/NRE, 2022)" lays down the requirements for medical management including first aid, treatment of radiation injuries, medical screening and triage, life stabilization, long term health monitoring through registration and psychological counselling for plant personnel within site and affected public at off-site shall be made by the licensee and local authority, respectively. This safety guide is one of the series of guides, under the safety code (AERB/NRF/SC/NRE, 2022) to describe and elaborate specific parts of the safety code. The Unique Identification Number (UIN) of this safety guide is changed from AERB/SG/MED-1 to AERB/NRF/SG/NRE-4.

This safety guide provides guidance to employer/licensee, health professionals and radiation safety personnel involved in medical management of persons exposed to radiation accidents. The safety guide provides broader guidance for external assistance/support for transportation of injured/contaminated persons in radiation accidents in nuclear facilities and radiation facilities. However, for detailed guidance, the AERB Safety Guide on "Management of Nuclear and Radiological Emergencies in Nuclear Facilities, (AERB/NF/SG/NRE-1)" and AERB safety guide on "Management of Radiological Emergencies in Radiation Facilities, (AERB/SG/NRE-2)" are referred.

The recommendations of international expert bodies, notably the International Commission on Radiological Protection (ICRP) and the International Atomic Energy Agency (IAEA) are taken into account while developing the AERB Regulatory safety documents.

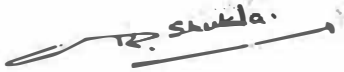
The principal users of AERB regulatory safety documents are the applicants, licensees, and other associated persons in nuclear and radiation facilities including members of the public. The AERB regulatory safety documents are applicable, as relevant, throughout the entire lifetime of the nuclear and radiation facilities and associated activities. The AERB regulatory safety documents also form the basis for AERB's core activities of regulation such as safety review and assessment, regulatory inspections and enforcement.

This safety guide is effective from the date of issue and supersedes the earlier safety guide on "Medical Management of Persons Exposed in Radiation Accidents. (AERB/SG/MED-1, 1990)" and earlier safety manual on "Handbook for Medical Management for Persons Exposed in Radiation Accidents," (AERB/SM/MED-2, 1989).

Safety related terms used in this safety guide are to be understood as defined in the AERB Safety Glossary (AERB/GLO, Rev.1, 2023). The special terms which are specific to this safety guide are included under section on 'Special Terms and Interpretation'. In addition, the terms already defined in AERB Safety Glossary AERB/GLO, Rev.1, and being used in this safety guide with a specific context that requires interpretation or explanation are also included in this section.

Appendix is an integral part of the document, whereas references and bibliography are included to provide further information on the subject that might be helpful to the user(s). For aspects not covered in this safety guide, applicable and acceptable National and International codes and standards shall be followed. Industrial safety shall be assured through good engineering practices and by complying with relevant industrial safety requirements under prevailing statutes.

This safety guide has been prepared by Task Group involving experts/specialists in the field, including medical professionals, drawn from technical support organisations and institutions. The Comments obtained from all the major stake holders have been suitably incorporated. The safety guide has been vetted by the AERB Advisory Committee on Nuclear and Radiation Safety (ACNRS). AERB wishes to thank all individuals and organizations who have contributed to the preparation, review and finalization of the safety guide.



(Dinesh Kumar Shukla)
Chairman, AERB

SPECIAL TERMS AND INTERPRETATIONS

Decorporation[1]

The action of the biological processes by means of which incorporated radionuclides are removed from the human body. Decorporation may be promoted by chemical or biological agents.

Health Professional[1]

An individual who has been formally recognized through appropriate national procedures to practise a profession related to health (e.g. medicine, dentistry, chiropractic, podiatry, nursing, medical physics, medical radiation technology, radiopharmacy, occupational health).

Mass Casualty Incident[2]

An event resulting in a number of victims, large enough to disrupt the normal course of emergency and health care services.

Radiological[3]

An adjective referring to both radiation and contamination (surface and airborne).

[1] IAEA Safety Glossary used in Nuclear Safety and and Radiation Protection 2018 Edition, pp55
[2] Management of the Dead in the Aftermath of Disasters, National Disaster Management Guidelines, Government of India, 2010.
[3] IAEA The international Nuclear and Radiological Event Scale, User's Manual, 2008

Table of Contents

1 INTRODUCTION

1.1 General

Radiation exposure to persons can occur either from an external source, external contamination with radioactive materials and/or internal contamination following intake of radionuclides. Radiation exposure to persons above certain levels can result in radiation injuries and sometimes may warrant medical management for reducing the radiological consequences. Medical management of such persons requires planning, infrastructure, trained staff and safety procedures.

1.2 Objective

The objective of this safety guide is to provide guidance to health professionals, health physicists (HPs)[1] and Radiological Safety Officers (RSOs) for medical management of persons exposed during radiation accidents. It provides guidance for the requirements of medical management specified in Safety Code 'Management of Nuclear and Radiological Emergencies' (AERB/NRF/SC/NRE, 2022) [1]. It also elaborates the roles and responsibilities of the employer/licensee of nuclear and radiation facilities for handling of exposed persons requiring medical management.

1.3 Scope

This safety guide is applicable for medical management of persons associated with nuclear and radiation facilities in case of accidental radiation exposure having potential for adverse radiological consequences or radiation injuries. This safety guide provides guidance for collection of information about radiation incident(s) and actions to be initiated for medical management of persons exposed to radiation including nuclear or radiological emergencies.

This safety guide also provides guidance for the typical infrastructural arrangement needed for handling persons with radiation injuries and safety aspects to be followed during medical management of exposed persons.

Medical (clinical) treatment per se of the exposed persons is beyond the scope of this safety guide. This safety guide does not provide guidance for medical management of radiation injuries to the members of the public and handling of mass casualties. The NDMA Manual 'Medical Management of Nuclear and Radiological Emergencies' [2] should be referred for handling such situations.

Assessment of radiation dose to the affected persons is a part of the medical management. However, this safety guide does not address the dose assessment methodologies, procedures and dosimetric techniques. Applicable documents, methodologies and procedures [3, 4] should be referred for the purpose.

[1] Health physicists working in Department of Atomic Energy (DAE).

2 HEALTH EFFECTS OF IONIZING RADIATION

2.1 General

Ionizing radiation has applications in various sectors, including medicine, industry, agriculture and research. Moreover, nuclear energy is harnessed to generate electricity. In applications of ionizing radiation and nuclear energy, there is a likelihood of persons getting accidentally exposed to ionizing radiation due to improper handling or misuse of radiation source(s). Some of these exposures may lead to manifestation of clinical symptoms in exposed persons. Knowledge of health effects of ionizing radiation will therefore be useful in identification of radiation injuries and their medical management. This chapter outlines the radiation exposures and radiation effects of ionizing radiation.

2.2 Radiation Exposures

Radiation exposures are described as below:

2.2.1 External Exposure

External exposure occurs when a partial or full body of persons gets exposed to penetrating radiation from an external source. Localized exposures can occur when radioactive sources are without shielding, partially shielded or contacted directly, such as being kept very close to the body or touched by hands. In contrast, whole body exposure with more or less uniform dose distribution can occur if a person is relatively far away from the source and/or the size of the source is commensurate with the person's body size. The medical management and prognosis of persons exposed to high dose (> 1 Gy, acute exposure) of external radiation depends upon whether the exposure is localized or uniform across the body.

2.2.2 Radioactive Contamination

Radioactive contamination is the presence of radioactive material either in the form of suspended particulate matter or liquid or aerosols on or in the body of a person. A contaminated person is a source of radiation to oneself and to others in the vicinity and has the potential to spread the contamination. Usually, radioactive contamination is not immediately threatening to life and its effects, among others, will depend upon the biokinetics, type and energy of radiation. Radioactive contamination is of two types (a) external and (b) internal.

Alpha particles being heavy and positively charged, ionize matter densely and do not penetrate much. Beta particles are basically electrons emitted from the nucleus with limited penetration capability and transfer energy in a short range. X-rays and gamma rays are ionizing radiation, having no mass and charge. They can penetrate deep into the body tissues and deep-seated organs. Also, conversion electrons and Auger electrons likely to accompany gammas and X-rays, have limited penetration capability and transfer energy in a short range.

(a) External Contamination

External contamination occurs when radioactive material in the form of dust, solid particles, aerosols or liquid, gets attached to a person's skin, hands or clothes. Presence of radioactive contamination can cause irradiation of the skin and underlying tissues and subsequently has the potential for entry inside the body. The possibility is high if integrity of the skin is lost due to wounds, abrasions, chemicals or ageing of the person.

(b) Internal Contamination

Internal contamination occurs when a person inhales or ingests radioactive materials, or when radioactive materials enter the body through an open wound or injection (due to accidental piercing by a sharp object) or absorbed through the skin. Over time, radioactive material is mostly eliminated from the body through sweat, urine and faeces depending on the type of radionuclides and their physical and biological half-lives.

2.3 Radiation Effects

Ionizing radiation can cause damage to the cells in an exposed person. Subsequently, cells respond to the damage with following possible consequences:

a) Cells completely repair themselves;
b) In the case of misrepair of damage, cells might mutate, which may cause stochastic effects; and
c) If the damage is too severe, the cells may die. The death of a large fraction of cells in tissues may lead to severe stress. In such a situation, they express clinically observable symptoms known as deterministic effects or tissue reactions.

2.3.1 Stochastic Effects

Stochastic effects are late effects caused due to modification of cells by radiation. These effects include somatic effects (induction of cancer) or hereditary effects. Probability of stochastic effects increases with the radiation dose.

2.3.2 Tissue Reactions (Deterministic effects)

Radiation exposure beyond a certain threshold dose to human tissues or organ can lead to killing of large numbers of cells enough to impair the function of the exposed tissues or organ. These effects are called tissue reactions or deterministic effects. They are clinically observable in an exposed person in the form of skin erythema (reddening of skin), epilation (loss of hair), radiation sickness and acute radiation syndromes (ARS) viz. Hematopoietic/gastro-intestinal/cardiovascular syndromes/ Central Nervous System (CNS). Severity of these reactions/effects increases with radiation dose. Deterministic effects are associated with respective threshold doses. The threshold dose may vary with dose as well as rate of dose delivery.

The acute radiation syndromes (ARS) occur after a whole-body or significant partial-body irradiation greater than 1 Gy of acute exposure. The actively multiplying cells such as hematopoietic and intestinal crypt cells are most sensitive

to radiation. The inherent sensitivity of these cells results in a constellation of clinical syndromes that predominate within a predictable range of doses of whole-body or significant partial-body exposure. Clinical components of ARS include the hematopoietic, gastrointestinal and cardiovascular syndromes.

The major ARS are given in Table 2.1:

Table 2.1 —Acute Radiation Syndromes along with four stages [6]

Syndrome	Dose[1]	Prodromal Stage	Latent Stage	Manifest Illness Stage	Recovery
Hematopoietic (Bone marrow)	>0.7 Gy [mild symptoms may occur at as low as 0.3 Gy]	• Symptoms are anorexia, nausea and vomiting. • Onset occurs 1h to 2d after exposure. • Stage lasts for minutes to days.	• Stem cells in bone marrow are dying, although person may appear and feel well. • Stage lasts 1 to 6 weeks.	• Symptoms are anorexia, fever and malaise. • Drop in all blood cell counts occurs for several weeks. • Primary cause of death is infection and hemorrhage. • Survival decreases with increasing dose. • Most deaths occur within two months.	• In most cases, bone-marrow cells will begin to repopulate. Full recovery for a large percentage of persons from a few weeks up to 2 years. • Death may occur in some persons at 1.2 Gy. • $LD_{50/60}$[2] is ~2.5 to 5 Gy.
Gastrointestinal (GI)	>10 Gy [some symptoms may occur at as low as 6 Gy]	• Symptoms are anorexia, severe nausea, vomiting, cramps, and diarrhea. • Onset occurs within a few hours after exposure. • Stage lasts ~2 d.	• Stem cells in bone marrow and cells lining GI tract are dying. • Stage lasts <1 week.	• Symptoms are malaise, anorexia, severe diarrhea, fever, dehydration, and electrolyte imbalance. • Death is due to infection, dehydration, and electrolyte imbalance.	• LD_{100}[3] is ~10 Gy

[1] The absorbed dose quoted here are "gamma equivalent" values. Neutrons or protons generally produce the same effect as gamma, beta or x-rays but at lower doses. If the person has to be exposed to neutrons or protons consult RSO/HP on how to interpret the dose.

[2] The $LD_{50/60}$ is the dose necessary to kill 50 % of the exposed population in 60 days.

[3] The LD_{100} is the dose necessary to kill 100% of he exposed population.

				• Death occurs within 2 weeks.	
Cardiovascular (CV) / Central Nervous System (CNS)	>50 Gy [some symptoms may occur at as low as 20 Gy]	• Symptoms are extreme nervousness and confusion, easy fatigability, severe nausea, vomiting and watery diarrhea, loss of consciousness and burning sensations to skin. • Onset occurs within minutes of exposure, stage lasts for minutes to hours.	• Person may return to partial functionality (level of consciousness). • Stage may last for hours but often is less.	• Symptoms are return of watery diarrhea, convulsions and coma. • Onset occurs 5 to 6 h after exposure. • Death occurs within 3 d.	• No recovery is expected.

3 ORGANIZATIONAL ARRANGEMENT FOR MEDICAL MANAGEMENT

3.1 General

The employer/licensee of the facility is responsible for medical management of persons exposed to radiation within the facility. This chapter outlines the organizational arrangement for medical management of persons exposed to radiation.

3.2 Responsibilities of Employee/Licensee of the Facility

The employer/licensee of nuclear and radiation facility should facilitate medical management to persons in the case of radiation injuries or radiation exposure having the potential of causing injuries. The arrangement for medical management for nuclear and radiation facilities includes a Decontamination Kit, First Aid Post, Decontamination Centre and Hospital for handling/treatment of radiation injuries. These arrangement should be established taking into account the hazard potential of the facility and its size.

The employer/licensee should have standard operating procedures (SOP) for handling of exposed/contaminated persons. The event causing radiation exposure to the persons should be investigated and adequate information should be provided to the health professional to facilitate handling of exposed persons. The employer/licensee should maintain the documents/records and also report to AERB and other relevant authorities as appropriate, with respect to radiological event and radiation exposure cases. The format for event reporting to AERB is included in Appendix-A.

3.3 Arrangement for Medical Management at Nuclear Facility

The licensee of nuclear facility should make provisions for medical management including First Aid Post, Decontamination Centre and Site Hospital for medical screening, treatment of radiation injuries, long term health monitoring and psychological counselling. The list of typical materials and equipment to be made available for contamination assessment and decontamination is included in Appendix - B.

In the absence of Site Hospital, the licensee should identify a hospital capable of treating radiation injuries located near the facility. All these aspects should be addressed in the SOP for handling exposed persons.

For transportation of injured or contaminated persons requiring immediate medical care, licensee of the facility should make arrangement for their transportation to the site hospital/identified hospital for treatment. The transportation of injured/contaminated persons should be carried out as per the standard procedures. Further details on external assistance/support for transportation of injured/contaminated persons are provided in AERB safety guide on “Management

of Nuclear and Radiological Emergencies in Nuclear Facilities, (AERB/NF/SG/NRE-1)" [5].

3.3.1 First-Aid Post

First- aid Post should be attached to the facility and it should have separate shower cubicles, a wash basin supplied with cold and hot water and a hand dryer. First-aid should be provided in the case of conventional injury and/or contamination of a person.

3.3.2 Decontamination Centre

The Decontamination Centre should be set up on-site at the nuclear facility and/or should be the part of site hospital. It should be equipped to receive and treat persons with persistent external or internal contamination. It should be self-sufficient in terms of carrying out minor surgery and other life-saving procedures. The licensee should ensure availability of medical doctors, nursing staff and health physicist at the Decontamination Centre, as and when need arises. The Decontamination Centre should have equipment/facility to wash both ambulatory and stretcher bound injured persons and provision for collection and management of generated radioactive waste.

3.3.3 Site Hospital

The site hospital should have arrangements for First-aid, triage, decontamination/ decorporation, sample collection, radiological dose (external/internal) assessment and provision for treatment of exposed persons. All the staff involved in medical management should be trained to handle exposed persons. The training topics for the medical doctors and paramedical staff for handling exposed persons are listed in Appendix-C.

The Medical Superintendent of site hospital should be responsible for medical management of persons exposed to radiation. He/she should have standard operating procedures (SOP) for handling of exposed and/or contaminated persons. He/she should also have the details of a nearby specialized hospital capable of treating radiation injuries.

The Medical Superintendent should be responsible for the following:

a) Making arrangements for availability of staff such as physician(s), surgeon(s), paramedical staff, transport staff etc.
b) Procuring and maintaining a stockpile of prophylactics and decontaminating agents.
c) Providing personnel monitoring devices (thermo-luminescence dosimeter (TLD) and direct reading dosimeters (DRDs), respirators, personal protective equipment (PPE) and protective clothing to the staff involved in medical management.
d) Maintaining dose records of medical staff handling exposed persons.

e) Managing contaminated and/or exposed persons at Hospital.
f) Providing emergency treatment to persons, if required.
g) Arranging services of medical specialist(s) and health physicist(s), internal dosimetry and bio-dosimetry personnel for radiological dose assessment.
h) Taking decisions in consultation with RSOs/HPs and referring the persons to the specialized Hospital, if required.
i) Providing periodic training to medical doctors, nurses and other paramedical staff for handling persons contaminated/exposed to radiation.
j) Maintaining documents/records of exposed persons including treatment, discharge and follow-up.

3.4 Arrangement of Medical Management at Radiation Facility

For radiation facilities handling unsealed radioactive sources of MBq order and above, licensee should have a Decontamination Kit in the premises handling unsealed radioactive sources. The licensee of a radiation facility should initiate following actions with the help of RSO [3, 4] in the case of events which cause radioactive contamination, external exposure and/or radiation injuries to persons. Further details on external assistance/support for transportation of injured/contaminated persons are provided in AERB safety guide on "Medical Management of Radiological Emergency in Radiation Facilities (AERB/SG/ NRE-2) [7].

3.4.1 Radioactive Contamination

For handling persons affected with radioactive contamination, the licensee should initiate following actions with the help of RSO [3]:

a) Assess external radiation and contamination levels at 10 cm from the skin surface using radiation survey meter and contamination monitor.
b) No action is required if measured radiation levels are comparable with natural background level and contamination levels are less than 10 $Bq.cm^{-2}$ for alpha and 100 $Bq.cm^{-2}$ for beta /gamma radiation.
c) Arrange gentle wash of contaminated area with soap and lukewarm water, if recorded contamination levels are greater than 10 $Bq.cm^{-2}$ for alpha and 100 $Bq.cm^{-2}$ for beta/gamma radiation. Decontamination steps should be discontinued if radiation levels fall below the levels as mentioned in (b). If radiation levels cannot be reduced further or if skin irritation is evident, refer such cases to a medical doctor and arrange medical management based on medical advice. Further guidance regarding external decontamination is mentioned in Appendix-D.
d) It is advisable to follow the procedure as mentioned in (c) if measured contamination levels are greater than 100 $Bq.cm^{-2}$ for alpha and 1000 $Bq.cm^{-2}$ for beta/gamma radiation or beta/gamma radiation level is greater than 0.2 μSv/h.
e) It is required to follow the procedure as mentioned in (c) if measured

contamination levels are greater than 1000Bq.cm^{-2} for alpha and 10,000Bq.cm^{-2} for beta/gamma radiation or beta/gamma radiation level is greater than 2 μSv/h.

Assessment of internal contamination and action plan for internal decontamination are mentioned in 4.2.3 and Appendix-D respectively.

3.4.2 External Radiation Exposure and Injuries

For handling persons affected with external radiation exposure and radiation injuries, licensee should initiate following actions:

a) If affected persons show symptoms such as nausea, vomiting, diarrhea, skin burn, erythema, blisters etc., arrange for blood tests and initiate bio-dosimetry tests from an accredited laboratory.
b) Arrange medical management, based on the advice of the medical doctor, who is reviewing blood test reports and/or bio-dosimetry reports. The medical doctor may consult with radiation oncologist(s), nuclear medicine physician(s) and medical physicist(s) for such cases as they are familiar with radiation effects.

Further guidance for management of radiation injuries is given in Table 4.2.

4 MEDICAL MANAGEMENT OF EXPOSED PERSONS

4.1 General

The aim of medical management is to minimise undesirable radiological impact and reduce the potential for deterministic and stochastic effects in exposed persons. This chapter outlines medical management of persons exposed to radiation. However, this chapter does not address medical (clinical) treatment per se of the exposed persons.

Following steps are involved in handling of exposed persons:

- Assessment of the condition of exposed persons
- Medical management
- Follow-up and care

4.2 Assessment of the Conditions of Exposed Persons

Examination and assessment of the condition of exposed persons includes the identification of their life-threatening injuries/conditions, their stabilization and providing them appropriate medical care. This would also help in identification of their other injuries, nature and type (external/ internal) of exposure, contamination levels and evidence of psychological distress, if any. The exposed persons should be monitored for external radioactive contamination and requested to provide relevant information for assessment of external radiation exposure. Person with external radioactive contamination should be decontaminated before proceeding for internal contamination assessment. The assessment of the condition of exposed persons should consider the following:

4.2.1 Signs and Symptoms of External Radiation Exposure and Injuries

The severity of signs and symptoms of radiation exposure depends on the amount of radiation received by the exposed persons. Signs and symptoms depend on the type of exposure- such as total or partial body exposure. The most common early symptoms of high radiation exposure are nausea, vomiting and diarrhoea. The early symptoms may start within minutes of exposure, but may keep recurring for several days. The exposed persons may also show skin changes such as transient erythema (reddening of skin), blisters or sores in the case of high external exposure. The time interval between exposure and manifestation of symptoms provides evidence to the severity of radiation injury.

4.2.2 External Contamination

The external contamination assessment of affected persons should be carried out to assess the radiation injury to skin and underlying tissues by measuring external radiation levels and contamination levels at 10 cm from skin surface using radiation survey meter and contamination monitor. It would help in deciding upon the treatment and decontamination. The contamination assessment should be carried out by RSO/Health Physicist. The skin contamination intervention levels as

mentioned in Table 4.1 should be followed for deciding upon subsequent handling and treatment of affected persons. Action plan for external decontamination is mentioned in Appendix-D.

In case of a nuclear facility, affected persons may be referred to site hospital for medical triage, decontamination and treatment depending on the contamination levels and severity of injury.

Table 4.1—Skin contamination intervention levels [3]

Alpha ($Bq.cm^{-2}$)	Beta/ Gamma ($Bq.cm^{-2}$)	Beta/Gamma radiation level(low background area)[1]($\mu Sv.h^{-1}$)	Actions[2]
<10	<100	Not detectable	• No action required • allow release
>10	>100	Not detectable	Intervention optional • Decontaminate or advise to shower and wash clothing.
>100	>1000	> 0.2	Intervention advisable • Prevent inadvertent ingestion and inhalation, limit spread of contamination and decontaminate.
>1,000	>10,000	> 2	Intervention required • Prevent inadvertent ingestion and inhalation, limit spread of contamination and decontaminate.

4.2.3 Internal Contamination

It includes identification of radionuclide(s), assessing their quantities with bioassay procedures, evaluation of intake and radiation dose of persons. Samples such as blood, urine, faeces, nasal swabs, filter paper etc. of affected persons should be collected for analysis. After assessment of internal contamination, affected persons should be referred to Site Hospital for decorporation and treatment. Medical treatment for decorporation for adults should not be a consideration when the estimated internal doses are below 20 mSv. When the internal dose is likely to be between 20 and 200 mSv, medical doctor in consultation with RSO/Health Physicist should decide the treatment for decorporation. When estimated dose exceeds 200 mSv then extended or protracted treatment should be implemented depending on

[1] Ambient dose equivalent rate measured at 10 cm from skin surface.

[2] Discharge/release the persons if the contamination level falls below 10 Bq/cm^2 for alpha and 100 Bq/cm^2 for beta. Decontamination steps should be discontinued if radiation level cannot be further reduced or if skin irritation is evident and such cases should be referred to a medical doctor.

the severity of radiation injury/effect [8, 9 and 10]. Medical decorporation for children and pregnant women should be implemented at one-fifth level of the adult value [2].

4.3 Medical Management

The medical management includes evaluation of persons' general condition, injuries, burns and other radiation effects. It determines the treatment priorities according to severity of each of these and implementation of appropriate treatment. It evaluates treatment efficacy and clinical follow-up plan. It includes the following steps:

- Medical triage
- Medical treatment
- Long term medical follow-up and care
- Psychological support

4.3.1 Medical Triage

Triage refers to the sorting of persons into classes on the basis of their injury and/or conditions, for the purpose of expediting clinical care and maximizing the use of available clinical services and facilities. The objective of triage is to segregate the affected persons into (a) those who require immediate care and urgent attention, (b) those who need medical care but can wait and (c) those who do not require extensive medical care and can be discharged without being admitted to the hospital. Triage should be conducted based on conventional, medical and surgical considerations. Life threatening injuries, comorbid medical/surgical conditions requiring priority attention should be addressed first. Following medical triage and stabilization, radiological assessment should be performed. Table 4.2 mentions the actions to be initiated in the case of external exposure management. Action plan for Personnel Decontamination is provided in Appendix-D.

For externally exposed persons without trauma, persons who had received a high dose can be differentiated from those with a dose < 1Gy using two criteria – (a) Neutrophil / Lymphocyte [N/L] ratio; and (b) Whether Emesis [E] (vomiting), has occurred.

A Triage Score - "T" is assigned as follows:

$$T = (N / L) + E$$

Where E = 0 if no emesis,
E = 2 if emesis has occurred.

In a normal healthy human population, N/L ratio from a complete blood count [CBC] with differential has been found to be approximately 2.1.

Table 4.2: Radiation symptoms following whole body exposure at various dose levels and suggested actions [11]

Symptom	Dose (Gy)	Suggested Actions
Nausea but no vomiting	< 1	Outpatient with 5-weeks surveillance period
Vomiting in 2-3 h after exposure	1 - 2	Surveillance in a Site Hospital (or outpatient for 3 weeks followed by hospitalization, if necessary).
Vomiting in 1-2 h after exposure	2 – 4	Hospitalization in a haematological or surgical (burns) department of a Site Hospital.
Vomiting earlier than 1 h after exposure and/or other severe symptoms	> 4	Hospitalization in a well-equipped haematological or surgical department of a Site Hospital OR Transfer to a specialized hospital for handling radiation injuries.

4.3.2 Medical Treatment

Radiation injury is suspected when persons are exposed to radiation and/or develop symptoms of illness or skin redness or sores after being exposed during a radiation incident. Medical doctors should assess the condition of exposed persons based on symptoms and available information. Based on triage and outcome of assessment, treatment of exposed persons should be performed. The treatment for radiation injuries generally considers the following:

- Treatment of serious and life-threatening injuries
- Decontamination of wounds, skin, and hair
- Treatment of internal contamination/ decorporation
- Treatment of compromised immune system/supportive care
- Psychological support

4.3.3 Long Term Medical Follow-up and Care

Medical follow-up and care should be undertaken for persons who have undergone decorporation therapy and treatment for ARS or as recommended by the medical doctor. Follow-up may also be needed for late deterministic effects, epidemiology and psychological conditions. The nature and extent of this follow-up is case-specific, depending on the exposure, radionuclide, mode and magnitude of intake and nature of treatment.

4.3.4 Psychological Support

Exposed persons may experience feelings such as intense fear and anxiety, helplessness, sadness etc. Medical doctors involved in treating such persons should give counselling and relevant information to exposed persons as well as their family members to reassure them and reduce fears and anxiety. Persons requiring long term counselling should be identified and followed-up. Psychological support should also

be provided for personnel involved in medical management of exposed persons, if needed. Persons who are not exposed to clinically significant doses, may also approach health professionals/medical doctors for assessment. These persons should also be assessed and reassured and counselled to restore their confidence.

4.3.5 Handling of Contaminated Decedents (Hospital and Mortuary)

In the event of death of contaminated/exposed person(s) due to any reason, there should be provision for safely managing the decedent body. The licensee and RSO of the facility should instruct and assist the medical and mortuary personnel as well as family members for taking protective measures to avoid undesirable exposure while handling contaminated decedents.

Following aspects should be considered in such situations:

a) In case, the decedent is known or suspected to have been contaminated/struck with radioactive shrapnel, dose-rate measurements, contamination levels etc. should be performed by the RSO prior to beginning an autopsy and records should be maintained.
b) A tag or note should be attached indicating the contamination level of decedent.
c) Materials used for decontamination should be safely managed as radioactive waste.
d) The radioactive source/contaminated organ removed from the body of decedent should be placed in a shielded container and safely managed as radioactive waste.
e) The disposal of decedents having radioactivity content or radiation field should be decided on a case-to-case basis in consultation with concerned government authorities and responsible family members.

5 CONTAMINATION CONTROL DURING MEDICAL MANAGEMENT

5.1 General

The medical and paramedical staff dealing with medical management of persons affected by radiation injuries and/or radioactive contamination should follow appropriate work practices and procedures to reduce the spread of contamination. This chapter outlines the guidance to be followed by medical and paramedical staff for minimizing spread of contamination from exposed persons to staff and facilities.

5.2 Controlling Spread of Contamination

Medical and paramedical staff should always follow universal precautions and refrain from smoking, eating and drinking while attending exposed persons. Medical and paramedical staff should follow the steps given below to control and avoid spread of radioactive contamination:

a) Remove watches, jewellery etc. while handling contaminated persons.
b) Wear surgical scrub suits, surgical caps and gowns, eye shields and rubber gloves.
c) Wear plastic or rubber laboratory aprons while performing decontamination with water.
d) Use respiratory protection and personal dosimeters (TLD badges or pocket dosimeters).
e) Cover the floor(s) with impervious disposable covering.
f) Establish boundaries by using tapes between contaminated and clean areas (area free from contamination).
g) Turn-off air conditioning and forced-air systems to prevent radioactive dust or aerosols from being carried into ducts or to other rooms.
h) Move stretchers and gurneys along the contamination control corridor, whenever possible.
i) Remove exposed persons clothing carefully (this may generally remove 80 to 90 % of contamination).
j) Shift the exposed persons to clean areas after decontamination and survey.
k) Restrict the entry of all non-essential personnel, family, visitors etc.
l) Use contamination-free equipment for medical management of exposed persons.
m) Place all contaminated clothing including those of exposed persons into properly labelled plastic bags.
n) Use labelled containers for collection, storage and disposal of contaminated materials.
o) Take care while removing own personal protective equipment (PPE) to avoid contamination and place all clothing including PPE into properly labelled plastic bags.
p) Get surveyed for personal contamination before entering the clean area.
q) Get the area surveyed and decontaminated, if required.
r) Get the ventilation restored.

6 RADIOACTIVE WASTE MANAGEMENT

6.1 General

Medical management of contaminated persons may generate radioactive solid and liquid wastes. Generation of radioactive gaseous waste during medical management is likely to be negligible. Ventilation system of Site Hospital should be designed to prevent the spread of contamination and adequate enough to exhaust the contaminated air through roof top of the building. Characteristics of waste generated from medical management depend on the nature of accident and type of radionuclide involved. It may be of short-lived radionuclides like ^{131}I, ^{32}P or long-lived radionuclides like ^{239}Pu, ^{241}Am etc. Consideration of non-radiological hazards associated with the pathogenic/biomedical aspects of waste should also be taken into account during waste management. This chapter outlines the guidance for management of solid and liquid waste generated during medical management of exposed persons.

Further, guidance regarding radioactive waste management arising from the use of radionuclides is addressed in safety guide (No. AERB/RF/SG/RW-6) [12].

6.2 Solid Waste Management

Solid waste generated from medical management of contaminated persons includes assorted waste like contaminated clothing, shoe covers, mops, paper, plastic, human excretion and contaminated decedent, etc. The waste should be collected in a suitable container/system and stored in a designated storage area after monitoring and tagging. The waste storage area should have adequate ventilation, provision for decontamination and system to avoid/minimise biodegradation of stored waste.

6.3 Liquid Waste Management

Liquid waste generated from medical management of exposed persons generally includes decontamination liquid, showers, urine etc. The liquid waste should be collected in designated tanks/containers. The tanks should have adequate capacity and provisions for level monitoring, sampling and pumping out or transfer.

7 RECORDS AND DOCUMENTATION

7.1 General

Records and documents pertaining to radiological accidents and medical management of persons include records of information of affected persons, their radiological assessment, medical treatment and follow-up action(s). These records are important for treatment follow-up and/or epidemiological studies as well as for medico-legal cases, if any. This chapter outlines records and documents pertaining to medical management of affected persons in radiation accidents.

In the case of public domain, records and documents pertaining to radiological incident(s) and medical management of the public should be maintained by the state/local authorities according to NDMA Manual [2]. In case of nuclear and radiation facility, related documents pertaining to radiological accident(s) and medical management of all persons should be retained by the licensee of facility until thirty years post completion of treatment of persons (Mandatory), if person is alive and regular follow up is on, or death of the person [2]. Typical record format for documenting a radiological event including information of symptoms of exposed persons is mentioned in Appendix-E.

7.2 Records Maintained by Licensee

7.2.1 Records of Radiological Incident

The records of radiological incident should include:

a) location;
b) date and time;
c) brief description and
d) information of exposed persons involved.

7.3 Records of Exposed Persons

The records of exposed persons should include the following:

a) duration of radiation exposure and type of exposure (external/internal or both);
b) period of unconsciousness, if any;
c) time of onset and severity of clinical symptoms;
d) identity of contaminant;
e) route and estimated quantity of intake;
f) survey records of initial and subsequent whole or partial body contamination;
g) initial dose assessment, if performed;
h) decontamination and/or decorporation treatment;
i) details of laboratory tests;
j) bioassay and bio-dosimetry sample testing methodology, their test results; and
k) dose records of internal and/or external exposure.

APPENDIX-A – EVENT REPORT – PROMPT INFORMATION

A.1 Details of the Institute

S. No.	Institute Details	
1.	Type of Facility (Pl. tick ✓ in box)	Nuclear Facility □ Radiation Facility □
2.	Institute's Name	
3.	Institute's Address	
4.	City	
5.	State	
6.	PIN Code	
7.	Practice	
8.	Name of Licensee/ Head of Institution	
9.	Contact Number	
10.	Email Id	

A.2. Details of Radiation Incident

Sr. No.	Incident Details		
1.	Date of Incident		
2.	Time of Incident		
3.	Location of Incident		
4.	Brief description of facility (*Mention only main activities with respect to radiation sources*)		
5.	Brief description of the Incident		
6.	Immediate action taken by the licensee (in brief)		
7.	Details of affected person	Name	
		Age	
		Gender	
		UID/Emp. No.	
		Contact Number	
		Job Profile	
		Personnel Monitoring Badge Number (if, available)	
		E-mail Id	

I hereby certify that all the information submitted above are correct to the best of my knowledge and belief.

Signature:

Place: Name of Licensee:

Date: Designation:

(Seal of the Institution)

APPENDIX-B - MATERIALS AND EQUIPMENT USED FOR ASSESSMENT AND DECONTAMINATION

List of typical materials and equipment to be made available for contamination assessment and decontamination:

Category	Items
Clothing	• Coverall or surgical scrub suits or waterproof surgical gowns • Surgical gloves and plastic aprons • Disposable plastic shoe coverings • Surgical masks and caps, face shields and masking tape • Respirators
Medical equipment	• Sterile-suture sets, scissors, forceps, scalpel, haemostats, irrigation sets, applicators, dressings, bandage and duct tape • Patient gowns or coveralls & blankets • Labelled containers for collecting urine, blood, fecal samples etc. • Emesis basins
Detection equipment	• Personnel dosimeters (TLD badges and pocket dosimeters) • Portal monitors • Portable beta/gamma survey meter and alpha contamination monitor • Replacement batteries or charging units, mains power extension leads
Decontamination equipment	• Cotton applicators • Towels or disposable wipes • Large plastic bags or suitable container for collection of contaminated clothing • Soft scrub brushes and general cleansing agents • Plastic sheets, tarpaulin and sponges • Catch basin for decontamination liquids
Miscellaneous	• Adhesive labels, barrier tapes, tacky mats • Radiation warning signs, radiation tags, radiation tape for marking areas • Hair clippers, nail cutters, soap, shampoo • Bioassay sample collection bottles
External Decontamination Chemicals	• 25% Di-ethylene Tri-Amine Penta-Acetic acid (DTPA) • Soda-bicarbonate solution • 10 % Ethylene Diamine Tetra Acetic Acid (EDTA) • Lugol's solution • Acetic acid (pH 4-5) or vinegar • 4% Xylocaine jelly
Internal Decontamination Chemicals	• Potassium Iodide/ Iodate tablets • Nebulizer • Ca DTPA / Zn DTPA ampoules • Colloidal Prussian Blue or Cap Radiogardase • Aluminium hydroxide gel Antacids

	• Sodium bicarbonate ampoules • Magnesium sulphate / Barium sulphate • Strontium lactate / Strontium Gluconate /Calcium Gluconate • Ammonium chloride • Dimercaprol • Furosemide • Normal Saline 5% Dextrose
Communication systems	• Mobile phones, telephone, audio system

APPENDIX-C- TRAINING TOPICS FOR HEALTH PROFESSIONALS

Training topics for medical and paramedical personnel involved in handling exposed persons include the following:

a) radiation fundamentals (types and properties of radiation);
b) radioactivity and its measurement;
c) basic principles of radiation protection, dose limits and action levels;
d) radiation health effects;
e) use of basic radiation survey instruments and interpretation of instrument readings;
f) recognizing radiation injuries (clinical symptoms);
g) prioritizing radiological and non-radiological health concerns;
h) basic contamination controls, decontamination and allowable contamination limits;
i) psychological and social concerns that may arise among exposed persons and their families;
j) basic information convey to exposed persons regarding the health effects of radiation exposure,
k) obtaining samples from exposed persons and interpreting of monitoring results; and
l) drills and hands-on training.

APPENDIX-D- ACTION PLAN FOR PERSONNEL DECONTAMINATION

Action Plan for personnel decontamination (external/internal) is mentioned below:

D.1 Action Plan for External Decontamination

External decontamination of exposed persons should be carried out by RSO/Health Physicist and medical staff to control external contamination, reduce radiation dose to skin, dermal injuries and internal contamination.

Action plan for external decontamination is as follows:

(i) Decontaminate areas with lukewarm water and normal saline in following order: open cuts or wounds, followed by mouth & nose and then skin.
(ii) Decontaminate the body/skin with lukewarm water and mild soap and do not scrub the skin vigorously.
(iii) Avoid use of abrasive tools for decontamination purpose.
(iv) Wash the skin and irrigate wounds with following decontaminating agents for suspected/known contamination with:
    a) Plutonium and Americium: DTPA solution (1 % for intact skin, 25 % for wounds).
    b) Uranium: 1.4 % Soda-bicarbonate solution.
    c) Strontium and Radium: 10 % EDTA solution.
    d) Iodine: Lugol's solution (solution of potassium iodide with iodine in water) and then with copious amounts of water.
    e) Cobalt: 25 % DTPA solution.
    f) Tritium: copious irrigation with water.
    g) Phosphorus: 5 % acetic acid solution or simply vinegar then rinse with water.
(v) Decontaminate skin around wound(s) as thoroughly as possible before suturing or other treatment.
(vi) After dressing, monitor the wound(s) for any residual activity.
(vii) Remove material embedded in the outermost layer of skin by using sticking tape.
(viii) Resurvey to confirm decontamination efficacy.
(ix) Document the steps.

D.2 Action Plan for Internal Decontamination (Decorporation)

Internal decontamination (decorporation) should be carried out by medical staff to reduce the amounts of radionuclides in wounds and body of affected persons by taking their individual health and exposure conditions into account.

Action plan for internal decontamination is as follows:

(i) Analyses of incident related samples like filter paper and nasal swab samples of affected persons for preliminary assessment of their radiation doses.
(ii) Move potentially-contaminated persons to a non-contaminated area.
(iii) Collect and analyse urine and fecal samples in the case of inhalation and ingestion intake.

(iv) Collect and analyse urine, blood and excised wound tissues samples in the case of injection / wound injury.

(v) Label the collected biological and physical samples and ship them to the laboratory for analysis. Guidance for collection and shipping of biological and physical samples is given in Appendix-F.

(vi) Perform in-vivo monitoring (whole body and lung) and wound(s) monitoring etc.

(vii) Obtain consent for decorporation treatment as well as for wounds excision and analysis of excised wound tissues as per the existing clinical practices.

(viii) Conduct follow-up in-vivo and bio-assay monitoring to confirm decorporation efficacy.

(ix) Monitor the wound(s) before, during and after surgical debridement.

(x) Follow radionuclide specific decorporation treatment and doses as given in Tables D.1 and D.2.

(xi) Administer laxatives to hasten elimination of radionuclide from the intestine.

(xii) Consider pulmonary lavage in case of non-transportable radionuclide inhalation. This procedure should be considered only in high exposure cases in which reduction of dose can be expected to prevent acute or subacute effects such as radiation pneumonitis or fibrosis.

(xiii) Document the steps.

Table D.1: Guide for radionuclide specific decorporation treatment [2,3]

Radionuclide of	Decorporation Treatment	Caution
Americium (Am) Californium (Cf) Curium (Cm) Iridium (Ir) Neptunium (Np) Plutonium(Pu) Ruthenium (Ru) Thorium (Th) Iron (Fe) Cobalt (Co) Zirconium (Zr)	**Substance:** Ca-DTPA (Trisodium Calcium Diethylene Triamine Penta Acetate **Administration:** 1 g Ca-DTPA by the most appropriate route. Children under 12 y: 14 mg.kg^{-1} intravenous not to exceed 1 g. **Medication route:** *Intravenous infusion:* 1 g in 5 mL intravenous push over 3 to 4 min, or diluted solution in 100-250 mL 5 % dextrose in water or normal saline over 30 min. *Nebulized inhalation:* 1g in 1:1 dilution with sterile water or normal saline.	• Blood pressure should be monitored during the infusion. • Ca-DTPA is contraindicated in cases of nephrotic syndrome or bone marrow depression. • Zn-DTPA should be used if available to treat a pregnant female. • DTPA should not be used in cases of massive uranium contamination because of the risk of acute nephritis due to uranium precipitation in the kidneys. • In combined internal contamination with uranium and plutonium, first decontaminate uranium and then administer DTPA preferably after 12–16 hours for plutonium decontamination. • Minor trace elements such as manganese, magnesium and zinc may be chelated with Ca-DTPA. These should be monitored or the patient given vitamin and mineral supplements as indicated.
Polonium (Po)	**Substance:** Dimercaprol [British Anti-Lewisite (BAL)] **Administration:** 2.5 mg kg^{-1} (or less) every 4 h for 2 d, then twice daily for 1 d then daily for days 5 to 10. **Medication route:** Intramuscular injection	• Alkaline urine protects the kidneys during therapy. • Hypertension and tachycardia are common. • There may be a need for antihistamine therapy. • Dimercaprol [British Anti-Lewisite (BAL)] may cause a sterile abscess and, in some cases, peanut allergy.
Caesium (Cs) Thallium (Tl)	**Substance:** Prussian Blue (ferric hexacyanoferrate). **Administration:** 3 g Prussian Blue 3 times daily. For children (2-12 y): 1 g 3 times daily. Continue for several days.	• Essentially no contraindications. It is effective only if gastrointestinal motility is intact. Persons will experience blue-tinged stool and should be so informed**.**

	Medication route: *Oral Administration:* The capsules are to be swallowed whole with some liquid or dispersed in warm water and drunk as a solution.	
Radium (Ra) Strontium (Sr)	**Substance:** Aluminium hydroxide **Administration:** Standard dose for hyperacidity: Adults: 10 mL (1200 mg) For children (2-12 y): 50 mg kg^{-1}, not to exceed adult dose. Dose to reduce intestinal absorption: 60 to 100 mL. **Medication route:** *Oral administration*	• It can cause constipation. • Prolonged use of aluminium hydroxide may cause hypophosphatemia. • Since radium and strontium are bone seekers, blood counts should be monitored for pancytopenia.
Tritium (^3H)	**Substance:** Water **Administration:** 3-4 L per day Continue for 5 days For forced Diuresis, use injection Lasix 40 mg intravenously or more if necessary. **Medication route:** *Orally*	• Caution should be used in patients in whom there is concern for fluid overload, such as those with congestive heart failure or renal disease who could be susceptible to fluid overload.
Uranium (U)	**Substance:** Isotonic sodium bicarbonate (1.4 % $NaHCO_3$). **Administration:** 250 mL of isotonic sodium bicarbonate **Medication route:** *Intravenous infusion:* Slow intravenous transfusion. Continue over the following days according to the seriousness of contamination.	• The sodium bicarbonate solution is alkaline. • Blood pH and serum electrolytes should be monitored. A pre-existing hypokalemia may be unmasked and this treatment should be used with caution in congestive failure or in disease states with sodium retention. • The use of sodium bicarbonate risks aggravating to unmasking an existing hypokalemia. • Administration of sodium ions to persons with sodium retention should be avoided.

Table D.2: Administration of stable Iodine [13]

S. No.	Age range	Decorporation Treatment
1	All persons above the age of 12 years	170 mg (KIO_3) – as soon as possible 85 mg (KIO_3) – second and third day only; 170 mg (KIO_3) – repeat after two weeks, if required (based on assessment).
2	Pregnant women and children of age 3 to 12 years	50 % of quantities given in (1)
3	Children under the age of 3 years	25% of quantities given in (1) above.

Note: For inhalation exposure, a decision should be taken to administer stable iodine as soon as possible depending on the assessed potential and estimated quantity of radio-iodine release. Administration of stable iodine prior to intake through ingestion route is as effective as for inhalation route.

APPENDIX-E - TYPICAL RECORD FORMAT FOR DOCUMENTING A RADIOLOGICAL EVENT

E.1 Basic Information

Name of Person			
Age		UID/Emp. No.	
Office Address			
Residential Address			
Phone			
Email Id			
Gender			
Name of Employer/ Reporter			
Phone			
Email Id			
Incident Details			
Location of incident			
Date of incident		Time of incident	
Brief description of incident			
The above information is correct to the best of my knowledge and belief.		Signatures of person/ employer/reporter with date	

E.2 Exposure Details

External exposure to penetrating radiation:

Type of penetrating radiation			
Precise location and position of the person relative to the source of radiation at time of exposure			
Partial irradiation (Pl. tick ✓ in box)	Yes □ No □	Whole-body irradiation	Yes □ No □
Exact time and duration of exposure			
Details of personnel dosimeter if worn			
Whether dosimeter has been collected?			
Where is it now located?			

External skin contamination:

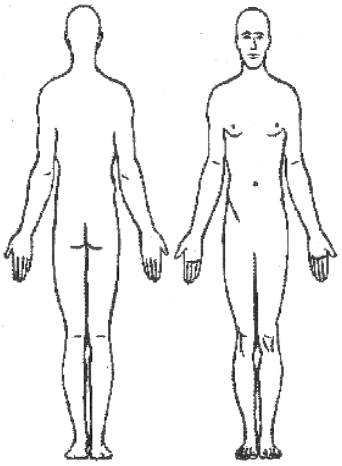
Whether skin of exposed person is contaminated? (Pl. tick ✓ in box)	Yes □ No □
Radionuclides involved	
Physico-chemical form of radionuclides	
Actions taken for decontamination	
Location, dose-rate and/or count-rate measurements	Before decontamination After decontamination

Internal radioactive contamination:

Contaminated? (Pl. tick ✓ in box)	Yes □ No □
Radionuclides involved	
Physico-chemical form of radionuclides	
Route of intake	Inhalation □ Ingestion □ Wound □ Absorption through intact skin □
Description of injury	Type (abrasions, cuts, stabs) / Site / Bleeding / Chemical or Thermal burns / any other information
Were PPE worn (before or after the incident)? What types?	

Measurements and Samples:

Give sample identification number, type, time and exact conditions of samplings and by whom samples were taken	
Physical measurements (list time of acquisition & results, as available)	External dosimeter readings: Surface measurements: Wound probe: Whole-body measurements: Thyroid measurements:
Bioassays measurements	Nasal / mouth / eye swabs:

(list time of collection, analysis & results as available)	Wound counts: Air samples: Sputum: Vomit Blood Washings from decontamination Urine Feces
Physical injuries (list here & show on figure)	
Signatures of Radiological Safety Officer (RSO)/Health Physicist (HP) with date	

E.3 Treatment Initiated:

Known allergies?	Yes □ (list) No □		
Disease and drugs taken			
Genetic disorder in family	Yes □ No □		
Viral infection, if family	Yes □ No □		
Radio-Therapy / Nuclear Medicine	Yes □ No □		
Blood Transfusion	Yes □ No □		
Describe other dosimetric studies underway			
Clinical Symptoms			
Nausea	Time of onset:	Duration:	Severity:
Vomiting	Time of onset:	Duration:	Severity:
Diarrhoea	Time of onset:	Duration:	Severity:
Headache	Time of onset:	Duration:	Severity:
Fatigue	Time of onset:	Duration:	Severity:

Possibly confounding medical measures (e.g. antiemetics)	
Sample taken	Right nostril Left nostril wound Skin urine clothing
If sample taken, give details/results	
Synopsis of actions taken and by whom.	First aid: Decontamination: Decorporation treatment:
Recommendations/ Instructions of the treating Physician	Outpatient/Follow -up
Signatures of treating Physician(s) with date	

APPENDIX-F – GUIDANCE FOR COLLECTION AND SHIPPING OF BIOLOGICAL AND PHYSICAL SAMPLES

1. Sterile specimen containers should be used for collection of urine, nasal swabs, filter paper, tissues, blood samples, nails, hair etc. of exposed persons.
2. Fecal samples should be collected directly in a plastic bag and placed inside the container.
3. After sample collection, container should be sealed and kept in freezer until shipment.
4. Blood samples for Chromosomal Aberration Analysis (CAA) should be collected in vacutainer tubes containing Lithium/Sodium heparin only. Sample should be stored in refrigerator but should not be frozen. The package containing CAA samples may be labelled "DO NOT X-RAY" while shipping.
5. Container should be labelled with exposed person's name, ID, time and date of collection.
6. Each container should be accompanied with necessary documents and referring medical doctor's contact details.
7. The outer package label should contain complete address and contact details of sender and recipient.

LIST OF ABBREVIATIONS

AERB	: Atomic Energy Regulatory Board
ARS	: Acute Radiation Syndromes
CBC	: Complete Blood Count
DC	: Decontamination Centre
DRD	: Direct Reading Dosimeter
DTPA	: Di-ethylene Tri-Amine Penta-Acetic acid
EDTA	: Ethylene Diamine Tetra Acetic Acid
NDMA	: National Disaster Management Authority
N/L	: Neutrophil / Lymphocyte ratio
PPE	: Personal Protective Equipment
RBC	: Red Blood Cells (Corpuscles)
SOP	: Standard Operating Procedure
TLD	: Thermo-Luminescent Dosimeter

REFERENCES

[1] ATOMIC ENERGY REGULATORY BOARD, Mumbai, India ’Code on Management of Nuclear and Radiological Emergencies’, No. AERB/NRF/SC/NRE, (2022)

[2] NATIONAL DISASTER MANAGEMENT AUTHORITY, GOVERNMENT OF INDIA, Manual on Medical Management of Nuclear and Radiological Emergencies, (2019)

[3] NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS, Bethesda, Maryland ‘Management of persons contaminated with radionuclides: Handbook, Report No. 161’, (2008)

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Vienna, ‘Medical Management of Radiation Injuries’, Safety Report Series No. 101, (2020)

[5] ATOMIC ENERGY REGULATORY BOARD, Mumbai, India, ‘Guide on Management of Nuclear and Radiological Emergencies in Nuclear Facilities’, No. AERB/NF/SG/NRE-1[*under preparation*]

[6] CENTRE FOR DISEASE CONROL AND PREVENTION, U.S ’Acute Radiation Syndrome: A Fact sheet for Physicians’, (2005)

[7] ATOMIC ENERGY REGULATORY BOARD, Mumbai, India, ‘Guide on Management of Nuclear and Radiological Emergencies in Radiation Facilities’, No. AERB/SG/NRE-2 [*under preparation*]

[8] Menetrier F, Berard P, Joussineau S, Stradling N, Hodgson A, List V, Morcillo MA, Paile W, Holt DCB, Eriksson T., 2007, “TIARA: Treatment Initiatives after Radiological Accidents”. *Radiation Protection Dosimetry;* 127(1–4):444–448, (2007)

[9] Youngman M. J., 2015, “Review of Methods to Measure Internal Contamination in an Emergency”. Journal of Radiological Protection, 35 (2015) R1 – R15

[10] Bhattacharyya, M.H., Breitenstein, B.D., Metivier, H., Muggenburg, B.A., Stradling, G.N., Volf, V, “Guidebook for the treatment of accidental internal radionuclide contamination of workers” Radiation Protection Dosimetry, 41(1), 1-49, (1992)

[11] INTERNATIONAL ATOMIC ENERGY AGENCY (2005b), Vienna, Generic Procedures for a Medical Response during a Nuclear or Radiological Emergency, (EPR-Medical-2005)

[12] ATOMIC ENERGY REGULATORY BOARD, Mumbai, India, ‘Guide on Management of Spent Radioactive Sources and Radioactive Waste arising from the use of Radionuclides in Medicine, Industry and Research, including decommissioning of such Facilities’, No. AERB/RF/SG/RW-6, (2007)

[13] ATOMIC ENERGY REGULATORY BOARD, Mumbai, India, ‘Guide on Criteria for Planning, Preparedness and Response for Nuclear or Radiological Emergency’, No. AERB/NRF/SG/EP-5 (Rev.1), (2014)

BIBLIOGRAPHY

1) Atomic Energy Act, 1962
2) Atomic Energy (Radiation Protection) Rules, 2004
3) Atomic Energy (Safe Disposal of Radioactive Waste) Rules, 1987
4) National Council on Radiation Protection and Measurements (2005). Key Elements of Preparing, Protecting and Equipping Emergency Responders for Nuclear and Radiological Terrorism, NCRP Commentary No. 19 (National Council on Radiation Protection and Measurements, Bethesda, Maryland).
5) Population monitoring and radionuclide decorporation following a radiological or nuclear incident, NCRP Report 166. Bethesda, MD, USA: 2010.
6) International Atomic Energy Agency, Vienna, 'Diagnosis and Treatment of Radiation Injuries, IAEA Safety Report Series No. 2, 1998.
7) International Atomic Energy Agency, Vienna 'Generic procedures for medical response during a nuclear or radiological emergency; 2005.
8) International Atomic Energy Agency, Vienna, 'Manual for First Responders to a Radiological Emergency', IAEA-EPR-First Responders, 2006.
9) International Atomic Energy Agency, Vienna, 'Criteria for Use in Preparedness and Response for a Nuclear or Radiological Emergency', IAEA/GSG-2, 2011
10) International Atomic Energy Agency (IAEA), Vienna, Communication with the Public in a Nuclear or Radiological Emergency, 2012.
11) International Atomic Energy Agency, Vienna, General Safety Requirements Part 3 (GSR Part 3), Radiation Protection and Safety of Radiation Sources: International Basic Safety Standards, 2014.
12) International Commission on Radiological Protection. Protecting People against Radiation Exposure in the Event of a Radiological Attack, ICRP Publication 96, Ann. ICRP 35(1) (Elsevier, New York) 2005.
13) International Commission on Radiological Protection. The Recommendations of the International Commission on Radiological Protection, ICRP Publication 103, Ann. ICRP 3**7**(2–3) (Elsevier, New York), 2007
14) International Commission on Radiological Protection: Application of the commission's recommendations for the protection of people in emergency exposure situations. ICRP Publication109, Ann ICRP. 2009; 39(1).
15) National Council on Radiation Protection and Measurements. Management of Terrorist Events Involving Radioactive Material, NCRP Report No. 138 (National Council on Radiation Protection and Measurements, Bethesda, Maryland) 2001.
16) Wood C.M., Depaolo F. and Whitaker D. "Guidelines for handling radioactively contaminated decedents" Health Phys. 94(5 Suppl.), S51–S55, 2008.
17) Radiation Emergency Assistance Center/Training Site (REAC/TS). The Medical Aspects of Radiation Incidents. 3. REAC/TS; Oak Ridge, TN, USA: 2013.
18) Medical Management of Radiation Injuries Safety Series No. 101 IAEA, 2020
19) Medical Management of Radiation Accidents. Cohen, K. S. United States: Taylor & Francis, 2001.
20) Iodine Thyroid Blocking Guidelines for use in planning for and responding to radiological and nuclear emergencies ISBN 978 92 4 155018 5 World Health Organization, 2017

LIST OF PARTICIPANTS

Task Group for Development of Safety Guide on "Medical Management of Persons Exposed in Radiation Accidents [AERB/NRF/SG/NRE-4]"

Date of Meetings of Task Group

Date of Meetings:

May 28, 2015, June 26, 2015, October 01, 2015, April 07, 2016, June 02, 2016, March 01, 2017, March 16, 2017, April 13, 2017, February 14, 2019, July 24, 2019, July 30, 2019, August 20, 2019, August 27, 2019, October 16, 2019, November 05, 2019, November 11, 2019, September 08, 2022, October 13, 2022, July 25, 2025

Work from Home/Virtual Meeting:

June 06, 2020, August 14, 2020, August 26, 2020, September 22, 2020, October 01, 2020, October 23, 2020, March 18, 2021, March 25, 2021, April 01, 2021, April 07, 2021, April 22, 2021, April 29, 2021, April 27, 20222, July 29, 2022, August 04, 2022, August 30, 2022, September 01, 2022, October 09, 2022, June 30,2023, October 04, 2023, October 16, 2023, November 03, 2023, April 26, 2024, June 20, 2024, June 21, 2024, July 08, 2024

Members of Task Group:

Dr. Pramilla D. Sawant, BARC	Convenor
Dr. Ravi Jammihal, Former Medical Division, BARC	Member
Shri V. Rajagopal, Former, IGCAR	Member
Dr. P. Vijayan, AERB	Member
Dr. Anita Gadgil, Former Medical Division, BARC	Co-opted Member
Dr. Nagesh N. Bhat, BARC	Co-opted Member
Shri R.K. Chaturvedi, AERB	Member-Secretary
Shri Ashish Ramteke, AERB	Invitee

Advisory Committee on Nuclear and Radiation Safety-Sub-Committee (ACNRS-SC)

Date of Meeting: June 01, 2023

Shri A. R. Sundararajan, Former Dir (RSD), AERB	-	Member
Dr. N. Ramamoorthy, Former CE, BRIT & AD, BARC	-	Member
Dr. A. N. Nandakumar, Former Head, RSD, AERB	-	Member
Shri Rajoo Kumar, R&DD, AERB	-	Member-Secretary
Dr. P.K. Dash Sharma, Head, RASD	-	Invitee
Shri. R. K. Chaturvedi, RASD	-	Invitee

Advisory Committee for Nuclear and Radiation Safety (ACNRS)

Date of meeting: April 29, 2024

Shri S.S. Bajaj Former Chairman, AERB	Chairman
Shri S. B. Chafle, Executive Director, AERB	Member
Dr. N. Ramamoorthy Chairman, SARCAR, AERB	Member
Shri. K. V. Suresh Kumar CMD, BHAVINI	Member
Shri. V. Rajesh Director (T), NPCIL	Member
Shri S. Jayakrishnan Director (T-LWR), NPCIL	Member
Prof. C.V. R. Murty Chair Professor, Dept. of Civil Engg., IIT, Madras	Member
Dr. Kallol Roy Former CMD, BHAVINI	Member
Shri. H.S. Kushwaha Former Director, HS&E group, BARC	Member
Shri. K.K.Vaze Former Director, RDDG, BARC	Member
Dr. (Smt). Sadhana Mohan Former Group Director, Chemical Engg. Group, BARC	Member
Dr. A.N. Nandakumar Former Head, RSD, AERB	Member
Dr. R. B. Solanki Head, RDS, IT&RDD, AERB	Member Secretary

TECHNICAL EDITING

Dr. D. Jeyaprakash, Medical Officer in Charge, Trombay Dispensary,
Medical Division, BARC

COPY EDITING

Shri K. Srivasista, Former, Head, R&DD, AERB

LIAISON OFFICER

Smt. Swathy K. Nair, RDS, IT&RDD, AERB

AERB SAFETY GUIDE NO. AERB/NRF/SG/NRE-4

Published by: Atomic Energy Regulatory Board,
Niyamak Bhavan, Anushaktinagar.
Mumbai – 400 094