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MANAGEMENT OF CONTAMINATED AND OVEREXPOSED INDIVIDUALS DURING A NUCLEAR OR RADIOLOGICAL EMERGENCY

REGULATORY GUIDE

PAKISTAN NUCLEAR REGULATORY AUTHORITY

For Further Details

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1. INTRODUCTION

Nuclear or radiological emergency may range from minor contamination or overexposure of the few workers to those in which large number of people (workers and public) is contaminated as a result of accidental or deliberate releases of large quantities of radionuclides. Such emergencies may occur in radiation facilities, nuclear installations or during transportation of radioactive material. They may also occur during activities involving warranted use of radioactive material or radiation apparatus like in industrial radiography or at unforeseen locations like metal scrap yard or border entry and exit points, etc.

Pakistan Nuclear Regulatory Authority (PNRA) Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914) require the licensee to have in place emergency plans, necessary trained workforce, equipment and mechanism for preparedness and response to nuclear or radiological emergencies. Under Regulation 8(8) of the PNRA Regulations PAK/914, the licensee is required to establish an appropriate system for managing the medical response in case of a nuclear or radiological emergency. Under Regulation 28(2)(c) of the PNRA Regulations on Radiation Protection - (PAK/904), the licensee is required to provide information, instruction and training to those workers who could be affected by emergency response actions. Furthermore, radioactive waste generated during a nuclear or radiological emergency needs to be managed as per PNRA Regulations on Radioactive Waste Management - (PAK/915).

2. OBJECTIVE

This Regulatory Guide (RG) provides guidance to the licensees, first responders and medical professionals regarding managing contaminated and overexposed individuals during a nuclear or radiological emergency.

3. SCOPE

This RG describes the arrangements for managing contaminated and overexposed individuals in case of a nuclear or radiological emergency. These include on-site management of victims, transportation of such individuals to hospitals, management at hospitals, post-hospital actions and management of contaminated descendants, etc.

4. PREPAREDNESS FOR MANAGEMENT OF CONTAMINATED AND OVEREXPOSED INDIVIDUALS

Individuals that may be affected in a nuclear or radiological emergency include emergency response personnel and members of the public. The emergency response personnel may include facility workers, Radiation Protection Officer (RPO), public health officials, emergency medical personnel, hospital staff, fire protection personnel,

law-enforcement officials, provincial and federal government officials, etc. For ensuring effective emergency preparedness and response arrangements for managing contaminated and overexposed individuals, the following important elements should be taken into account at the preparedness stage, i.e. well before the onset of any emergency situation.

4.1 Roles and Responsibilities

The nuclear and radiation facilities are responsible to ensure that the radiation workers, general public and the environment are protected from harmful effects of radiation sources under their control, as appropriate, in coordination with relevant off-site authorities. The licensee, first responders and hospitals should designate emergency response personnel responsible for taking preparedness measures and response actions during a nuclear or radiological emergency. This should include provisions for the appointment of an individual (incident coordinator), who has the authority and responsibility to direct the response. The authority of the incident coordinator should be recognized by all the local and national organizations that may be part of the response. General responsibilities of emergency response personnel have been indicated as follows, whereas specific responsibilities related to the facility or site may vary from facility to facility and should be identified and assigned before the commencement of facility or activity operation. The emergency response personnel should:

i. be aware of their roles and responsibilities;
ii. have pre-requisite knowledge and skills specific to their roles and tasks;
iii. be medically fit to perform the intended functions and responsibilities;
iv. be regularly trained to perform the specific functions and responsibilities;
v. have access to related facilities and equipment to be used during emergency response for notification and response, etc.

The licensees should ensure that the following arrangements are in place:

i. Organizational relationships and interfaces between all the response organizations have been established including availability of diverse communication arrangements for notification and seeking assistance;
ii. The positions responsible within the operating organization and off-site response organizations for performing specific response functions are assigned in the related plans and procedures; and
iii. Sufficient number of qualified personnel are available at all times to take response actions in case of a nuclear or radiological emergency.

4.2 Plans and Procedures

The applicable plans and procedures to be used in case of a nuclear or radiological emergency should be identified, prepared, reviewed and approved by the

licensee and, as appropriate, by relevant off-site response organizations well before the onset of any emergency situation. The licensed facilities should also submit those plans to PNRA for review, assessment and approval that are required under PNRA regulations. The off-site response organizations should be involved in preparation of such plans and procedures and a copy of approved plans and procedures should also be shared with relevant off-site response organizations. Examples of such plans and procedures are listed below:

i. External and internal contamination assessment of victims and emergency response personnel;
ii. External decontamination and decorporation of victims and emergency response personnel;
iii. Handling of contaminated or overexposed individuals at the accident site;
iv. Transportation of contaminated or overexposed individuals from site to hospital;
v. Managing contaminated and overexposed individuals at hospitals including their decontamination;
vi. Notification and information sharing with PNRA and with other response organizations (the "Incident Reporting Proforma" for radiation facilities and activities in order to share initial information with PNRA is given at Annexure I);
vii. Communication with the public;
viii. Dose assessment;
ix. Radioactive waste management and handling of contaminated deceased persons, etc.

4.3 Logistic Support and Facilities

The logistic support and related facilities should be identified following a graded approach, considering the possible emergency situations to be handled at the accident site, during transportation and at the hospitals. Adequate resources, tools, instruments, supplies, equipment, communication systems, facilities and documentation such as procedures, checklists, contact numbers and manuals for performing specified functions, should be made available. These support items should be located or provided in a manner that allows their effective use under simulated emergency conditions. A generic list of such equipment and supplies are given in Annexure II.

4.4 Regular Trainings, Drills and Exercises

The response personnel at the facility or incident site should have sufficient knowledge and skills regarding contamination monitoring, radiation protection, biological effects of radiation, decontamination of contaminated individuals, estimation

of the severity of internal contamination and provision of emergency first aid to the victims before they are moved to the hospital.

A regular training and exercise program should be established by the licensee and relevant off-site response organizations including medical professionals to ensure that:

i. arrangements are in place for training of emergency response personnel to have the requisite knowledge, skills, abilities, equipment and procedures to perform their assigned responsibilities;

ii. ongoing refresher trainings are arranged for emergency response personnel;

iii. training material is developed, which is flexible for improvement and can be updated after evaluation of the training ("Types of Training and General Training Topics for Emergency Workers" is given at Annexure III); and

iv. regular field exercises are conducted under simulated emergency conditions with the use of procedures, equipment and facilities to be used during an actual response (such as provision of first aid and initial decontamination, transportation of contaminated patients and handling of victims at hospitals, etc.).

4.5 Personal Protective Equipment and Radiation Monitoring

4.5.1 Personal Protective Equipment

Personal Protective Equipment (PPE) should be made available and used correctly, under the direction of a trained expert, whenever possible.

The following PPE, as appropriate should be made available, according to the risk and level of contamination:

i. Gloves;

ii. Shoe covers and booties;

iii. Coveralls (coats and pants);

iv. Head and hair covering;

v. Tape to close open ends of clothing;

vi. Respiratory protection;

vii. Lead apron;

viii. Face shield;

ix. Goggles, etc.

The PPE should be maintained at an accessible location so that in case of an emergency, these items are readily available.

4.5.2 Personnel and Area Radiation Monitoring

The workers like radiation specialists, RPO and radiological assessors, who may undertake an intervention or take mitigatory actions during a nuclear or radiological emergency, should be designated as emergency workers. Interventions may include saving lives, prevention of serious injuries as well as severe deterministic health effects, taking actions to avert large collective doses, or taking actions to prevent the development of catastrophic conditions. Appropriate arrangements should also be made for the provision of dosimeters to the emergency workers to be used in response to a nuclear or radiological emergency. In situations where the off-site workers are called upon to respond to such an emergency at a facility, they should also be designated as emergency workers. Those personnel who may be called upon from off-site authorities should be well-aware of the risks of radiation exposure and the meanings of radiation signs and placards. Plans and procedures should be followed for managing, controlling and recording the doses received by emergency workers and the public. The licensee should make arrangements for taking all practicable measures in order to provide protection to emergency workers for the range of anticipated hazardous conditions in which they may have to perform on-site and off-site response functions. This should include arrangements to:

i. assess and record the doses received by emergency workers;
ii. control personal radiation doses and minimize contamination; and
iii. provide specialized protective equipment for response in the anticipated hazardous conditions.

Once the emergency intervention has ended, emergency workers should undertake recovery operations as per the requirements for occupational exposure specified in PNRA Regulations on Radiation Protection - (PAK/904). The doses received and the consequent health risk should be communicated to the workers involved.

Area radiation monitoring should be carried out by radiation monitoring team using suitable radiation monitoring equipment. The radiation monitoring equipment to be used during response should be made available at an accessible location. The periodic calibration and maintenance of equipment should be performed at a pre-defined frequency in accordance with manufacturer recommendations and as per regulatory requirements. Types of surveys to be performed and appropriate instruments to be used are listed in Table 1.

Table 1: Types of Surveys and Appropriate Instruments

Sr. No.	Survey	Purpose of Survey	Instruments
i.	Personal contamination monitoring	To check personal contamination	Handheld contamination monitor, fixed hand & foot and portal contamination monitor

ii.	Smear wipe sample	Contamination monitoring (removable) by collecting samples using smear wipe and by placing in front of a handheld contamination monitor (alpha, beta, gamma monitor) and subsequently using gamma spectrometry system for detailed analysis	Smear wipes, handheld contamination monitors
iii.	Area survey	Radiation monitoring	Handheld survey meter with neutron, alpha, beta and gamma probes, as appropriate
iv.	Spills	Contamination monitoring and area survey	Handheld survey meter and contamination monitor including alpha, beta and gamma probes, as appropriate
v.	Radionuclide identification	Identification of radionuclide	Portable spectroscopy survey meter and radionuclide identifier
vi.	Airborne Monitoring	Radiation monitoring in air	Air sampler, detectors for detailed spectrometric analysis

5. MANAGEMENT OF POTENTIALLY INJURED AND CONTAMINATED INDIVIDUALS

Management of injured and contaminated individuals during a nuclear or radiological emergency requires pre-incident coordination between different stakeholders to cope with the effects of such incidents, e.g. arrangements for providing the on-site medical response, medical transport, advice to local hospital on associated radiation risks & appropriate protective actions to be taken and for establishing a temporary morgue area. Arrangements should be made in coordination with local hospitals and emergency medical services to cordon off the accident and treatment area to redirect self-presenters or the worried-well to the secondary locations established for monitoring and reassurance. Related protocols should be adopted by the hospital to identify and recover any evidence from the contaminated or overexposed individuals including:

i. Blood samples before transfusion;

ii. X-ray examination;

iii. Evidence, such as foreign objects removed during surgery; and

iv. Radiation monitoring results of the affected individuals and their belongings.

Given below are some of the important activities on the site, during transportation, in hospital and post-hospital discharge that are deemed necessary for managing nuclear or radiological emergencies. These are also summarized in the form

of a flowchart diagram in Figure 1.

5.1 On-Site Management Activities

In radiological emergencies, medical evaluation and stabilization of affected individuals should be the first priority at the site of an incident. An appropriate response to a radiation emergency will reduce the risk of contamination and exposure for individuals in general, i.e. the public as well as for responders. Response to an emergency involving radioactive material with injured persons requires on-site assessment and triage of the injured. Some examples of assessment and triage considerations include:

i. Determining how many affected individuals are present and if they are ambulatory or non-ambulatory;

ii. Deciding whether to shift affected individuals to the hospital or if there is time to perform field decontamination before transport;

iii. In case of overexposure, the licensee or first responders should gather information concerning the circumstances helpful for reconstructing the doses. Investigating the cause of overexposure should not delay the provision of medical treatment to the affected individual. Severely overexposed persons identified based on predetermined criteria, should be transported to local hospitals and treated there in accordance with relevant procedures. The licensee should conduct an investigation to determine the cause of the overexposure, take action to prevent further overexposure and protect information that may be important in further investigation of the case. Furthermore, the licensee should submit an investigation report to PNRA within thirty (30) days. The investigation report should state the cause of the incident and protective and other response actions taken;

iv. Following steps should be considered while establishing on-site triage area:

   a. Establish a field triage or first aid area outside the inner cordoned area and within the outer cordoned area, as described in section 5.1.2 below;

   b. Consider appropriate marking signs, symbols and placards to draw attention of people towards the triage area;

   c. Categorize affected individuals (based on their respective medical conditions) according to the following priority levels:

      (i) Priority 1: need immediate treatment;

      (ii) Priority 2: need early treatment;

      (iii) Priority 3: can wait for treatment; and

      (iv) No actions: no treatment is required.

The field triage at the scene of a radiation emergency is elaborated in Figure 2.

d. The victims with priority 1, 2 and 3 are later on further categorized according to secondary triage (exposure), possibly at the hospital, into the following three subcategories:

(i) Contamination with radionuclides;

(ii) Exposure of the whole body; and

(iii) Local exposure of parts of the body.

e. Tag victims with medical conditions, type and level of contamination;

f. Provide first aid, as required;

g. If there is an indication that people could be contaminated, take the following actions to limit the spread of contamination:

(i) Persons with life-threatening injuries should be wrapped in plastic sheets and transported to any nearest hospital immediately; and

(ii) Persons with non-life-threatening injuries and non-injured persons should undergo field decontamination or full decontamination, as appropriate.

h. Inform the ambulance, rescue services and the medical facilities on nature of the event, number of injured people, nature of injuries and contamination or overexposure; and

i. Arrange for transportation of injured individuals depending on their injuries, as follows:

(i) Individuals with life-threatening injuries should be transferred to any nearest hospital. Once the person is stable, he may be shifted to the designated hospital (for radiation-induced injuries), if necessary; and

(ii) Individuals with non-life-threatening injuries should be transferred to the designated hospital.

v. Wounds should be protected with impermeable dressing to avoid contamination or intake of radionuclides. If contamination is present, it is not advisable to attempt to decontaminate the wounds at the site;

vi. If contamination is fixed in equipment, and it has to be used necessarily, cover the contaminated part of the equipment and continue using it;

vii. Measuring and identifying radionuclides at the site is not normally possible. Therefore, if victims or patients are potentially internally contaminated, they need to be transferred to a hospital or facility where measuring and identification of radionuclides can be performed by in vivo counting (e.g. whole-body counting, thyroid counting, and lung counting, etc.) or by in vitro analyses (faeces and urine bioassays), or both; and

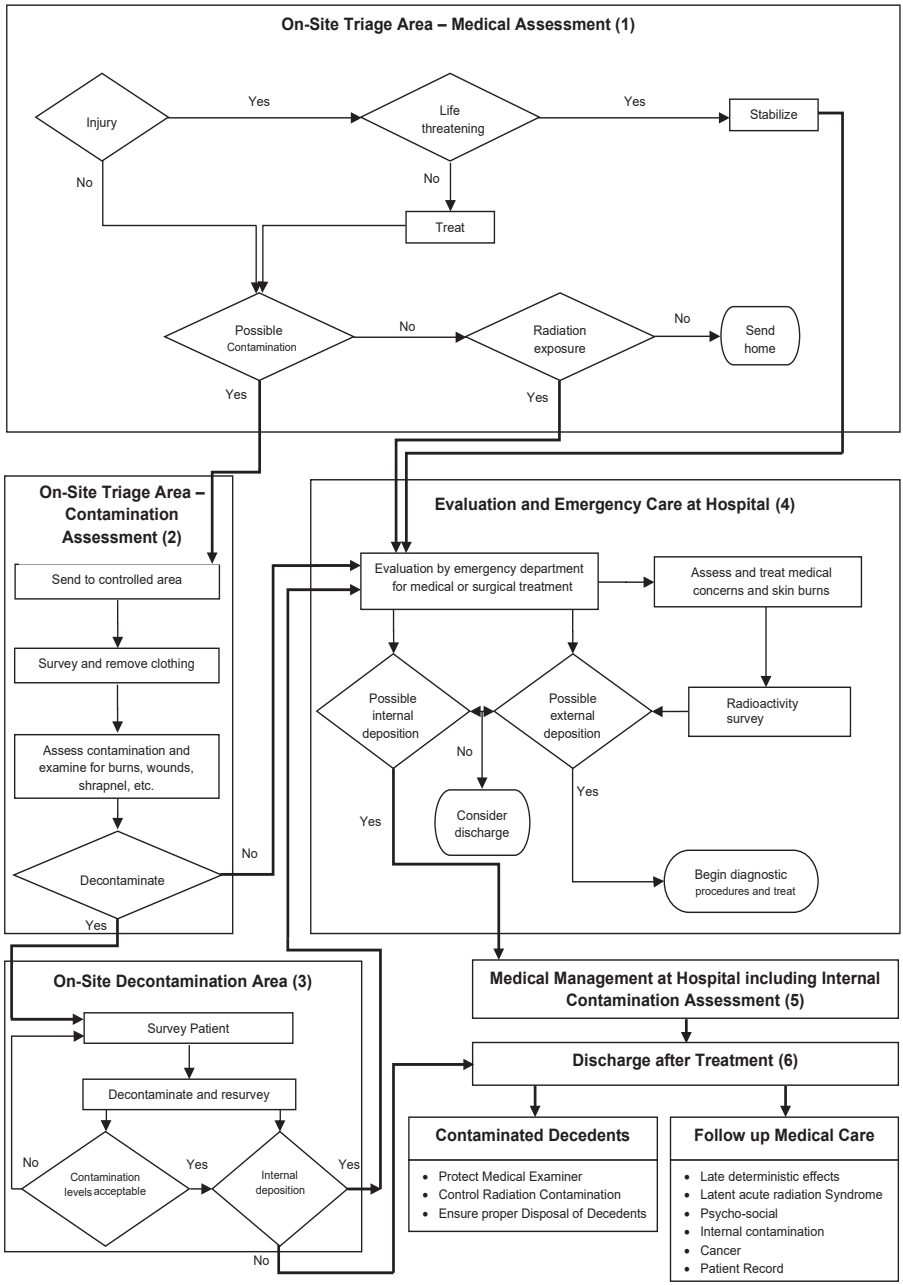


Figure 1: Decision Tree for Management of a Nuclear or Radiological Emergency

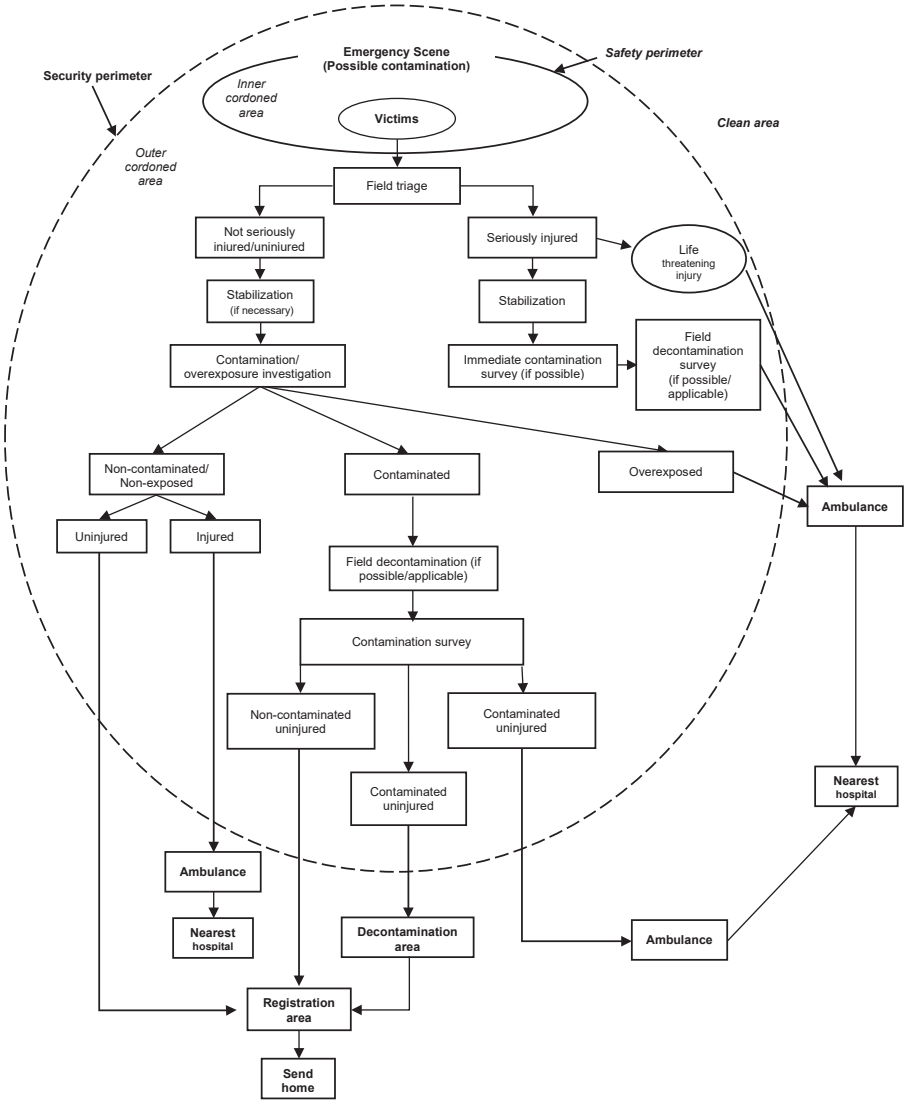


Figure 2: Field Triage during Radiological Emergency

viii. Decorporation treatment is not recommended at the site of a radiation emergency and transport of injured victims should not to be delayed.

5.1.1 Radiation Monitoring and Contamination Survey

First responders are required to perform various surveys to detect external radiation sources and radioactive contamination. A key objective of on-site medical assessment or triage is early identification of persons exposed to external radiation and those externally and internally contaminated with radionuclides. Other stages in the management of contaminated individuals at the site and at treatment facilities require further and more thorough surveys for the identification of exact contaminated areas. An example of "Area/Object/Equipment Contamination Survey Data Sheet" and "Personal Radiation Exposure Data Sheet" is provided in Annexure IV and V respectively. It is advisable that these surveys should be performed by trained experts or at least under their guidance whenever possible. The first responders performing the survey should:

i. check the calibration certificate. Radiation survey instruments are generally accompanied by a calibration certificate. The information on this certificate should be documented with the results of the surveys taken with the instrument;

ii. turn on the equipment, check the battery charge and observe for response;

iii. allow the instrument to perform a self-test and obtain a background reading. When possible, the background reading should be taken in the general area, but not near the incident site. The value of the background reading should be subtracted from survey readings;

iv. hold the detector at a distance of less than one (1) cm for beta and gamma radiation, and at less than 0.5 cm for alpha particle, from the item being surveyed for measuring contamination. Avoid touching the contaminated material and move the detector at a speed of about 3 to 5 cm per second (one to two inches per second);

v. use appropriate survey meters along with probes for area radiation monitoring. Hold the detector at one (1) meter horizontal distance and also near the surface to record the values and at one (1) meter height and on the surface; and

vi. record results on a survey map or diagram and note areas with high radiation and contamination levels.

5.1.2 Establishment of Safety and Security Perimeters and Radiation Control Zones

First responders should perform an initial assessment of the emergency situation and radiological hazard. Based on this assessment, the incident coordinator

should establish a safety perimeter in coordination with first responders, which is the boundary of the inner cordoned area, as shown in Figure 3. An appropriate security perimeter should also be established beyond the inner cordoned area for access control.

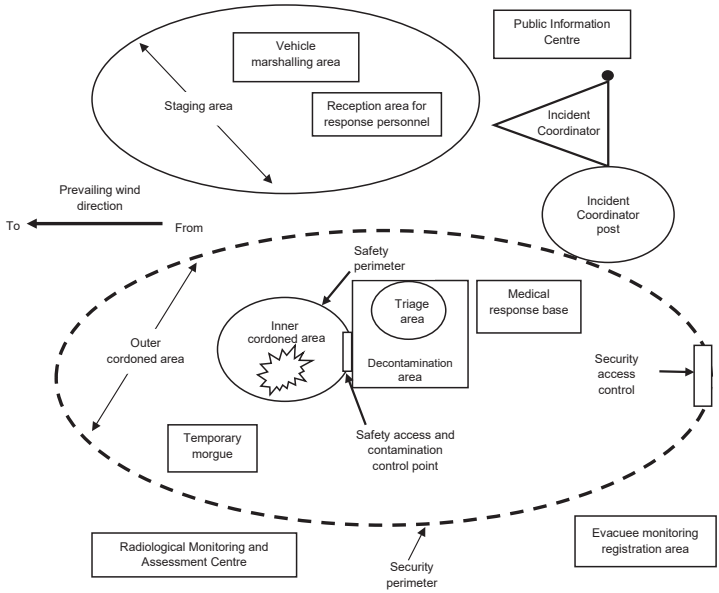


Figure 3: Generic Layout of Response Facilities within Areas Established for a Radiological Emergency. The Specific Layout in an Emergency will depend on the extent of the Particular Emergency Situation.

The inner cordoned area is the area around a dangerous radioactive source, where precautions should be taken to protect the responders and the public from potential external exposure and contamination. The outer cordoned area is the area around the inner cordoned area that is secured. Table 2 provides suggestions for the approximate sizes and locations of the inner cordoned area (within the safety perimeter in Figure 3) for various radiological emergencies. The determination of size for the inner cordoned area is based initially on information that can be directly observed (e.g. markings). The size may be expanded based on ambient dose equivalent rate readings, when this data becomes available. However, since dose rate cannot assess all exposure pathways, it should only be used as a basis for expanding the area. Additionally, a radiological assessor can assess the entire radiological hazard and adjust the boundaries of the inner cordoned area accordingly. Actual boundaries of the safety and security perimeters should be defined in the way that they are easily recognizable (e.g. roads) and easily secured. However, the safety perimeter should be established at least as far from the source as indicated in Table 2, until the radiological assessor has assessed the situation. The first responders should also establish, as appropriate, facilities and areas described in Table 2 and shown in Figure 3.

Table 2: Suggested Radius of Inner Cordoned Area (Safety Perimeter) for a Radiological Emergency

Situation	Initial Inner Cordoned Area (Safety Perimeter)
Initial Determination - Outside	
Unshielded or potentially damaged dangerous source	30 m around
Major spill from a potentially dangerous source	100 m around
Fire, explosion or fumes involving a potentially dangerous source	300 m radius
Suspected bomb (potential RDD), exploded or unexploded	400 m radius or more to protect against an explosion
Initial Determination - Inside a Building	
Damage, loss of shielding or spill involving a potentially dangerous source	Affected and adjacent areas (including floors above and below)
Fire or other events 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 at one (1) m above ground level or from an object	Wherever these levels are measured

Table 2 has been elaborated in flowcharts shown below in Figure 4 and 5.

5.1.3 Contamination Monitoring and Decontamination of Individuals

5.1.3.1 Contamination Monitoring

After medical triage at the site, if there is no need for urgent transport of victims to the hospital, contamination monitoring should be performed by qualified personnel on-site or in a reception centre of victims with no serious or life-threatening conditions or on those that have already been stabilized. In the following situations, it is possible that victims incurred internal contamination, hence confirmatory evaluation may be needed:

i. In a radiation emergency with dispersion of radioactive material (dust, smoke, liquid); and
ii. If contamination is detected, especially on the head, hair, face or hands.

For personal contamination monitoring, the following steps should be considered:

i. Perform QC checks on contamination monitor;

ii. Turn contamination monitor audio on and place probe in a light weight plastic bag or cover to prevent it from being contaminated. Do not cover the probe window;

iii. Determine and record the background radiation level periodically at the location where the monitoring is to take place;

iv. Place the probe about one (1) cm from the person's body, being careful not to touch him. Starting at the top of the head, move the probe downward on one side of the neck, collar, shoulder, arm, wrist, hand, underarm, armpit, side, leg, cuff, and shoe. Monitor the insides of the legs and the other side of the body in a proper sequence. Monitor the front and back of the body. Pay particular attention to the feet, elbows, hands and face. The probe should be moved at a speed of approximately five (5) cm per second. Any contamination will be detected primarily using the audio response. In noisy environment, earphones may be appropriate to listen to the audio response of the instrument;

v. If contamination is detected, record results (an example of "Personal Contamination Control Record" is given in Annexure VI). Measured area (active surface of the detector) should also be recorded; and

vi. All personal belongings should be monitored including watches, handbags, money, etc. Contaminated items should be bagged and labelled for decontamination. Contaminated personal clothing may be removed, bagged and labelled and substitute non-contaminated clothes be provided.

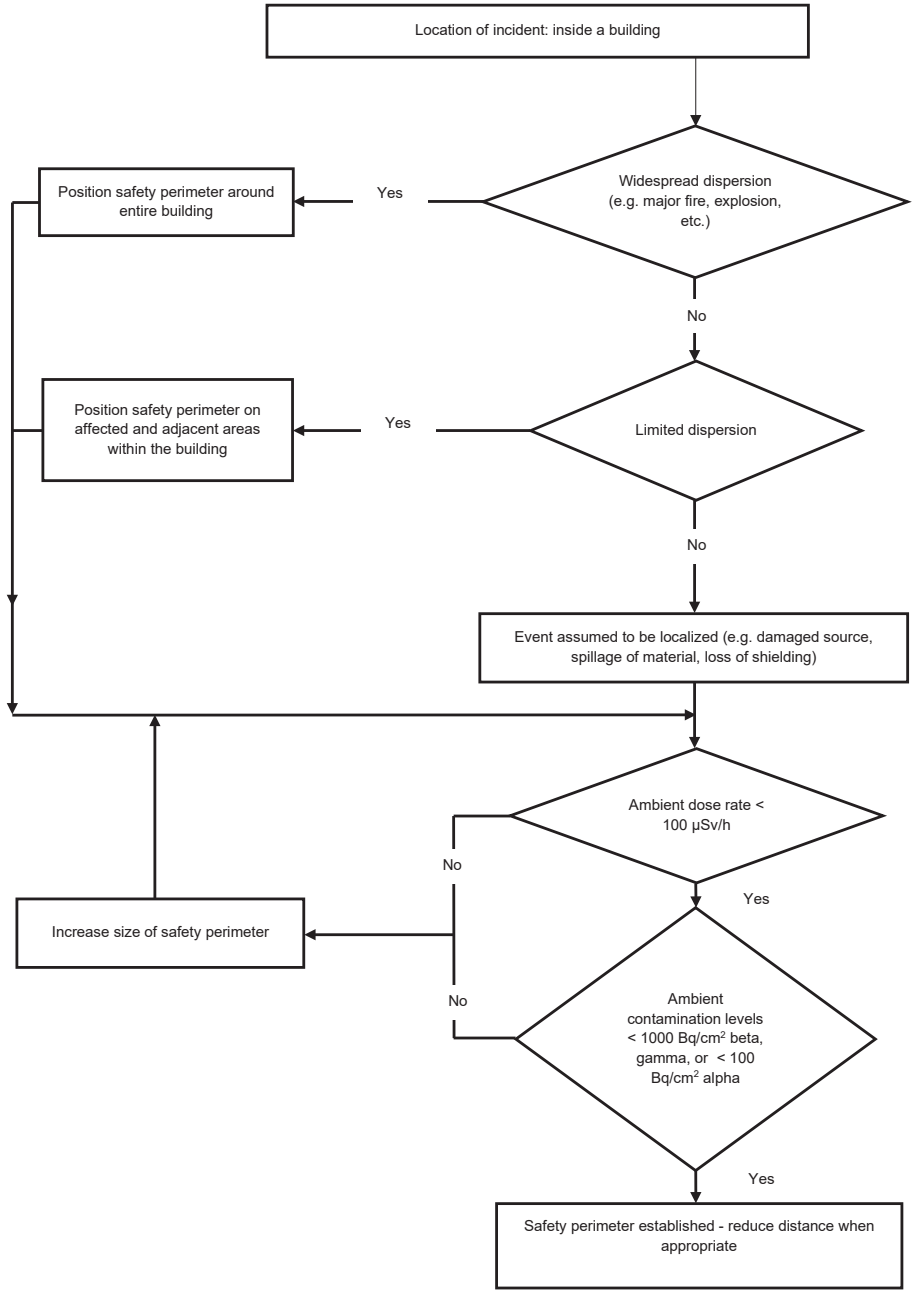


Figure 4: Establishment of Safety Perimeter for a Radiological Emergency inside a Building

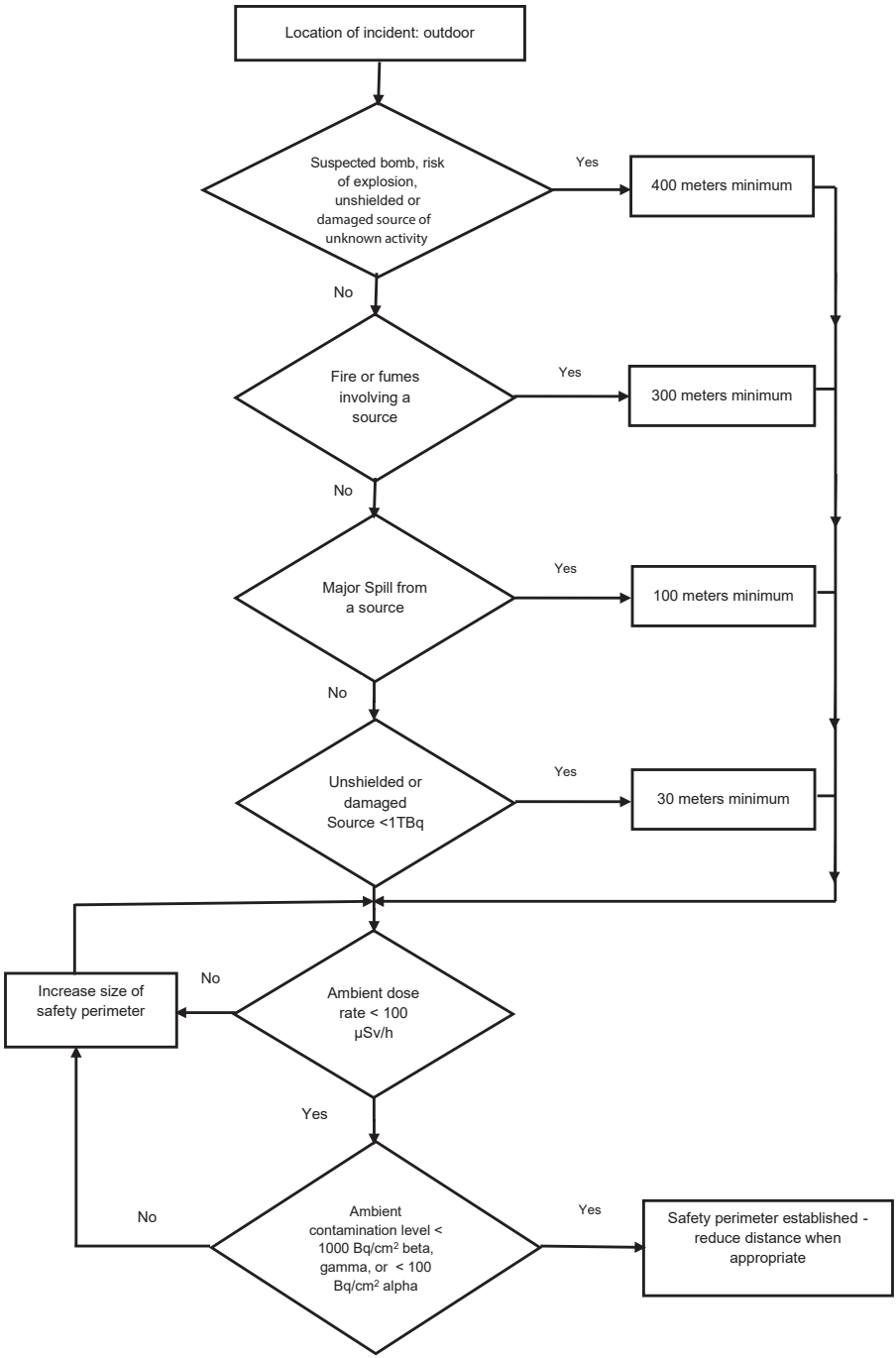


Figure 5: Establishment of Safety Perimeter for Outdoor Emergency

5.1.3.2 Decontamination Arrangements

If there is an indication that people (not requiring immediate medical treatment or transport) may be contaminated by the presence of radioactive material, a decontamination area should be established outside the inner cordoned area (as shown in Figure 3) keeping in view the available resources and number of people to be decontaminated. A generic layout of on-site decontamination facility has been shown in Figure 6. Such arrangements should be able to opt for one of the following strategies, depending upon the number of contaminated individuals:

i. Field decontamination for large numbers with controlled entrance and exit points and provisions for people to wash hands and face and partly remove outer clothing; or

ii. Full decontamination for small numbers and provisions for taking a shower and immediately obtain clean clothing. Considering the social and cultural norms, appropriate arrangements must be established for female contaminated victims.

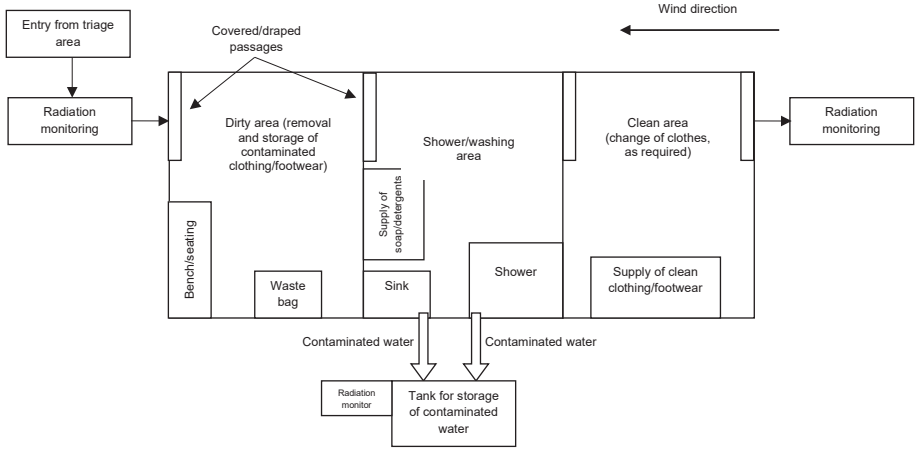


Figure 6: Generic Layout of On-site Decontamination Facility

Water used for decontamination should be collected and stored without delaying the decontamination. Such run-off water should be stored till its proper disposal in the light of PNRA Regulations PAK/915. Following arrangements should be made by first responders in order to perform decontamination at the site:

i. Arrange blankets and clothing, etc., as appropriate, that could be used to dress people who have removed their outer clothing;

ii. Wear gloves and protective clothing as available and change gloves regularly;

iii. Instruct not to eat, drink, smoke or chew to prevent the possibility of internal contamination;

iv. Follow personal protection guidelines e.g. taking iodine thyroid blocking, where appropriate, medical follow-up and psychological counselling, as appropriate, etc. The "Total Effective Dose Guidance for Emergency Workers" is given in Annexure VII;

v. Periodically get monitored (It is recommended that the first responder carrying out decontamination procedures must be monitored for contamination every hour). If radiation dose rate due to contamination is greater than 0.3 μSv/h, get the first responder decontaminated. A lower criteria (0.3 μSv/h) to get decontaminated is used for the first responder performing decontamination than for the public (i.e. decontamination at a dose rate greater than 1 μSv/h) to ensure that the ambient dose rate from a contaminated first responder does not interfere with process for public decontamination;

vi. Keep families together and ask adults to assist children or others needing assistance (if possible);

vii. Assess the situation for performance of field or full decontamination depending on the number of contaminated individuals;

viii. Fill out a "Registration Form" as given at Annexure VIII;

ix. Provide people with information on where to get further instructions once released;

x. Use tags to clearly distinguish bags or cartons of contaminated clothing from those of other items;

xi. Issue a receipt for contaminated clothing and personal items and release the persons;

xii. Move bags with potentially contaminated items to an isolated and secure location;

xiii. Maintain records of monitoring results, registration form and contaminated clothing; and

xiv. When relieved from their monitoring duties, emergency workers should not leave until decontaminated.

A generic layout of on-site decontamination facility is shown in Figure 6, although specific arrangements for establishing such a facility depend on the prevailing emergency situation. The items needed for decontamination are enlisted in Annexure IX.

5.2 Transportation to Designated Hospitals

In transportation of patients contaminated with radioactive material from the site of emergency to the hospital, pre-established radiation protection protocols should be followed, as long as this does not cause any delay in the medical assistance of individuals with life-threatening conditions. The designated hospital should treat

the contaminated victims with trained specialists and should be equipped to perform immediate specialized treatment and management of exposed and contaminated victims. The first responders should look for the conditions to determine, if the victim has life-threatening injuries and immediate transport is necessary. These conditions may include:

i. Unconscious or altered mental status;
ii. Respiratory arrest or distress;
iii. Severe haemorrhage, that cannot be controlled at the site;
iv. Poor perfusion or associated signs and symptoms of shock, etc.

An early notification should be provided to the receiving hospital that a potentially contaminated patient is en route. Early notification will allow time for the hospital management to initiate its procedures for dressing up of their responsible professionals in appropriate PPE and implementation of necessary contamination control practices. The following should be considered by first responders in this regard:

i. A brief but informative description of patient's condition should be given;
ii. An estimate on the number of victims that the transport unit and hospital can handle should be obtained;
iii. Hospital should be alerted of possible contamination and material involved;
iv. Number of patients involved in the incident should be identified;
v. Patient should be transported to the appropriate medical facility;
vi. Hospital staff should be consulted for any specific arrival instructions including alternate arrival entrance, hospital radiation safety support and unloading of the patient; and
vii. Arrangements should be made at the hospital to receive the ambulance outside the emergency entrance.

While shifting patient or victim to hospitals, the following measures should be taken:

i. Transport personnel should wear proper PPE, including personal dosimeters;
ii. Cover the patient area in the ambulance with plastic sheets and tape the covering securely to the area;
iii. Wrap contaminated body areas or whole patient or victim in two layers of full-body sheets;
iv. Preserve ability to observe and monitor patient fully during transport even though patient is wrapped;

v. Pay attention to the patient's body temperature. Avoid patient hyperthermia or hypothermia on a hot or cold day; and

vi. After transport of contaminated patient or victim:

   a. Ensure complete survey and decontamination of transport vehicle. The "Vehicle Contamination Survey Data Sheet" is attached as Annexure X;

   b. All materials that were used to handle and treat the patient or that may have come in contact with the patient during transport, including gloves, pads, bandages, splints, oxygen masks, blood pressure cuffs, etc., and any waste remaining in the ambulance should be considered contaminated. It should be monitored properly and if found contaminated, it should be decontaminated or disposed of properly; and

   c. Arrange for contamination monitoring and decontamination of responders, as needed.

5.3 Management at Hospital

Hospitals designed and designated to respond to radiation emergencies should ensure that their staff is well informed of the actual risks related to assisting patients contaminated with radionuclides, and a hospital plan should be established and periodically updated for proper management. Radiological emergency medical response team at hospital should be activated well before transporting victims to the hospital. Radiological emergency medical response includes radiation protection officers, emergency department personnel i.e. physicians, nurses, nuclear medicine personnel, hospital safety and security coordinator, nursing staff and health specialists with relevant expertise who must be part of the response teams e.g. radiation oncologists, medical oncologists/haematologists, pediatric oncologists, psychiatrists, blood bank personnel, trauma and burn care, engineering and housekeeping staff, security, etc. Figure 7 describes the initial preparation for possible contamination control by hospital emergency department response team in case of a radiation emergency situation.

Specific decorporating drugs (elaborately described in IAEA-EPR 2018 "Medical Management of Persons Internally Contaminated with Radionuclides in a Nuclear or Radiological Emergency") should be made available, and the stockpile should be kept under strict control. It is important that medical protocols for the management of internal contamination with radionuclides be available and periodically updated. Assessment and treatment of contaminated/exposed/injured and non-contaminated/ exposed/injured people in hospital treatment area is mentioned in Annexure XI. Proper procedures for returning ambulance personnel, equipment and vehicles to normal service should also be established. The following instructions should be considered in such procedures:

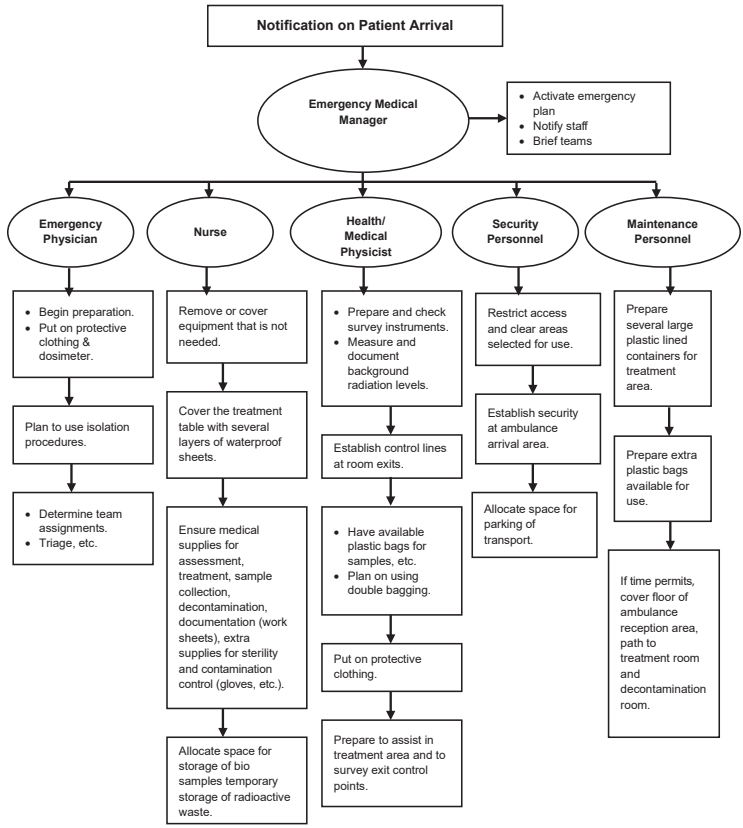


Figure 7: Preparation for Contamination Control by Hospital Emergency Department Response Team

i. Remain in the controlled area at the hospital until surveyed;

ii. Do not eat, drink, smoke, or chew to prevent the possibility of internal contamination;

iii. After being surveyed, and as a matter of precaution, take a shower and change clothing;

iv. Return to regular service only after being surveyed and decontaminated if necessary;

v. Designate an ambulance reception area and treatment area. Set up an area large enough to handle the anticipated number of victims. Clear the area of visitors and patients. Re-route the traffic of other patients as appropriate, e.g. direct other medical emergencies to the alternate entrance of the hospital. Make a path from the ambulance entrance to the hospital entrance using rolls of plastic, wrapping or butcher paper

of about one (1) m width. Cover the floor. Tape the covering securely to the floor. Remove or cover equipment that will not be needed. Rope off and mark the route to prevent unauthorized entry;

vi. Restrict access to the controlled area;

vii. Prepare several large plastic lined waste containers, plastic bags of varying sizes and labels for personal effects or belongings, and warning labels and signs;

viii. Prepare the decontamination room of the treatment area if one has been previously designated, otherwise, designate a decontamination room near the entrance of the treatment area. Decontamination should be performed with the following priorities: wounds, orifices, high-level skin areas, low-level skin areas. The decontamination of wounds, body orifices, hair, intact skin - localized areas, etc. may be performed in accordance with the guidance given in IAEA "Generic Procedures for Medical Response during a Nuclear or Radiological Emergency, EPR-Medical (2005)";

ix. Establish a control line at the entrance to the decontamination room. Use wide strip tape to clearly mark the floor at the entrance to the room to differentiate the controlled (contaminated) from the non-controlled (uncontaminated) side. Check and prepare survey meters for use;

x. Prepare enough instruments and supplies (e.g. outer gloves and dressings, etc.) to change when they become contaminated;

xi. Perform medical stabilization first, if necessary, for life-saving, bypass the decontamination room. Remove the patient's clothing and wrap the patient in a plastic sheet to limit contamination of the treatment area;

xii. In case of serious overexposures, arrange to gather information needed to reconstruct the dose promptly in order to determine the course of treatment. This information should include: estimates of the dose received to the whole body or tissues, information about the practice and activities in which the victim was involved, a description of the source of exposure (e.g. activity, radionuclide, dose rate at one (1) meter), a detailed description of circumstances of the exposure (e.g. location of persons as a function of time), readings of all personal dosimeters (all staff members) or other monitoring devices, samples of items worn by the overexposed persons, a full description and time of onset of any early clinical symptoms (e.g. vomiting), results of a general medical examination of all systems and organs, including the skin, visible mucosa and total blood counts in order to detect the first occurrence of symptoms related to exposure. The decision on treatment takes both the physical and psychological suffering of the patient into consideration;

xiii. If patient is contaminated, proceed with full decontamination, involving

the main steps which are described as follows:

a. Patient's clothes should be removed very carefully, cutting of clothes with scissors is recommended instead of removing them overhead (if this was not done previously), and be placed in plastic bags adequately labeled with the patient's name, date and time of the procedure. Clothes are excellent samples for the identification of the contaminant radionuclides, if equipment for radiological analysis is available;

b. A quick head-to-toe radiological survey should be performed by an RPO (or by another trained professional) with the appropriate equipment, including a judicious survey of wounds. The activity in the wounds may be counted with appropriate detector (e.g. Geiger-Muller (GM) detector), and the count rate may be used to estimate the intake initially. This will normally provide sufficient evidence of the presence or absence of gross contamination;

c. Decontaminate the skin with soap using warm water. Do not scrub too vigorously;

d. Handle any unknown metal objects with a hemostat or forceps;

e. Save samples and label them (smears of contamination, nasal smear, extracted tooth, hair and nails, purged bone pieces, etc.);

f. If a wound is contaminated, survey, rinse, debride only for surgical reasons;

g. If contamination persists, consider covering area of the wound or consider that contamination may be internal;

h. Perform a final radiological survey of the victim;

i. Transfer the decontaminated patient to the clean area. Use clean gloves to move the patient to a clean stretcher and exit the decontamination room; and

j. Control the spread of contamination.

xiv. Survey staff for possible contamination, remove contaminated clothing and shower before exiting controlled area. Survey medical equipment for contamination before removing it;

xv. Evaluate and treat patients with injuries and psychological distress;

xvi. Direct media inquiries to the Public Information Officer (PIO), as designated by respective facility;

xvii. After discharging the patient and at the end of the emergency phase, clean up the area following the pre-established hospital procedures to control doses. Do not return the area to normal until approved by the radiological assessor;

xviii. Pack contaminated items, secure the ambulance stretcher and transport

vehicle, unless such items are needed back at the accident site;

xix. Segregate presumptive or confirmed radiological waste for retrospective analysis in consultation with law enforcement agencies and representatives from forensic department; and

xx. Assess needs and request additional resources, if needed. Inform NRECC in case of assistance required from national experts or at international level (if necessary) on the contact numbers provided at Annexure I.

5.4 Post Hospital Management

In radiation exposure cases, it is common to distinguish late physiological and psychological effects from the early effects of radiation exposure. Most deterministic effects occur early and the severity of harm from the radiation exposure increases with dose. In contrast, stochastic effects are probabilistic and without a threshold, and generally appear later in an exposed population. Follow-up medical care of an internally irradiated individual will therefore focus on the evaluation of late effects, most significantly directed to the detection of cancer. In addition, late psychological issues related to radiation exposure have been found to be quite important and should always be considered by the examining physician as part of continuing medical surveillance. In case of a relatively low dose internal exposure, the long term psychological trauma may be more medically significant than any radiation induced organ damage. In follow-up medical care, the following should be considered:

i. Late deterministic effects;
ii. Latent acute radiation syndrome;
iii. Psycho-social indications;
iv. Internal contamination;
v. Cancer;
vi. Epidemiology studies;
vii. Patient record documentation; and
viii. Triage documentation.

The details of contamination incident radionuclides, possible routes of intake and all other pertinent information should also be made available for later use by medical staff and health physics trained professionals.

5.4.1 Management and Prevention of Psycho-Social Effects

Past experiences have shown that psycho-social effects of a radiation emergency can far outnumber any direct effects. Women with young children, pregnant women, those individuals with prior mental disorders and sometimes first responders are the groups of people that are at the highest risk of developing psychological effects

due to radiation emergency. Treatment of these issues would require psychological support and assistance in the acute phase of an incident as well as long-term follow-up activities. Following the detonation of a Radiological Dispersal Device (RDD), an Improvised Nuclear Device (IND), or any other incident involving either external irradiation or internal exposure, the management of acute psychological and behavioral responses is likely to be as important and challenging as the treatment of trauma or radiation related medical injuries and illnesses. Furthermore, the psychological effects of radiation exposure can manifest years after the causative exposure and the patient may experience fear for the safety of future generations. Those who have been exposed may also experience feelings of vulnerability, chronic anxiety, and lack of control.

Public officials, teachers, ministers, psychologists, nurses and others who are in positions of trust and who have the respect of the community should be offered specific information that would enable them to assist the public during an emergency. This should help to improve public acceptance and compliance and in the implementation of protective actions.

Social and psychological support programs should provide help for affected individuals after an emergency. Social assistance is necessary for an affected population, especially for those who have been evacuated or relocated.

It is important to note that the first responders are also likely to have major psychological concerns and a rotation policy should be implemented for them during and after a radiation incident.

5.5 Management of Contaminated Decedents

Decedents that have been exclusively exposed externally to ionizing radiation entail no radiological risks to the professionals. Procedures regarding management of such decedents will follow the conventional biosafety rules. When handling a decedent who is internally contaminated with radionuclides, as during an autopsy, health personnel could be exposed to ionizing radiation from the radioactive material located in the body. Improper manipulation of a contaminated body can cause external or internal contamination of the professional themselves. Biosafety accidents involving punctures and cuts, or eye and mucosa splashes are some examples of contamination routes when dealing with a radioactively contaminated body. The bodies of contaminated decedents should be managed with due account taken of religious and cultural practices.

5.5.1 Autopsy

Autopsies ought not to be performed on internally contaminated bodies unless absolutely necessary (for medico-legal reasons). However, if the body only contains a small quantity of radioactive material and there is a compelling need, an autopsy would not carry any significant radiological risk and could be performed as long as it is well planned.

In all instances, when an autopsy needs to be performed on a contaminated body, the planning for the procedure is essential. For this purpose, the participation of a RPO is required to determine that all protective measures would be implemented. Some considerations include:

i. **Limiting external exposure:** This is mainly achieved by limiting the exposure time, for example by rotating the working shifts of professionals (pathologists, coroners, technicians and others) during the procedures. It is extremely unlikely, in any event, that a single body would contain sufficient radioactive material for which the time of exposure needs to be limited. However, with mass casualties, when many corpses need to be autopsied, this could happen if the number of available forensic and pathology professionals is limited. Another method to limit exposure is to delay the procedures, waiting for the decay of the contaminating radionuclides so that a lower and safer dose rate level is reached.

ii. **Avoiding radioactive contamination:** This can be done by means of protective clothing intended to protect against contamination. The assistance of an experienced RPO is strongly recommended during implementation of the whole procedure.

iii. **Protection of the premises:** The morgue, autopsy room and facilities inside can be protected from contamination by using plastic sheets or other appropriate and waterproof material. The autopsy room should be properly decontaminated after such use.

iv. **Disposal of biological samples, clothes and material:** All biological material from the autopsy and all instruments used during the procedure have to be checked by competent radiation protection professionals before their release to their conventional destination. If feasible, instruments have to be decontaminated properly. If this is not possible, they should be considered as radioactive waste and disposed of in accordance with instructions laid down in PNRA Regulations PAK/915. Nothing should be removed from the autopsy room without a radiological survey and authorization by the RPO.

v. **Monitoring of professionals:** All personnel involved should wear personal dosimeters and be monitored throughout the procedures. No one should leave the autopsy room without a radiation survey and authorization of the RPO. If contamination is detected, decontamination procedures should be followed accordingly.

If a victim is pronounced dead at the site of an emergency, the body should not be transported to hospital. In such an instance, guidance should be obtained from the local coroner or public health officials and RPO for the transport of bodies. In a

mass casualty event, refrigerated trucks might be necessary for holding the bodies until thorough assessments can be made. Depending on the amount of contamination, these trucks should be placed in allocation so as to minimize exposure to others.

5.5.2 On-Site Recovery of Decedents

After the medical examination, with the authorization of coroner for removal of bodies, each body should be surveyed. When surveying a body using a flat surface contamination probe, the probe is held about two (2) cm from the body and moved at a speed not exceeding fifteen (15) cm per second. If the count rate from a body exceeds three times the normal background, RPO has to be consulted regarding whether it is necessary to place a radioactive warning tag on the body and another one on the outer surface of the body bag before it is sent to the morgue.

5.5.3 Field Morgue near the Site

A malicious act, for example, a terrorist attack, involving the use of radioactive material can cause a radiation emergency with many deaths and bodies contaminated with radionuclides. If this happens, it would probably be necessary to establish a field morgue near the site, but in an area where dose rates are comparatively low, as shown in Figure 3.

Background levels should be measured using the available monitoring instruments. Bodies arriving at the morgue may contain embedded and highly radioactive shrapnel, low level loose surface contamination, low level internal contamination or no contamination at all. The morgue should set up a clean processing area with boundary, a contaminated processing area and a refrigeration facility at least ten (10) meters from the clean and contaminated areas.

Radiation survey of each body coming into field morgue should be conducted using a radiation survey meter and probe sweeping one (1) inch away from the body surface. There may be the following cases:

i. **Decedents without measurable levels of external contamination:** In this case, confirm absence of contamination by conducting complete radiation survey of the body and transport body directly to city morgue or to uncontaminated field morgue following complete radiation survey.

ii. **Decedents with measurable levels of contamination:** In case dose rate due to contamination is less than 1 mSv/h, may be processed in field morgue by decontamination of decedent prior to release of body. On the other hand, if dose rate due to contamination is greater than 1 mSv/h, move the decedent to a refrigeration unit (at least 30 feet away from work area). An RPO or health physicist will help determine how long to store the body based on rate of decay of radioactive material.

5.5.4 Basic Procedures in the Morgue and Release of Bodies

A medical examiners team at morgue area consists of at least two medical examiners, a photographer and a clerical assistant. The team should adapt personal protective measures, i.e. wearing coveralls, gloves, a particulate respirator (if necessary) and goggles. They should examine the body and then carefully remove and bag all clothing and jewelry or wearable, documenting and photographing each step. The field morgue should be surveyed periodically and any radioactive contamination should be cleaned up, under the supervision of radiation protection professionals. This will decrease the spread of contamination and prevent incorrect labeling of uncontaminated bodies as contaminated or vice versa.

After bodies have been released by the team, they should be moved to a decontamination area and washed. The run-off water from contaminated bodies should be collected for later disposal as low level waste. The collection of run-off water is not necessary for uncontaminated bodies. After washing a decedent and removing any radioactive shrapnel, a last survey should be performed.

To release the body for burial, embalming or cremation without restrictions, an RPO should be consulted. A tag should be attached to the body indicating the date, dose rate and distance at which this dose rate was measured, the results of any measurements of external and internal contamination, as well as the equipment used to perform the measurements. All clothing, contaminated hair and waste generated after decontamination procedure (including liquids) should be disposed of as radioactive waste.

5.5.5 Embalming

The embalmer will have to manipulate the body to remove all clothing, bandages, intravenous needles, catheters, etc. Shaving is necessary in many cases. The embalming table and facilities will be covered with plastic and disposable absorbent materials to the maximum extent possible. A body with internal contamination with radionuclides has to be embalmed under the close orientation and supervision of an RPO.

5.5.6 Cremation

Internally contaminated decedents are only to be cremated when adequate measurements can be taken for preventing radioactive contamination of the facility and the surrounding environment. Cremation of decedents contaminated with long-lived radionuclides from a nuclear emergency could cause sufficient contamination and require extensive decontamination efforts. Shrapnel or brachytherapy seeds will not be destroyed in the process of cremation. If cremation is desired, shrapnel, brachytherapy seeds or any other discrete sources have to be removed and dealt with in accordance with the PNRA Regulations PAK/915. The pieces removed could be characterized as

forensic evidence and medico-legal regulations need to be observed.

5.5.7 Funeral Services

Depending on the outcome of the decontamination procedures employed, family members may be allowed to stay or touch the decedent's body. A briefing by the RPO can be a useful way to make family members aware of any radiation risks. Family members and other persons attending the funeral services and those concerned about radiation exposure should receive a clear explanation of its meaning.

5.5.8 Burial

Burial of a body that has internal contamination usually constitutes minimal health risk to humans or the environment. Minimizing release of radioactive material into the environment is a good practice, even if the amounts are very small.

A wooden casket or coffin is not sealed against elements entering or exiting the container. A rustproof metal casket should be considered, but only in very rare cases where bodies are heavily contaminated with gamma-emitting radionuclides which would require lead-lined caskets mainly to address significant public concern.

5.6 Protection of Emergency Workers

In order to avoid deterministic health effects, efforts should be made to keep doses to emergency workers at a minimum as specified in PNRA Regulations PAK/914, for example:

i. Below twice the maximum single year dose limit; or

ii. Below ten times the maximum single year dose limit, only for life-saving actions.

The dose limit may approach or exceed ten times the maximum single year dose limit, only when the benefits to others clearly outweigh their own risk. Emergency workers should be volunteers and be clearly and comprehensively informed in advance of the associated health risk and should be trained.

In large scale releases of radiation and radioactive materials, individual pocket-sized alarming dosimeters should be used by all emergency responders in the inner contaminated area. The instrument would warn the wearer when the radiation exposure approaches a predetermined level or is likely to reach the level.

Protective clothing worn by emergency workers will provide protection only from radiological contamination hazards. A typical protective clothing kit includes:

i. Disposable coverall or gown;

ii. Shoe covers;

iii. Head cap;

iv. N-95 airborne pathogen tuberculosis mask, which provides some protection against airborne radioactive material. For work inside the hot zone, or areas where higher levels of radioactive contamination are suspected, use of additional respiratory protection is suggested;

v. Glasses with side shields; and

vi. Gloves, wearing multiple pairs of gloves are recommended.

5.6.1 Removing Personal Protective Equipment

After such times when use of PPE is no longer necessary, a PPE user should remove PPE in the following order:

i. Outer gloves;

ii. Dosimeter, which should be handed over to health and safety personnel;

iii. Tape at ankles and wrists;

iv. Coveralls (coat and pants);

v. Head cover, helmet and hoods;

vi. Respiratory protection;

vii. Shoe covers, after removal of which, a user should step to clean area; and

viii. Inner gloves.

5.7 Recovery Operations

For those involved in recovery operations, normal occupational dose limits apply as per PNRA Regulations PAK/904. Furthermore, the arrangements for the termination of a nuclear or radiological emergency is descriptively addressed in IAEA General Safety Guide GSG-11 and should be used when guidance related to termination of an emergency is required.

5.7.1 Management of Radioactive Waste

Equipment and supplies used for decontamination should be isolated and kept in plastic bags or containers with radiation labels and appropriately checked for radiation dose rate, both at the surface and at different distance levels. Medical equipment should be decontaminated for safe re-utilization, otherwise it should be treated as radioactive waste and stored or disposed of in accordance with the PNRA Regulations PAK/915.

Radioactive waste generated in a nuclear or radiological emergency, including radioactive waste generated from associated protective actions and other response

actions taken, should be identified, characterized and categorized. Radioactive waste handling at hospital morgue area include stringent actions, e.g. an organ removed during autopsy as radioactive material should be disposed of properly as radioactive waste after the autopsy is completed. The laboratory within which such organs are examined should be labeled as a radioactive material storage area or a radiation area while the organ is present. All clothing, contaminated hair and decontamination materials (including liquids) at morgue area should be disposed of as radioactive waste. Waste containers should be clearly marked "radioactive waste" in controlled areas and should be lined with plastic bags. The contaminated water resulting from decontamination of individuals at the site and in hospitals should be collected, stored and treated according to the requirements laid down in PNRA Regulations PAK/915.

Arrangements should be made for radioactive waste to be managed safely and effectively. These arrangements should include the following:

i. Developing a radioactive waste management program that describes in detail activities to be performed with regard to radioactive waste management as per PNRA Regulations PAK/915 and applicable RG on "Format and Content of Radioactive Waste Management Program for Nuclear Medical Centres (PNRA-RG-915.01)" or "Format and Content of Radioactive Waste Management Program for Nuclear Installations (PNRA-RG-915.02)";
ii. Characterizing the radioactive waste in terms of its physical, mechanical, chemical, radiological and biological properties;
iii. Classification of the radioactive waste according to the activity concentration and half-lives of the radionuclides keeping in view the perspective of its future disposal;
iv. Avoiding the mixing of waste of different categories to the extent possible;
v. Minimizing the amount of material unduly declared as radioactive waste; and
vi. Waste originated from human and animal remains should be managed, taking into account religious and cultural practices.

5.7.2 Decontamination of Equipment

Decontamination of equipment includes the following considerations:

i. Smooth or non-porous surfaces (e.g. glass, plastic or metal, etc.) can be decontaminated using any of the following methods:
    a. Wipe with cloths dampened with water or commercial cleaning products;
    b. "Tape press" using the sticky side of tape (duct tape or masking

tape, etc.); or

c. Immersion in an ultrasonic cleaning sink.

ii. Contamination that cannot be removed is considered "fixed". The actions that should be performed for fixed contamination are as follows:

a. If ambient dose rate at 10 cm is >1 μSv/h and <10 μSv/h then equipment can be used for response activities only;

b. If ambient dose rate at 10 cm is >10 μSv/h and <100 μSv/h, then equipment can be used for critical response activities only. The use of these items must be controlled. The first responders who use these equipment must take all reasonable actions to reduce their skin exposure (wear gloves) and limit use to less than a few hours; and

c. If ambient dose rate at 10 cm is >100 μSv/h, the equipment should be isolated and used only with radiological assessor's approval.

iii. Porous or fibrous surfaces cannot be decontaminated by washing or wiping. The following can be considered to decontaminate porous or fibrous surfaces:

a. Soft items (e.g. wood, plastic and lead) may be shaved with a knife or razor to remove contamination; and

b. Contaminated sections of fabric or paper can be cut out and the remainder be used.

iv. Large areas (such as ambulance interiors or floors) may be decontaminated by wiping with a sponge or rags soaked in soapy water, detergent or other cleaning solutions.

5.8 Documentation and Record Keeping

The licensees, first responders and hospitals should have in place the related plans, procedures, checklists and records, etc. for managing response to a radiological emergency. The following record should be maintained during emergency situations:

i. Dose record of contaminated or overexposed individuals and emergency workers;

ii. Area monitoring record;

iii. Record of decedents (e.g. no. of decedents and dose level, etc.);

iv. Record of contaminated or overexposed individuals transported to hospital;

v. Radiation monitoring and contamination level record; and

vi. Any other information necessary for future use.

6. REFERENCES

[1]. Regulations on Management of a Nuclear or Radiological Emergency - (PAK/914).

[2]. Regulations on Radiation Protection - (PAK/904).

[3]. Regulations on Radioactive Waste Management - (PAK/915).

[4]. RG on "Preparation of Radiation Emergency Plan for Radiation Facilities and Activities (PNRA-RG-914.02)".

[5]. IAEA Safety Standard GSG-2.1 "Arrangements for Preparedness for a Nuclear or Radiological Emergency".

[6]. IAEA Safety Standard GSG-11 "Arrangements for the Termination of a Nuclear or Radiological Emergency".

[7]. IAEA EPR-METHOD (2003) "Method for Developing Arrangements for Response to a Nuclear or Radiological Emergency".

[8]. IAEA EPR FIRST RESPONDERS (2006) "Manual for First Responders to a Radiological Emergency".

[9]. IAEA EPR INTERNAL CONTAMINATION (2018) "Medical Management of Persons Internally Contaminated with Radionuclides in a Nuclear or Radiological Emergency".

[10]. IAEA EPR MEDICAL (2005) "Generic Procedures for Medical Response during a Nuclear or Radiological Emergency".

[11]. TMT Handbook on "Triage, Monitoring and Treatment of People Exposed to Ionising Radiation Following a Malevolent Act".

[12]. NCRP Report No. 161 "Management of Persons Contaminated with Radionuclides".

[13]. IAEA Safety Glossary "Terminology Used in Nuclear Safety and Radiation Protection 2018 Edition".

ANNEXURE I

INCIDENT REPORTING PROFORMA

(To be used in case of an emergency at a radiation facility/activity)

Incident Date:	Incident Time:
Facility Type: ☐ Diagnostic Radiology ☐ Radiotherapy ☐ Nuclear Medicine ☐ Industrial Radiography ☐ Irradiators ☐ Nuclear Gauges/Oil Well Logging ☐ Education/Research ☐ Other_____ (Please Specify)	**Nature of Incident:** ☐ Undue/Over exposure of worker/patient/public ☐ Source lost/stolen/theft ☐ Spill/dispersion of radioactive material ☐ Orphan source found ☐ Contamination ☐ Internal exposure due to ingestion/inhalation ☐ Transport accident ☐ Any other
Name and location of facility/site where incident occurred: _____ City:_____ Contact No.: _____	
Facility Licensed with PNRA: Yes ☐ No ☐	License Number: _____ (If licensed)
Incident Summary: (Brief description of event) (Use another sheet if required)	
Sender Details: Name:_____ Designation:_____ Contact No:_____ Reporting Time: _____Signature with date:_____	

Please send filled form to:

National Radiation Emergency Coordination Center (NRECC)

PNRA HQs, Mauve Area, G-8/1, Islamabad.

Telephone	Fax	Email address
Primary: 051-9262019 Backup: 051-2289210 Toll Free: 0800-77766 Officer In-charge: 0300-8540319 Alternate Officer In-charge: 0334-5131978	Primary: 051-9260201 Backup: 051-2289233	nrecc@pnra.org

ANNEXURE II

EQUIPMENT AND SUPPLIES

Equipment and supplies recommended for immediate medical response to be performed at the accident site, during transportation and at hospitals (depending on the availability) are listed below:

At Accident Site:

i. First aid kit (containing analgesics, cardiogenic drugs, antihypotensive or antihypertensive drugs, antiemetics, antibiotics, diuretics, topical antibiotic cream, rehydration salts, disposable syringes, bandages, scissors);
ii. Ambubag and mask;
iii. Containers for biological sample collection and storage;
iv. Radiation survey/detection instruments;
v. Personal protection equipment;
vi. Communication equipment;
vii. Plastic sheets, tapes, bags (different sizes);
viii. Portable stretchers;
ix. Tags and adhesive labels;
x. Medical information forms;
xi. Waste bags; and
xii. On-site decontamination facility (with the equipment given at Annexure IX), etc.

During Transportation:

Standard ambulance with all the necessary equipment, for example, first aid kit, ambubag, mask, plastic sheets, etc.

At Hospital:

i. Set of standard surgical instruments and aids;
ii. Necessary drugs for treatment and decorporation;
iii. Decontamination kits;
iv. Necessary documents, manuals and guides;
v. Necessary equipment for handling of patients;
vi. Clinical laboratory equipment;
vii. Equipment for blood transfusion;
viii. Plastic sheets, tapes, bags (different sizes); and
ix. Waste bags, etc.

ANNEXURE III

TYPES OF TRAININGS AND GENERAL TRAINING TOPICS FOR EMERGENCY WORKERS

Types of Training:

During an emergency response, the use of skilled and experienced manpower familiar with the monitoring equipment, sample collection, preparation procedures and sample analyses in their routine work is vital. It should be recognized that persons performing routine monitoring and sampling should also receive specific training for non-routine & emergency monitoring and sampling, in which higher readings may be expected, greater care in sample handling techniques may be needed and novel methods such as screening large numbers of samples using less sophisticated techniques may be required.

In an emergency, it is undesirable to use inexperienced personnel and untried techniques as this may lead to inappropriate and faulty technical information that may cause decision-makers to make wrong judgments or allocate resources inappropriately. It is therefore, essential that emergency workers are well trained and regularly exercised in their assigned roles. Operational experience in routine and non-routine monitoring is highly desirable as technical staff responding to an emergency need to be skilled in the measurement and sampling techniques they are to apply. As a part of training and readiness, intercomparison exercises have to be prepared and performed to thoroughly test the response abilities of the teams and to check sampling, measurement and other procedures.

Furthermore, all the workers within a workplace are educated about the type of emergencies that may occur in their workplace and train them in the proper course of action. The size of workplace and workforce, processes used, materials handled and the availability of on-site or off-site resources will determine the training requirements of the workers. Special attention is given to any special hazards that are present on the site such as flammable materials, toxic chemicals, radioactive sources, or water-reactive substances and discussion may be made to handle such incidents if they happen.

General Training Topics:

The following topics may be considered for general training:

i. Types of emergencies e.g. nuclear emergencies, such as dirty bombs, radiological exposure devices, nuclear power plant accidents, transportation accidents involving radiation, occupational accidents, such as overexposure to radiation in health care facilities, etc.;

ii. Reporting procedures e.g. use of Incident Reporting Proforma attached at Annexure I;

iii. Alarm systems;

iv. Evacuation plans;

v. Measurement techniques for dose rates and environmental samples, etc.;

vi. Emergency communication equipment such as two-way radio, map reading and Global Positioning System (GPS) equipment;

vii. Turn back guidance;

viii. Protective actions for safety (evacuation, shelter, shelter in-place, lockdown);

ix. Individual roles and responsibilities;

x. Threats, hazards and protective actions;

xi. Notification, warning and communication procedures;

xii. Means for locating family members in an emergency;

xiii. Emergency response procedures;

xiv. Evacuation, shelter and accountability procedures;

xv. Location and use of common emergency equipment;

xvi. First-aid procedures and respiratory protection; and

xvii. Methods for preventing unauthorized access to the site, etc.

ANNEXURE IV

AREA/OBJECT/EQUIPMENT CONTAMINATION SURVEY DATA SHEET

Surveyed by: _____ (Full Name)

Provide to: ☐ Environmental Analyst or Radiological Assessor

Team No.*: _____

Date and Time: _____

Item monitored: ☐ Equipment ☐ Object ☐ Area ☐ Other ☐

Specify: _____ (Type of equipment, object, area, ID No. if any, area location, etc.)

Contamination monitor used:

Type: _____ Model: _____ Serial No.: _____

Location	Initial Contamination Reading (cps)**		After Decontamination Reading (cps)		Remarks
	α	β+γ	α	β+γ	

Smears:

Sampling Location	Area Swapped [cm^2]	Date and Time	Smear Code	Remarks

Comments:

_____

_____

Team Leader Signature

* If there are more than one team for contamination survey, they will be allotted numbers for identification.

**cps (counts per second): The activity or intensity of radiation is measured in counts per second (cps), which expresses a rate of counts per unit time as recorded by a radiation monitoring instrument.

ANNEXURE V

PERSONAL RADIATION EXPOSURE DATA SHEET

Surveyed by: _____(Full Name) Provide to: _____

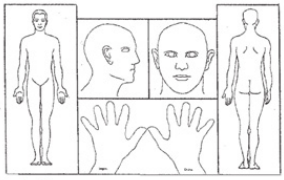
Date and Time: _____ Name of Individual:_____

ID Number: _____ Address: _____

Sex: ☐ Male ☐ Female

☐ Emergency Worker ☐ Evacuee ☐ Member of public

Instrument type: _____ Model: _____ Serial No.: _____ Background reading: _____

Personal Exposure Information
Actions at the time of incident:
Individual incident description:
(Include location, time, duration and use of any personal protective equipment)
Sites of injury or trauma:  Use the code: 1 - Thermal burn 2 - Wound 3 - Erythema 4 - Contamination 5 - Other injury/trauma (specify)

Dose Estimates (Fill as soon as results are available)					
Evaluation of average Total Body Irradiation (TBI)	Date	Method		Dose (Gy)	
Evaluation of local doses	Date	Method		Dose (Gy)	
Other	Date	Method		Dose (Gy)	
Kind of Irradiation	Alpha particles	Beta emitters	Gamma source	X-rays	Others
If patient had a dosimeter: Dose meter number:_____ Dose meter readings:_____ Body location of the Dose meter:					

Surveyor Signature

ANNEXURE VI

PERSONAL CONTAMINATION CONTROL RECORD

Surveyed by: _____ (Full Name)

Provide to: _____

Date and Time: _____

Name of Individual: _____

ID Number: _____

Address: _____

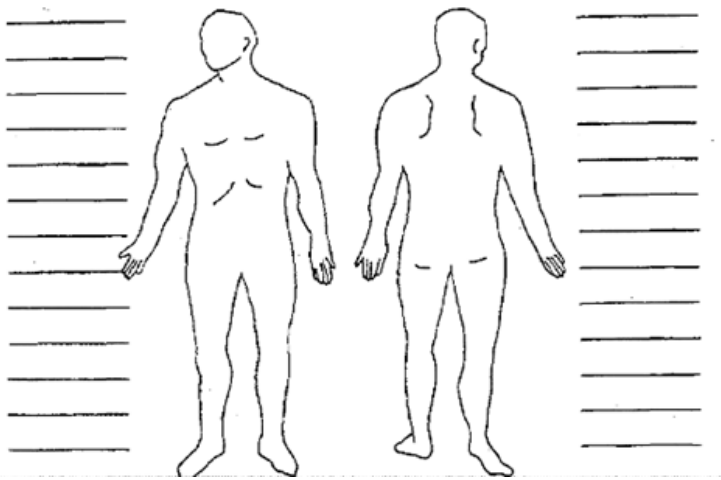
Sex: ☐ Male ☐ Female

☐ Emergency Worker ☐ Evacuee ☐ Member of Public

Contamination survey:

Instrument type: _____ Model: _____ Serial No.: _____

Background reading: _____ Detector active surface: _____ [cm^2]



Remarks: Indicate reading in the lines provided in the diagram. Indicate location of the readings by arrows. Only record readings that is greater than that of background.

Decontamination procedures necessary: ☐ Yes ☐ No

Results of thyroid survey: _____ (net count rate) [ ] (Unit)

Further evaluation at medical facility necessary: ☐ Yes ☐ No

Surveyor Signature

ANNEXURE VII

TOTAL EFFECTIVE DOSE GUIDANCE FOR EMERGENCY WORKERS

Emergency worker guidance values are given as an integrated external dose on a personal dosimeters (TLDs, film badge etc.). Emergency workers should make all reasonable efforts not to exceed these values. Following are the tasks that can be performed keeping the doses below the mentioned limits:

Type 1 tasks: Below 500 mSv

i. Life-saving actions;
ii. Prevention of core damage; and
iii. Prevention of a large release.

Type 2 tasks: Below 100 mSv

i. Prevent serious injury;
ii. Avert a large collective dose;
iii. Prevent the development of catastrophic situation;
iv. Recovery of reactor safety system; and
v. Off-site ambient dose rate monitoring.

Type 3 tasks: Below 50 mSv

i. Short-term recovery operations*;
ii. Implement urgent protective actions; and
iii. Environmental sampling.

Type 4 tasks: Occupational exposure guidance

i. Long-term recovery operations**; and
ii. Work not directly connected with an accident.

* Short-term recovery operations refer to health and safety needs of the population.

** Long-term recovery operations refer to rebuilding and reconstruction of community and economic base.

ANNEXURE VIII

REGISTRATION FORM

Date: _____

Full Name: _____

Date of Birth: _____ -_____-_____

Sex: ☐ Male ☐ Female

ID Number: _____

Full Address: _____

Contact No.: _____

Member of: ☐ Public ☐ Emergency Services ☐ Other (specify) _____

Witness to the incident: ☐ Yes ☐ No Photographed: ☐ Yes ☐ No

Possibly pregnant: ☐ Yes ☐ No If yes, estimate term:_____

Location(s) during emergency: _____

Time spent at each location: _____

Radiological Survey Performed: ☐ Yes ☐ No

Instrument type:_____

Model: _____ Background reading: _____

Personal survey measurements: _____ μSv/h

Decontamination Procedures Performed:

Field decontamination: ☐ Yes ☐ No Full decontamination: ☐ Yes ☐ No

Primary Triage Category (based on the medical condition):

Priority 1: Need immediate treatment

Priority 2: Need early treatment

Priority 3: Can wait for treatment

No actions: No treatment is required

Scheduled for follow-up: ☐ Yes ☐ No

Remarks:

Signature: _____ (Full Name)

Date: _____ Time: _____

Organization: _____ Telephone number: _____

Provide the form to Resource Coordinator or _____ (specify)

ANNEXURE IX

DECONTAMINATION ITEMS

The items needed for decontamination are listed as follows:

i. Scissors;
ii. Soap, detergents and shampoo;
iii. Soft brushes or sponges;
iv. Physiological saline solution;
v. Water or solution for wound irrigation;
vi. Eyewash solution;
vii. Nail brushes, nail clippers, hair clippers;
viii. Drapes and masking tape for covering non-contaminated skin or area during decontamination;
ix. Indelible felt pens for marking contaminated spots;
x. Data forms (e.g. decontamination forms);
xi. Large towels and clean patient gowns or clothing, etc.;
xii. Appropriate PPE for personnel performing decontamination;
xiii. Respirators (if contamination levels are very high);
xiv. Personal dosimeters;
xv. Large plastic bags for collection of contaminated clothing; and
xvi. Radiation tags for marking contaminated items or bags, etc.

ANNEXURE X

VEHICLE CONTAMINATION SURVEY DATA SHEET

Surveyed by: _____

Provide to: _____ Environmental Analyst or Radiological Assessor

Vehicle monitoring location: _____ Vehicle license plate No. _____

Vehicle type: _____ Driver's Name: _____

Type of vehicle: _____ ☐ Bus ☐ Car ☐ Truck ☐ Van ☐ Other

Contamination monitor used:

Model: (specify) _____ Serial No.: _____

Initial contamination reading Survey after decontamination

Date/time: _____ _____

Area Monitored	Initial Survey Reading (cps)		After Decontamination Reading (cps)	
	α	β+ γ	α	β+ γ
Background				
A. Front bumper				
B. Rear bumper				
C. RT* Front tire or wheel well				
D. RT Rear tire or wheel well				
E. LT** Front tire or wheel well				
F. LT. Rear tire or wheel well				
G. Grill				
H. Other exterior (specify) a. b. c.				
I. Air intake filter				
J. Interior (specify) a. b. c.				

Smears:

Sampling Location	Location Swapped (cm²)	Date/ Time	Smear Code	Remarks

Vehicle Impounded ☐ Yes ☐ No If yes, indicate the reason below

Comments:

Team Leader Signature

*RT: Road/Track

**LT: Luxury Touring

ANNEXURE XI

ASSESSMENT AND TREATMENT OF CONTAMINATED/EXPOSED/ INJURED AND NON-CONTAMINATED/EXPOSED/INJURED PEOPLE IN HOSPITAL TREATMENT AREA

The victims are transferred from ambulance reception area in accordance with their condition as follows:

Patient Condition	Transfer to	Precautions
Contaminated and exposed	Hospital treatment/ decontamination area in the emergency department	Do not transfer to decontamination area if medically contraindicated. Use clean hospital stretcher to transfer.
Non-contaminated and exposed	Regular patient treatment area in the emergency department	
Conventional trauma		
Contaminated and non-injured	Remains in a controlled area and transferred to decontamination area.	Remains until a complete radiological assessment and decontamination is accomplished.

Exposures are of two types, i.e. external exposure and internal exposure. The exposure can be external to the body, in which case it may be to the whole body or limited to larger or smaller parts of the body; or it can be internal due to contamination with radioactive materials, if ingested, inhaled or deposited in wounds.

Assessment and Treatment in Hospital Treatment Area:

i. If the patient has a conventional injury or illness, save life and treat as normally required. Note that radiation does not produce life-threatening early symptoms;

ii. Be aware that a radiation injured person does not present a health risk to the doctor;

iii. Do not touch any unfamiliar object in the patient's possession and move staff and patients to another room until the nature of the object has been determined by a radiation protection specialist;

iv. Symptoms of radiation sickness may include weakness, fatigue, fainting, bleeding from the nose, mouth, gums, and rectum, bruising, skin burns, dehydration, hair loss, inflammation of exposed areas (redness, tenderness, swelling, bleeding), nausea and vomiting, including vomiting of blood, etc.;

v. If contamination is suspected, avoid spread of material by using isolation procedures. Contaminated patients are admitted to a specially prepared and isolated part of the treatment area. They can have radioactive material deposited on skin surfaces, in wounds, or internally (ingested, inhaled or absorbed):

   a. If the patients have internal contamination only, then they don't present a direct hazard to others, unless the internal contamination is extremely large. In that case, medical personnel and other people around (patients, relatives) may be subject to external exposure as a result of internal contamination of the patient. However, such exposure usually is low;

   b. If the patients have external contamination of the skin, clothing and/or contaminated excreta, then they present hazard in spreading contamination and special precautions need to be implemented to prevent the spread of contamination.

vi. The following steps should be followed while treating contaminated/ exposed/injured patients:

   a. Reassess the patient's airway, breathing and circulation prior to paying attention to his/her radiological status. Promptly assess level of consciousness and vital signs and stabilize the patient's condition;

   b. Remove clothing as promptly as possible and place the clothing, any accompanying sheets, blankets, etc. in a plastic bag. Label the bags with warning signs and patient's identification information. Store the bags in a secure place away from the immediate work area;

   c. Change gloves after handling clothing or other potentially contaminated items;

   d. A radiological survey should be performed by the Health/Medical Physicist or dosimetry team;

   e. Obtain complete and detailed medical, occupational and emergency history. Examine the patient. If history is incomplete, observe for radiation induced signs or symptoms. Request Health/ Medical Physicist to perform dose assessment;

   f. Assess possibility of internal contamination. If suspected, initiate collection of samples for analysis (as described in Table D2 of EPR-MEDICAL 2005). Request Health/Medical Physicist to perform assessment of internal dose. Initiate decorporation treatment if necessary (as described in procedure D3 of IAEA EPR-MEDICAL 2005);

   g. Observe patients with nausea and vomiting in the emergency

department for about six hours. Manage radiation injuries from whole body exposure based on time of vomiting in accordance with guidance given in Table D1 of IAEA EPR-MEDICAL 2005;

h. Determine the possibility of Local Radiation Injury (LRI). If LRI is suspected, photographs of the affected area(s) should be obtained twice weekly and then daily if signs of radiation injury become evident. Photographs should be added to the patient's medical history records;

i. Take necessary laboratory samples using guidance in Table D2 of IAEA EPR-MEDICAL 2005; and

j. Complete medical information form.

vii. Non-contaminated victims are admitted to the standard hospital emergency treatment area. Absence of contamination means that no special procedures to prevent the spread of contamination should be undertaken at this stage. If the patient has been exposed only to external sources of radiation, there is no radiation threat to medical personnel and others around (patients, relatives, etc.).The steps (a, e, f, i, j) from subsection (vi) above, should be followed while treating non-contaminated/exposed/injured patients; and

viii. Physician should inform RPO regarding any radiation injury and the RPO may inform relevant authorities.

DEFINITIONS

i. **Decorporation:** The therapeutic processes by which radioactive materials are mobilized from tissues and organs, and removed from the body by enhanced material excretion.

ii. **Deterministic Effect:** A health effect of radiation for which generally a threshold level of dose exists above which the severity of the effect is greater for a higher dose.

iii. **Nuclear or Radiological Emergency:** An emergency in which there is, or is perceived to be, a hazard due to: (a) The energy resulting from a nuclear chain reaction or from the decay of the products of a chain reaction; or (b) Radiation exposure.

iv. **Emergency Worker:** A worker who may be exposed in excess of occupational dose limits while performing actions to mitigate the consequences of an emergency for human health and safety, quality of life, property and the environment.

v. **Emergency Procedures:** A set of instructions describing in detail the actions to be taken by response personnel in an emergency.

vi. **Field Decontamination:** Decontamination carried out at the scene of radiation emergency that may include actions like removal of outer clothing, washing of face and hands, covering of victim in the blanket, etc.

vii. **First Responder:** The members of an emergency service to response at the site of an emergency. In the earliest stages of a mass casualty event or other disaster, first responders are responsible for protecting and preserving of:

   a. Life (e.g. paramedics, emergency medical technicians, ambulance service personnel);

   b. Property (e.g. firefighters);

   c. Evidence (e.g. law enforcement); and

   d. Environment (e.g. HAZMAT teams).

viii. **Full Decontamination:** Decontamination carried out at the scene of radiation emergency or at the hospital that may include actions like complete removal of clothing, shower with water and detergents, provision of new clothing, etc.

ix. **Incident Coordinator:** In-charge/commander/head/senior first responder of the emergency response.

x. **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.

xi. **Inner Cordoned Off Area:** An area established by first responders in an emergency around a potential radiation hazard, within which protective actions and other response actions are taken to protect first responders and the public from possible exposure and contamination.

xii. **Preparedness Stage:** The stage or phase at which arrangements for an effective emergency response are established prior to a nuclear or radiological emergency.

xiii. **Primary Triage:** Triage at the site of radiation emergency.

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

xv. **Response Organization:** An organization designated as being responsible for managing or implementing any aspect of an emergency response.

xvi. **Radiation Specialist:** A person trained in radiation protection and other areas of specialization necessary in order to be able to assess radiological conditions, mitigate radiological consequences or control doses to responders.

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