



**GUIDANCE FOR THE USERS OF IODINE-131 IN NUCLEAR  
MEDICINE CENTERS**

**REGULATORY GUIDE**

**PAKISTAN NUCLEAR REGULATORY AUTHORITY**

**For Further Details**

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# TABLE OF CONTENTS

<b>ABSTRACT .....</b>	<b>1</b>
<b>1 INTRODUCTION .....</b>	<b>2</b>
<b>2 OBJECTIVE .....</b>	<b>2</b>
<b>3 SCOPE .....</b>	<b>2</b>
<b>4 PRE-REQUISITES FOR PLANNING OF RADIO-IODINE FACILITY .....</b>	<b>2</b>
4.1 DESIGN CONSIDERATION FOR FACILITY .....	3
4.2 GENERAL RECOMMENDATIONS .....	4
4.3 DESIGN OF RADIOISOTOPE LABORATORY (HOT LAB).....	4
4.4 DESIGN OF DISPENSING ROOM.....	6
4.5 DESIGN OF ISOLATION ROOM .....	6
4.6 STORAGE AND DISPOSAL OF RADIOACTIVE WASTE .....	7
4.7 WARNING SIGNS AND LABELS .....	7
<b>5. PROCEDURE FOR HANDLING RADIO-IODINE.....</b>	<b>7</b>
5.1 MINOR SPILLS .....	8
5.2 MAJOR SPILLS.....	9
<b>6. DOSE ADMINISTRATION .....</b>	<b>10</b>
6.1 PRECAUTIONARY MEASURES AFTER DOSE ADMINISTRATION .....	11
<b>7. DECONTAMINATION .....</b>	<b>11</b>
7.1 DECONTAMINATION OF PERSONNEL.....	11
7.2 DECONTAMINATION OF CLOTHING AND BEDDING .....	12
7.3 DECONTAMINATION OF EQUIPMENT AND APPARATUS .....	12
7.4 DECONTAMINATION OF SURFACES AND FLOORS .....	13
7.5 WIPE TEST.....	13
<b>8. VISITORS ACCESS CONTROL .....</b>	<b>14</b>
<b>9. RADIATION PROTECTION PROGRAM.....</b>	<b>14</b>
<b>10. EMERGENCY PROCEDURES .....</b>	<b>15</b>
<b>11. REFERENCES.....</b>	<b>16</b>
<b>ANNEX-I.....</b>	<b>17</b>

## **GUIDANCE FOR THE USERS OF IODINE-131 IN NUCLEAR MEDICINE CENTERS**

### **ABSTRACT**

This regulatory guide is developed to provide guidance to the users of Iodine-131 (I-131) which is mainly used in nuclear medicine centers for diagnostic and therapeutic purposes. This guide will be useful in implementation of regulatory requirements set under Section - 28(1) of PNRA regulations on radiation protection (PAK/904) and international safety standards set by ICRP through its Publication - 103. The effective implementation of these requirements would help to ensure protection of radiation workers, public, environment and patients from harmful effects of radiation.

## **1 INTRODUCTION**

Radio-iodine (I-131) is a gamma emitter which is used for diagnosis and treatment of thyroid carcinoma or hyperthyroidism. It is generally administered orally in liquid form in Pakistan. However, it is also available in capsule or caplet form in all over the world. Radiation dose to be administered to the patient for treatment of tumor is prescribed by a nuclear physician and it depends on many factors including tumor size, its location and staging etc.

I-131 has been widely used in Nuclear Medicine Centers and its applications are largely beneficial for thyroid patients. The prime safety concern in the use of radioisotopes is that the patients, radiation workers and general public are not exposed to unnecessary radiation which is harmful to their health. While dealing with patients administered with I-131, all possible efforts should be made to minimize radiation exposure of the workers directly involved in administering I-131 to the patients and to other workers and general public in and around the facility.

This guide is issued under the provisions of section-28(1) of PNRA “Regulations on Radiation Protection” - PAK/904 [1]. It mainly addresses various safety measures which are required to be taken during planning, designing and construction of radio-iodine facility. It also focuses on arrangements for handling and storage of radio-iodine, dose administration, actions to be taken in case of its spillage, decontamination procedure, storage of generated waste, visitors access control and radiation protection program of a facility.

## **2 OBJECTIVE**

The objective of this regulatory guide is to provide guidance for protection of patients, radiation workers, general public, and the environment from undue exposure and harmful effects of I-131.

## **3 SCOPE**

This regulatory guide contains guidance on radiation safety, handling, usage and storage of I-131 and is mainly applicable to the nuclear medicine centers involved in diagnostic and therapeutic use of radio-iodine. The guide may also be used by the personnel involved in production of radio-iodine for medical and other industrial applications.

## **4 PRE-REQUISITES FOR PLANNING OF RADIO-IODINE FACILITY**

Proper planning of the facility ensures more efficient radiation protection and easier supervision. The design of the facility should always allow for modifications and extension to meet future needs. Radio-Iodine facilities serve as clinical department of the hospital and preferably should be located such that the access of unauthorized personnel is controlled. Common use of other facilities of Nuclear Medicine Department (such as dispensing room, measurement room, storage room, radioactive waste disposal/storage room, and radiation

protection arrangements etc.) reasonably reduces the costs of construction and number of personnel required.

At planning stage, the radio-iodine facility should generally be categorized into following four groups:

- i. Laboratories and premises not frequented by patients, including rooms for the storage, preparation, and dispensing of radio-iodine (controlled area).
- ii. Premises frequented by patients, including rooms for administration of radio-iodine and for carrying out measurements on patients (controlled area).
- iii. Storage places for radioactive waste materials (controlled area).
- iv. Offices for doctors and other facility personnel (supervised area).

#### **4.1 Design Consideration for Facility**

Gamma emitters are commonly used in Nuclear Medicine Departments; therefore, the background radiation is generally elevated. Radiation workers are exposed not only to the radiation received in nursing or dispensing the patients with radiopharmaceuticals in the laboratory but also to the continuous background radiation. Following recommendations should be considered in planning the radio-iodine facility to minimize the occupational exposure:

- i. Unnecessary radiation exposures should be avoided.
- ii. Radiation dose received by the radiation worker should not exceed his annual dose limit of 20 mSv/year, as prescribed in PAK/904.

An effort should be made to ensure that the exposure received by a radiation worker remaining continually in a radiation room should be as low as reasonably possible. If the exposure of a radiation worker approaches to maximum annual limit of a radiation worker, then he may not be allowed to continue work in radiation environment for the remaining year. In addition, Section 27 of PNRA regulations on radiation protection (PAK/904) and Publication 103 of International Commission on Radiological Protection (ICRP) [2] recommend following conditions of work with respect to radiations:

- a. Conditions such that the resulting (effective) dose might exceed 3/10th of the annual dose limit of radiation worker (Controlled Area).
- b. Conditions such that the resulting (effective) dose is most unlikely to exceed 3/10th of the annual dose limit of radiation worker (Supervised Area).

An important practical implication is that; under condition (a), the dose assessment of a radiation worker is usually based on individual monitoring for external radiations or internal contamination as appropriate; whereas under condition (b), workers may not require individual monitoring or special health supervision and it is sufficient in some cases to rely on area

monitoring. If these factors are considered at planning stage, the initial design cost of the facility may increase, however, running cost of the facility which incur on account of dose monitoring, health surveillance, and provision of shielding equipments is reasonably reduced which in-turn compensate for initial design cost.

It is recommended that planning and construction should be carried out on the basis of assumption that there would be no area within the facility where the radiation workers can receive more than 10% of his average weekly dose limit i.e. the dose should not exceed 100  $\mu\text{Sv}/\text{week}$ . As a result, the average dose will not be greater than 2  $\mu\text{Sv}/\text{h}$  in a working week of about 50 hours (as is often the case in hospitals).

The radiation detection and measuring equipment used in the diagnostic measurement rooms is usually very sensitive and may require extra shielding. Therefore, the background radiation level in such locations should be as low as that in the normal rooms e.g. about 0.1  $\mu\text{Gray}/\text{h}$ .

## **4.2 General Recommendations**

A standard Radio-Iodine Facility/Nuclear Medicine Center should have following features:

- i. All rooms should be spacious i.e. having about 10m<sup>2</sup> floor area [3].
- ii. The radio-pharmacy should be tidy and separate benches should be used for dispensing.
- iii. Separate areas/rooms should be designated for patients and staff.
- iv. Warning signs and instructions for visitors (particularly for pregnant women) should be prominently displayed in waiting area for the patients to whom radio-iodine is to be administered.
- v. Radiation warning signs and instructions should also be displayed in storage areas and dispensing rooms.
- vi. Isolation rooms should be available for admission of patients to whom therapeutic dose of radio-iodine is administered.
- vii. Radioactive waste collection bins should be available in hot lab, dispensing room and patient's isolation rooms.
- viii. Appropriate shielding devices should be provided for nursing staff and comforters entering the isolation rooms.
- ix. Bench tops, floors and patient toilets should be easy to wash and decontaminate.
- x. All relevant records should be prepared and maintained in an auditable form.

## **4.3 Design of Radioisotope Laboratory (Hot Lab)**

Radioisotope Laboratory or Hot Lab is the most important place within the facility. Since

large activity of Iodine-131 is handled here, therefore, a trained technician should be available to handle radiopharmaceuticals under the supervision of a qualified Medical Physicist/ Radiation Protection Officer (RPO). Following important points should be taken into consideration while designing a radioisotope laboratory or hot lab:

- i. The radioisotope laboratory should be separate from other laboratories/places.
- ii. Special attention should be given during the planning for ventilation, drains, fume hood, laminar airflow cabinet, disposal of waste and shielding requirement such that;
  - The ventilation of fume hoods should never be connected with the ventilation system of the building and the exhaust air should be released through charcoal filter and a straight corrosion-resistant tube at about 2 m above the roof.
- iii. The radioisotopes should be placed in shielded containers so that the background radiation level can be maintained as low as that in normal rooms (about 0.1 $\mu$ Sv/h) [3].
- iv. Building expansion joints should not pass through the laboratory.
- v. The seating arrangement should allow ready escape in case of an emergency.
- vi. Surface finishes to the walls, ceilings and furniture in the laboratory should be chosen so that they can be easily cleaned.
- vii. Floors should be made non-slip. Floor covering should be impermeable with welded joints and be coved against the walls for ease of decontamination. Rubber, Vinyl, or Asphalt tiles used in the floor have the advantage that these can readily be removed by replacing a few tiles, if contaminated.
- viii. Cupboards used to store radioisotopes should be lockable; provided with metal trays to contain spill and protect against fire.
- ix. All hazards involved in the work should be considered such as radioactive contamination, fire, mechanical, electrical, chemical and biological hazards etc.
- x. The entrance to hot lab should display a radiation warning sign and a text indicating "entrance is restricted to authorized persons only".
- xi. Hot Lab should be of sufficient size and separate work surfaces for handling radioisotopes and office work should be provided.
- xii. If dispensing room is part of the laboratory, this area should be segregated from the rest of the area, with no thorough passage. It should not be adjacent to film storage area or areas where low-level measurements are performed.
- xiii. Work should be performed over absorbent surfaces; bench paper or spill trays should be plastic-backed to prevent spread of contamination.
- xiv. Wash basins, provided with automated or elbow operated water taps, should be installed.
- xv. Sources of gamma or high-energy beta radiation should be handled using screen of lead glass or lead Perspex to protect the radiation worker.



- xvi. The vials containing radiopharmaceuticals should be placed in a fume hood to avoid airborne contamination and be stored away from high-occupancy areas of the laboratory.
- xvii. Cupboards or enclosed storage areas that are used for holding radiopharmaceuticals should be well shielded.
- xviii. If significant quantities of liquid waste are to be disposed off into the sewerage system, disposal should preferably be attached with delay tanks. Otherwise, dilution and dispersion method should be opted.
- xix. Pedal-operated shielded buckets, reserved for radioactive waste only, labeled with radiation symbol should be provided in the hot lab [3].
- xx. After completing the work with radiopharmaceuticals, workers should wash their hands and monitor their hands and shoes for the presence of any contamination.

#### **4.4 Design of Dispensing Room**

Following recommendations should be taken into consideration while designing the dispensing room:

- i. The room should be of 8-10m<sup>2</sup> area having a non-slip waterproof floor finish extending up to the walls to a height of about 10 cm [3].
- ii. The floor covering should be impermeable with welded joints and be coved against the walls for ease of decontamination. Preference should be given to Rubber, Vinyl, or Asphalt tiles which have the advantage that these can readily be removed by replacing a few tiles, if contaminated.
- iii. Wash basins for washing hands should be provided along with a hand monitor to ensure that the staff has no contamination.
- iv. Dispensing room should only be used for dispensing of radiopharmaceuticals for diagnostic and therapeutic purposes.
- v. Pedal-operated shielded buckets, reserved for radioactive waste only, labeled with radiation symbol should be provided in the dispensing room.

#### **4.5 Design of Isolation Room**

Following points should be taken into account while designing the isolation rooms:

- i. An isolation room should have an attached toilet and shower facility.
- ii. The bed should be located as remotely as possible from the entrance door and portable shielding screens should be used by the staff while visiting the patient's room.
- iii. Floor, walls and furniture surfaces should be smooth, continuous and impermeable for ease of decontamination.
- iv. Warning signs and instructions should be displayed outside the room door for

awareness of the visitors/comforters.

#### **4.6 Storage and Disposal of Radioactive Waste**

Radioactive waste should be disposed off in a manner that all regulatory requirements as specified in PNRA regulations on radioactive waste management - PAK/915 [4] are met. Solid radioactive waste should be collected and stored in shielded bins available in the area where it is generated prior to disposal. Liquid radioactive waste should be collected in delay tanks and not to be discharged in ordinary sewerage for disposal (except for patient excreta) unless authorized by RPO after ensuring that there is no radiation risk to the environment. General guidelines for handling and disposal of radioactive waste are outlined below.

- i. Volume of solid waste should be kept as small as possible.
- ii. A separate room for interim storage of radioactive waste should be available.
- iii. The room should be locked, ventilated and properly marked with instructions and radiation warning signs.
- iv. Radioactive waste (vials, syringes, bags, etc) should be segregated and should be collected in separate containers properly labeled providing information about the radionuclide, its activity and concentration etc.
- v. Flammable material should not be kept inside the radioactive waste storage room.
- vi. Lids of radioactive waste bins and containers should be securely placed at all times even when the containers are not in use.
- vii. Radioactive waste containing infectious material should be treated to render it non-infectious prior to disposal.
- viii. Record should be maintained in a retrievable manner which includes the date of disposal, model and serial number of survey instrument used, the background radiation level, dose rate measured at the surface of each waste container, and the name of individual who performed the disposal.
- ix. Generated radioactive waste should be stored for the purpose of delay and decay for a minimum period of 6 months prior to its final disposal (irrespective of its activity and half life) and relevant records should be retained for 3 years.

#### **4.7 Warning Signs and Labels**

Radiation warning signs and instructions should be displayed prominently outside the radiation area. These instructions should indicate possible radiation risk and dose level that may be present in the area. Magenta or black on a yellow background trefoil warning sign should be used to indicate the presence of ionizing radiations.

### **5 PROCEDURE FOR HANDLING RADIO-IODINE**

The following procedures should be adopted in all cases where radioiodine is being handled.

- i. The radioiodine should always be stored in a shielded container placed in a controlled area.
- ii. The lead container should be of 1-3 cm thickness to ensure minimum dose rate at external surface of the container [3].
- iii. Vials containing radio-iodine should always be handled in the fume hood.
- iv. Receptacles, fabrics, clothing, handkerchiefs etc., likely to become contaminated should be of disposable nature, whenever practicable.
- v. All items known or suspected to be contaminated should be stored in containers, which can be readily decontaminated or disposed off. Such items should be disposed off under the supervision of RPO to ensure the level of contamination is below the exemption level.
- vi. All items of non-disposable nature should be checked under the supervision of RPO to determine the level of contamination before and after decontamination, and returned to routine use when declared to be clear by the RPO.
- vii. Nursing staff carrying out procedures which may result in contamination of skin and/or clothing should wear protective gloves and gowns. Their hands and clothing should be monitored after completion of work and if necessary, decontamination should be performed under the supervision of RPO, without any delay.
- viii. Catheterization should be considered when the patient is, or likely to be, incontinent or otherwise incapacitated, to avoid spread of contamination over his clothes, bedding or floor.
- ix. Nappies of infant inpatients administered with radio-iodine should be changed frequently and the used ones, properly sealed in thick plastic bags, should be disposed off/ stored for decay.
- x. The ideal method for hospitalized patients, administered with greater than 30mCi radio-iodine, is the use of special toilet suite connected to delay-and-decay tanks. However, the patient, who is administered with less than 30mCi should use an ordinary toilet which has been reserved solely for that patient's use during treatment.

Special precautions should be taken to reduce the risk of spill of radioactive body fluids e.g. vomit, blood, urine and feces etc. Instructions should be given by RPO to take appropriate action in the event of a spill of radioactive body fluid. These instructions should be prepared based on following detail regarding minor and major spill of radioactive fluids:

### **5.1 Minor Spills**

Minor spills include typically less than 100 times exempted quantities of radionuclides mentioned in ANNEX-I of PNRA regulations on radiation protection (PAK/904). In case of a

minor spill, following procedural steps should be followed:

- i. Inform persons in the affected area that a spill has occurred. Keep them away from the contaminated place.
- ii. Clean up the spill by wearing protective clothing and disposable gloves, using absorbent paper and place it in a plastic bag for transfer to a labeled waste container.
- iii. Work from outside of the spill towards the centre to avoid spreading of contamination.
- iv. Carry out wipe test or survey for residual contamination as appropriate. Repeat decontamination, if necessary, until surface contamination monitoring results reach the dose rate less than 0.02mR/h (0.2  $\mu$ Sv/h) [8].
- v. Check hands, clothing, and shoes for presence of contamination, if any.
- vi. Report the spill and decontamination results to the person incharge and, if necessary, to the RPO.
- vii. Record necessary details regarding spill and decontamination results. Update the radionuclide's inventory and waste records accordingly.

## 5.2 Major Spills

Major spills involve more than 100 times of exempted quantities of radionuclides or contamination of personnel or release of volatile radioactive material. In case of major spills, following procedural steps should be followed:

- i. Immediately evacuate and cordon off the spill area and post warning sign(s) to prevent further entry of personnel.
- ii. Notify the RPO or person in-charge immediately.
- iii. The RPO should take decision for carrying out decontamination of affected area, personnel and necessary cleanup operations.
- iv. Decontaminate personnel by removing their contaminated clothing and flushing contaminated part of skin with lukewarm water and mild soap.
- v. Follow the decontamination procedures as prescribed earlier for minor spills and repeat if necessary until contamination monitoring results approaches the dose rate value of less than 0.02mR/h (0.2  $\mu$ Sv/h) [8].
- vi. If the spill occurs in a laboratory, leave the fume hood running to minimize the release of volatile radionuclides to adjacent rooms and hallways.
- vii. Record the names of persons involved in handling the spill and conducting necessary recovery operations.
- viii. All the persons involved should be monitored for contamination before leaving the spillage area.
- ix. The RPO should arrange for any bioassay measurements, if necessary.

- x. The RPO should submit a detailed report to PNRA within two months of the incident.

## 6 DOSE ADMINISTRATION

There are different methodologies for dose administration that are adopted worldwide. Usually therapeutic dose of I-131 is administered in a single dose/fraction having activity about 5550MBq or in multiple doses/fractions of activity 1110MBq per fraction. The patient, to whom more than 1110MBq of I-131 is administered, should be hospitalized and should not be discharged until the activity is less than 1110MBq and the measured dose rate at one meter from the patient is less than 20-50 $\mu$ Sv/h (as a good practice). Moreover, if patient-specific calculations demonstrate that potential total effective dose to any individual around him would not be greater than 5mSv then he may be discharged from the hospital with specific set of instructions .

On a specified time, the vial containing radio-iodine which is to be administered is brought on a cart to the patient's room in its shielded shipping container according to the transport requirements as specified in PNRA regulations for the safe transport of radioactive material - PAK/916 [6]. Before dose administration, the nursing staff must ensure that all aspects of therapy have been explained to the patient and that the patient has signed the therapy consent form. Once this has been confirmed, the dose can be administered. All contamination precautions must now be observed. The nursing staff or any other individual entering the isolation room should wear necessary protective clothing which include; 2 pairs of shoe covers, 2 pairs of disposable gloves, surgical gown, a mask and optional hair cover.

Greater care must be exercised while administering the radio-iodine dose. Plastic-lined absorbent pads should be used to cover the dosing table and those areas of patient's body that may be subjected to any potential spillage. The vial must remain in its shielded container during administration and a straw should be provided to the patient to drink the radionuclide contents. Once the dose is administered, the nursing staff should wrap the shielded dose vial, straw, and any other possibly contaminated items in the absorbent pads and remove them from the room. The dose vial should be assayed promptly to determine the residual activity so that the actual administered activity could be calculated. This determination of administered activity can be used in conjunction with daily exposure rate measurements to determine the activity remaining in the patient's body. An expression to determine the activity remaining in the patient's body based on exposure rates is given below:

$$\text{Activity Administered} = (\text{Total Activity} - \text{Residual Activity}) \text{ MBq}$$

$$\text{Remaining Activity} = \frac{\text{New Exposure Rate}}{\text{Initial Exposure Rate}} \times \text{Administered Activity}$$

## **6.1 Precautionary Measures after Dose Administration**

Following precautionary measures should be followed after the administration of radio-iodine dose to the patient [7]:

- i. Nursing staff should be trained and strict compliance of radiation protection requirements must be ensured by the licensee.
- ii. Once the patient is admitted in the isolation room after administration of radio-iodine dose, nurse in-charge should inform him about any expected cause of contamination and duration of its persistence.
- iii. Door of the isolation room should be kept closed when the patient is admitted.
- iv. Containers should be provided for temporary storage of used utensils and linen, before they are checked for contamination.
- v. The patient should be instructed to attend the collection of excreta preferably himself and hand it over to the nursing staff.
- vi. When prolonged nursing care is necessary, it should be so divided among the ward staff that the dose received by each individual during his shift is kept to a minimum.

## **7 DECONTAMINATION**

Contamination occurs when a radionuclide spreads beyond its normal place of confinement. The radionuclide thus spread may contaminate the environment (air, water, floors, and surfaces in general) and become partly fixed. It may eventually affect human beings internally or externally by exposing them to the radiations being emitted. The external contamination may involve; personnel, clothing and bedding, laboratory equipment and instruments, working surfaces and other surfaces in the room. Every nuclear medicine centre handling radio-iodine should establish decontamination team composed of personnel specially trained in decontamination techniques and possessing all necessary equipment and chemicals required for decontamination.

### **7.1 Decontamination of Personnel**

Radio-iodine can affect persons who handle it or those who come in contact with the patients carrying radio-iodine (through vomiting, discharges associated with injections, contaminated bed linen, and excreta). It takes the form of contamination on the hands or other areas of the skin or scalp.

Radiation exposure to the skin considerably increases when the skin is externally contaminated. Moreover, internal contamination increases if radio-iodine passes through open wounds. If contamination monitor detects contamination of hands or skin, the radioactivity can be reduced below the detection level by carefully washing the skin with soap. Ordinary soap has proved to be the best decontaminant in the event of skin contamination. If the contamination persists, decontamination should be repeated by a decontamination team. One

can try to reduce the radioactivity by washing the skin with an entraining agent (A detergent ointment with a titanium dioxide base/or saturated potassium permanganate solution). Chemical treatments of this kind should be applied with care in order not to damage the skin, and the same is true for the use of light abrasives and scrubbing agents. Every nuclear medicine center should be equipped with eye-cups and shower facility in the vicinity of change room.

## **7.2 Decontamination of Clothing and Bedding**

In nuclear medicine centers/hospitals, clothing and bedding usually become contaminated by perspiration, discharges following injections, incontinence of a patient, vomiting, or due to some other reasons. It is important to change the contaminated clothing and bedding immediately and to seal and store them in polythene bags until they can be sent to laundry.

Contaminated clothing carries the risk of irradiation of skin and the hazard of internal exposure, if radio-iodine is inhaled or ingested. It can easily be detected with portable contamination monitors. Contaminated clothes and bedding or linen should be washed in a special laundry so as to avoid the washing of contaminated and non contaminated clothing together. Either soap or a detergent can be used for washing.

The operation is preceded and followed by extensive rinsing. A hot 1% Citric Acid solution can also be used. Highly contaminated clothing or linen can be stored for a while to allow the short-lived radionuclides to decay. If contamination with long-lived radioisotopes cannot be removed by laundering, the linen should be treated as radioactive waste. After laundering, clothing should be monitored for residual contamination. Residual levels should be within the limits specified in ANNEX-I of PAK/904.

## **7.3 Decontamination of Equipment and Apparatus**

The contamination of equipment such as glassware and minor laboratory tools is highly undesirable as it may lead to contamination of the staff and may also be a source of errors in analyses and measurements. The degree of contamination of laboratory equipment and apparatus is often difficult to determine with accuracy. All parts of equipment/instrument should be assumed as contaminated, prior to conducting decontamination activity.

After use, porcelain and glassware should be cleaned with appropriate detergents or chemical decontaminants. Chromic Acid cleaning mixture ( $K_2Cr_2O_7 + H_2SO_4$ ) is most commonly used chemical decontaminant. Other chemical agents such as Ammonium Citrate  $[(NH_4)_3C_6H_5O_7]$ , Penta-sodium Tri-phosphate ( $Na_5P_3O_{10}$ ) and Ammonium Fluoride ( $NH_4HF_2$ ) can also be used. Metal objects should first be cleaned with good detergents; if contamination persists then complexing agents (Acitrate-Edetic Acid mixture), Ammonium Fluoride, or dilute acid solutions may be used. Ordinary metal cleaners are usually used to clean stainless steel equipment/instrument. If contamination still persists, a mild abrasive such as a mixture of

Nitric Acid and 1% Sodium Fluoride can be employed.

If above methods prove inadequate, one can resort to sand-blasting and/or ultrasonic techniques. The choice of method depends primarily on the type of equipment and whether or not it can withstand the treatment which might lead to the loss of material. If the contaminant is a short-lived radionuclide, the equipment/instrument which proves difficult to decontaminate must be stored until the radioactivity has decayed; otherwise it must be disposed off as a radioactive waste.

#### **7.4 Decontamination of Surfaces and Floors**

Contamination of working surfaces, floors, and corridors may originate from spills, settling of aerosols present in the air and the transfer of contamination through shoes. It may also result from an incident involving contamination such as overturning of radioactive solutions or substances and vomiting etc. The result of such incident may be the contamination of surfaces, floors, skin, clothing and bedding. The contaminating material may also form a suspension in the air and lead to internal exposure if inhaled.

Working surfaces and floors should be periodically checked for contamination and should be decontaminated whenever the levels exceed allowable limits. The cleaning-up operation should usually be carried out by sweeping the surface with a broom or brush wetted with a suitable agent, or by mopping it with a damp cloth. Dry sweeping should always be avoided as it may result into the contamination becoming airborne. Linoleum-covered or painted floors should be decontaminated by means of detergents, care being taken to avoid the spreading of contamination. If contamination persists, the floor coverings or paint must be removed.

When a radioactive solution is spilt, the first step is to prevent the contamination from spreading. The liquid should be covered with sawdust, absorbent material or dry rags immediately. Decontamination can be carried out by mopping the surface with a damp cloth, by ordinary washing, or by scrubbing. If a patient vomits within five hours of administering radio-iodine dose, all affected floors, bedding, linen, and persons around him must undergo same decontamination procedures as are applied in the event of spillage of radio-iodine.

#### **7.5 Wipe Test**

Wipe tests are used to determine the amount and level of contamination present in the affected area, however, it does not measure the entire contamination that is present. The procedure followed for wipe test consists of the following steps:

- i. Put on disposable gloves.
- ii. Wipe the filter paper or a cotton swab of appropriate size across the affected area. Dry wipes should preferably be used.



- iii. For determination of contamination on the surface of a package, an area of 300 cm<sup>2</sup> should be wiped.
- iv. For determination of contamination on a working surface or a floor, an area of 100 cm<sup>2</sup> should be wiped.
- v. Take the activity counts of a background sample and the test sample using a well shape counter with Sodium Iodide (NaI) detector.
- vi. Compare this reading with the applicable threshold levels; carryout the decontamination procedure, if it exceeds the applicable threshold level.

## **8 CONTROL OF VISITORS**

The management of the facility is responsible to protect the visitors from undue exposure to radiations. Following precautionary measures should be adopted for the protection of personnel visiting the patients:

- i. Visitors should not be allowed to visit their patients within 48 hours after administration of radio-iodine. Un-necessary visits/meetings should be discouraged.
- ii. Pregnant women and children under the age of 18 should not be permitted to visit the patient admitted in isolation room.
- iii. The duration of visit should be as short as possible.
- iv. Visitors should be advised to keep themselves at a reasonable distance from the patient (preferably at a distance of about 2m or behind the shielded screens).
- v. Visitors should be advised not to kiss the patient and not even eat, drink or smoke in the patient's room.
- vi. Visitors should also be advised to avoid using the toilet or sink in the patient's room.

## **9 RADIATION PROTECTION PROGRAM**

The management of a facility/nuclear medicine center must ensure that a Radiation Protection Program is developed, documented, implemented and regularly reviewed to ensure safety in all practices in which radioisotopes are used. The radiation protection program of the facility should include the following:

- i. Work practices;
- ii. Roles and responsibilities of RPO, Nursing Staff etc;
- iii. Radiation monitoring requirements and availability of monitoring equipment ;
- iv. Control of incidents involving contamination;
- v. Storage and transportation arrangements of radiopharmaceuticals;
- vi. Radiation protection measures applicable in isolation rooms;
- vii. Inventory control and records of radiopharmaceuticals; and

- viii. Any other requirement that may have bearing on safety.

## **10 EMERGENCY PROCEDURES**

Each facility/nuclear medicine center is responsible to ensure that emergency plan for the incidents and emergencies involving radionuclides is developed and effectively implemented. Emergency procedures for the implementation of emergency plan should be identified while developing the emergency plan of the facility. Following items should be considered during preparation of emergency procedures:

- i. Instructions on immediate actions that need to be taken to protect human life, limit injury and provide first aid where required;
- ii. Instructions on immediate actions needed to bring the incident under control, including details on actions necessary to prevent further spread of contamination (if this possibility arises);
- iii. Instructions for personnel involved to report the incident to RPO or his designated alternate;
- iv. Instructions for the RPO or his designated alternate to communicate this information and any follow-up on the developing situation to PNRA;
- v. Lists containing names, addresses and telephone numbers of responsible personnel required in the event of an emergency (these should be checked and updated at least once every six months and/or whenever changes in the arrangements are made);
- vi. Instructions to be followed when safety procedures or working rules are not sufficient; and
- vii. Instructions on emergency response actions following radioactive spillage, vomiting, fire, flood, explosion or any other disaster or incident within the facility.

## 11 REFERENCES

- [1] PNRA “Regulations on Radiation Protection” - PAK/904.
- [2] ICRP Publication No. 103, “Recommendations of the International Commission on Radiological Protection”, 2007, ICRP, Elsevier.
- [3] FROST, H. JAMMET, “Manual on Radiation Protection in Hospitals and General Practice”, Volume 2, World Health Organization, and Geneva: 1975.
- [4] PNRA “Regulations on Radioactive Waste Management” - PAK/915.
- [5] IAEA Safety Reports Series No. 63, “Release of Patients After Radionuclide Therapy”, 2009, IAEA, and Vienna, Austria.
- [6] PNRA “Regulations for the Safe Transport of Radioactive Material” - PAK/916.
- [7] Michael A. Thompson “Radiation Safety Precautions in the Management of the Hospitalized I-131 Therapy Patient”, Journal of Nuclear Medicine Technology, Volume 29, Number 2, pp. 61-66, 2001.
- [8] IAEA “Manual for First Responders to a Radiological Emergency”, October, 2006, Vienna, Austria.

## GLOSSARY

**ABSORBED DOSE:** The energy imparted to matter by ionizing radiation per unit mass of irradiated material

**CONTROLLED AREA:** A defined area in which specific protection measures and safety provisions are or could be required for controlling normal exposures or preventing the spread of contamination during normal working conditions, and preventing or limiting the extent of potential exposures

**DECONTAMINATION:** The complete or partial removal of contamination by a deliberate physical, chemical or biological process.

**DOSE:** A measure of the energy deposited by radiation in a target. It includes absorbed dose, committed equivalent dose, committed effective dose, effective dose, equivalent dose or organ dose.

**DOSE RATE:** The radiation dose delivered per unit time and measured in dose per second or dose per hour e.g. millisieverts per hour.

**DOSIMETER:** A device that measures radiation dose, such as film badge, ionization chamber, or TLD.

**EXPOSURE RATE:** The amount of ionization produced in air per time, in units of R/hr for example.

**NORMAL/RADIATION ROOMS:** A room in which radiation level is about  $10\mu\text{rad/h}$  is known as normal room and if in any room radiation level is higher than  $10\mu\text{rad/h}$  is categorized as radiation room.

**OCCUPATIONAL EXPOSURE:** Exposure of an individual to radiation (1) in a restricted area; or (2) in the course of employment in which the individual's duties involve exposure to radiation.

**PNRA:** Pakistan Nuclear Regulatory Authority.

**RADIATION:** Ionizing radiation i.e. gamma rays, X-rays, alpha and beta particles, high speed electrons, neutrons, and other nuclear particles.

**RADIATION AREA:** Any area accessible to individuals in whom there exists radiation at such levels that a person could receive a dose equivalent in excess of  $50\mu\text{Sv}$  in one hour at 30 centimeters from the source or any surface that the radiation penetrates.

**RADIOACTIVE MATERIAL:** Any material (solid, liquid, or gas) which emits radiation spontaneously.

**RADIOACTIVITY:** The disintegration of unstable atomic nuclei by the emission of radiation.

**RESTRICTED AREA:** Any area where access is controlled by the licensee for the purpose of protection of individuals from exposure to radiation and radioactive material.

RPO: Radiation Protection Officer.

**SUPERVISED AREA:** A defined area not designated as controlled area but for which occupational exposure conditions are kept under review, even though no specific protection measures or safety provisions are normally needed.

**TLD:** Thermo luminescent dosimeter.

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