NRLSD Bulletin No. 91-2 CONTAMINATION AND DECONTAMINATION OF RADIOPHARMACEUTICAL

A. ADDRESSEES

All licensees using radiopharmaceuticals.

B. PURPOSE

This bulletin is issued to provide guidance to licensees on radioactive material contamination, its causes, prevention, and decontamination.

C. DESCRIPTION OF CIRCUMSTANCES

During spot-check monitoring of nuclear medicine personnel who pick up shipments of radioiodine at the Institute, a physician and his assistant were found to be grossly contaminated not only in their hands but also in their clothing and large areas of their vehicle, such as the steering wheel, gear shift, seat cover, etc. A radiological survey on the nuclear medicine laboratory was also done and it was found that nearly all areas were grossly contaminated, e.g., working table tops, sinks, refrigerator door handle, knobs of instruments and entrance door, switches and many parts of the tiled floor. Significant activity was also detected in the physician's office table top and visitor's chair. The extent of contamination on the flooring was such that even after decontamination with radiac wash, the RHSO still decided to replace the floor tiles.

Obviously, contamination has occurred in the laboratory for some time before it was discovered. Because the initial contamination was not immediately detected and attended to, cross contamination of equipment, flooring, and other work areas occurred.

D. DISCUSSION

Contamination

Operations involving the use of radiopharmaceuticals are likely to cause contamination.

The laboratory air and working surfaces, equipment, clothing, and skin of personnel can become contaminated, e.g., by spills, volatilization or aerosol formation.

Contamination must be controlled not only because the external radiation dose will contribute substantially to the total radiation dose one may receive under operating limits but also because of technical considerations such as desirability of minimizing transfer of radioactivity from one area to another, the necessity for low radiation background in the use of certain instruments, or of the administrative

desirability of minimizing the need for special precautions to avoid personal contamination with radioactivity while working in laboratory areas.

Radiation exposures due to external contamination is minimal compared to those from internal contamination. Radionuclides that gain entry into the body remain in the body for varied periods of time and cause irradiation of critical organs until they are eliminated. Thus, alpha and low-energy beta emitters, which are not hazardous as external sources of radiation, become radiation hazards once they gain entry into the body. Internal contamination must be controlled to ensure that the annual dose equivalent limits (refer to Table 1 of Appendix B) are not exceeded.

Internal contamination can be brought about by ingestion, inhalation, or absorption through the skin. For example, the operator uses his contaminated hands to handle his food, or inhales contaminated air in the room, or the radioactive material enters the body through wounds or by penetration through the skin.

It would be useful to evaluate the basic and proximate causes of contamination so as to prevent similar occurrences. It is also essential that all persons who may be subjected to radioactive contamination be aware of the appropriate actions to be taken to ensure protection against contamination, the ways to prevent or minimize its spread and the methods of decontamination.

Causes of Contamination

Some of the possible causes of contamination are the following:

1. Chemical/physical operations in the area, e.g., evaporation, solvent extraction, chemical reactions, stirring in beakers.

2. Minute particulates of the radioactive material getting into the atmosphere.

3. Spillages.

4. In-leakages of contaminated air from fume hoods where radioactive work is progressing.

5. Spread of contamination due to poor housekeeping habits in the laboratory, e.g., further use of contaminated absorbent material.

6. Transfer of radioactive material from one area to another.

Prevention of Contamination

Contamination can be prevented by a combination of the following:

1. Proper design of working areas.

2. Proper choice of surface materials.

3. Use of correct and appropriate protective clothing.

4. Training of operating personnel.

5. Correct operating procedures.

6. Good housekeeping procedures.

7. Use of appropriate contamination monitoring instruments.

(Refer to Appendix A-1 for discussion of the above.)

Decontamination

Before decontaminating, one has to decide whether to decontaminate an article or not because there are cases where it would be better to store the contaminated article and let the activity die down to permissible levels or to dispose of it as waste. Also, one has to take into account the continuing value of the material compared with the risks and cost of decontamination.

The fundamental principles which are applicable to all decontamination procedures are:

1. Wet decontamination methods should always be used in preference to dry.

2. Mild decontamination methods should be tried before resorting to treatment which can damage the surfaces involved.

3. Precautions must always be taken to prevent the spread of the contaminating radioactive material during decontamination operations.

4. Where possible, contamination involving short-lived activities should be segregated and isolated to allow natural decay to take its course.

(Principles of decontamination of personnel, working areas, equipment and protective clothing are discussed in Appendix A-2.)

Limits of Contamination

The levels of contamination on accessible and inaccessible surfaces shall be limited so that the associated radiation levels and the concentrations of radioactive material in air and water from releases and dispersions are within operational limits (refer to Appendix B of CPR Part 3 for the DAC and DWC limits). However, it is not possible to express a simple quantitative relationship between the levels of radioactivity on various surfaces and the resulting radiation doses to personnel since the doses will depend on several factors associated with the contamination, such as: (a) the nature and quantity of the contaminating radionuclide; (b) the nature of the

contaminated surface, e.g. its structure and condition; (c) environmental factors, e.g. degree of occupancy, kind of work performed, ventilation, humidity; (d) personnel contamination control measures provided in the working area, e.g. protective clothing, respiratory protection, and others; and (e) personal habits of workers, e.g. biting pencils and fingers.

(Values of the limits for removable surface contamination in medical institutions are shown in Table 3 of Appendix B.)

E. REQUIRED LICENSEE ACTIONS

In response to this bulletin, licensees are required to familiarize their personnel with the probable causes of contamination in their particular laboratory and methods of minimizing and controlling radioactive contamination, and of preventing its spread. They should designate one individual who will be responsible for measures dealing with contamination, formulate instructions and provide materials and device for decontamination procedures, and ensure that the staff be fully trained in such procedures.

A copy of the decontamination procedures established for specific isotopes used in the laboratory should be submitted to the Institute.

F. COMPLIANCE SCHEDULE

Licensees shall inform the Institute of the actions taken to comply with this Bulletin within 60 calendar days after receipt hereof.

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APPENDIX A-1

PREVENTION OF CONTAMINATION

Prevention of contamination can be accomplished by a combination of the following:

1. Proper design of working areas.

    a. Floors, walls and working surfaces should be such that they can easily be kept clean.

    b. Furniture should be reduced to a minimum and should be easily washable. Dust-collecting items such as drawers, shelves and hanging lamps should be as few as possible.

    c. Adequate ventilation should be provided; air flow should be from least to most contaminated area.

    d. The work area should be adequately lighted.

    e. The inlet and exhaust vents should be located so as to prevent any recirculation of exhausted air.

2. Proper choice of surface materials.

    The following should be considered in making the choice:

    a. The provision of a smooth, chemically inert surface for easy decontamination.

    b. The environmental conditions of temperature, humidity, and mechanical wear and tear to which the surfaces may be exposed.

    c. The need for repair in the event of damage.

3. Use of correct and appropriate protective clothing.

    Protective clothing for radioactive work may be considered under two headings -- routine and emergency.

    a. Routine protective clothing

        This includes laboratory coats, overalls, aprons, rubber or disposable plastic gloves, footwear and breathing apparatus.

b. Emergency protective clothing

This includes special clothing for purposes such as maintenance work, decontamination and emergency operations.

4. Training operating personnel in methods of:

a. Minimizing contamination
b. Controlling the spread of contamination
c. Monitoring for contamination
d. Decontamination procedures

5. Correct operating methods.

a. Proper planning of work with radioactive material according to approved written operating procedures.

b. Proper technique to avoid build-up of contamination (i.e., on reusable gloves).

c. Provision of absorbent material over working surfaces when handling liquid sources.

d. Storage of radiopharmaceuticals in tightly closed containers, except where chemical, radiation, or other action may produce undesirable gas pressures within the container.

e. Confinement of work with volatile and gaseous radioactive materials in fume hoods.

f. Use of special equipment or specially modified conventional chemical apparatus (e.g., shielded cell, remote-handling apparatus, etc.).

6. Good housekeeping procedures.

a. Regular and proper cleaning of controlled areas by persons aware of the precautions to be taken to avoid spread of contamination.

b. Periodic monitoring of cleaning equipment (e.g., mops, brushes, rags) used in controlled areas and restricting their use in such areas.

c. Proper storage and/or management of contaminated glasswares, syringes, pipettes and similar laboratory devices.

d. Periodic monitoring of laboratory sink and adjacent areas where open sources are usually handled.

7. Use of appropriate contamination monitoring instruments.

The suitability of monitoring instruments relates to the matching of the instrument to the type, nature, intensity and energy of the radiation that has to be monitored and to the conditions of use.

APPENDIX A-2

DECONTAMINATION

Decontamination of Personnel

Decontaminate the skin by washing and scrubbing very lightly the affected areas using soap and copious amount of water. The soap chosen should be mild so as not to produce skin abrasions after frequent use. Treated area shall be dried with fresh non-contaminated paper towel and monitored. If the contamination persists after two wash-and-scrub treatments, the person affected must be referred to the medical officer for any further treatment.

For the face, frequent rinsing is necessary, keeping the eyes and the mouth closed during washing. If the eye is being irrigated, it should be ascertained that the adjacent skin is not highly contaminated and that measures are taken to prevent contamination from being washed into the eye. The eye should be irrigated outwards to avoid contamination of their ducts. In drying with towels or other suitable materials, rubbing should be avoided. All cases of face contamination should be referred to the medical officer after the decontamination procedure.

For contaminated hair, wash several times with shampoo and water. Rinsing with copious amounts of water is necessary to ensure that contamination removed from the hair does not remain in the ears or on the face.

In case of contaminated small open wounds, cuts, punctures, etc., wash immediately with large volumes of running water, bleeding should be encouraged if necessary, and the medical officer should be consulted.

Decontamination of Working Areas

Measures for decontaminating working areas will depend upon the nature of the contamination, i.e. whether it is in loose form or is relatively fixed.

Removal of Loose Contamination

Loose contamination may be removed by using special decontamination apparatus, such as vacuum cleaners fitted with special filters. No attempt should be made to brush or dust it off, though in the case of slight contamination on the

floor, a wet medium such as dampened sawdust sprinkled over the contaminated area before brushing is acceptable.

For all other surfaces, wet methods such as swabbing are essential. The removal of contamination should be done with the minimum of rubbing and the swabs should be frequently discarded as radioactive waste.

Where there is copious loose contamination, a suitable strippable lacquer may be carefully applied to the contaminated surfaces. Lacquer is allowed to dry and then removed together with the contamination. After stripping, the affected areas should be washed.

Removal of Relatively Fixed Contamination

Only wet methods should be used. The first wash should be with suitable detergent solution which will remove loose contamination and all grease-held material. Contamination remaining after this treatment should be removed by further washing with suitable decontaminating solutions (refer to Table 2 of the Appendix) which may be allowed to remain in contact with the contaminated surfaces so that chemical reaction at the surface may assist the decontamination.

If surface contamination still remains, further treatment should be undertaken depending on the material of the surface (refer to Table 2 of the Appendix for more stringent treatments).

Decontamination of Equipment

Decontamination of equipment should be carried out as soon as possible after its removal from the active area to avoid contamination from becoming fixed. Decontamination should be carried out using wet methods. The same decontamination procedure can be followed for all equipment, except in the reagents used and the application techniques which should be appropriate to the type of material (e.g., glasswares, metal or plastic laboratory tools). The routine procedures are:

1. Wash in detergent solution at raised temperatures to remove all loose and grease-held contamination or immerse in cleaning baths. This may be followed by swabbing and light scrubbing with the same solution.

2. Decontaminated equipment should be rinsed in clean water and dried before monitoring.

3. If contamination remains after the above treatment, further scrubbing and steeping techniques may be used. The equipment is placed in suitable decontaminating solution which contains complexing agents (e.g., citric acid or salts of ethylene diamine tetraacetic acid (EDTA)), preferably at raised temperatures. Precautions should be taken to ensure that the surface of the equipment is not unduly etched.

4. Further methods will depend upon the extent and nature of residual contamination i.e., abrasives or strong acids may be applied over the contaminated surface or soaking in acid solution will be necessary.

Decontamination of Clothing

Contaminated clothing should not be released to public laundries or centralized laundries in hospitals. Segregate the clothing according to the different contaminants and different levels of contamination. Give clothing two full washes (washing solution may consist of detergent, sodium metasilicate, sodium acid phosphate and citric acid) with a rinse in clean water after each wash and dry thoroughly before monitoring it. For articles contaminated above the prescribed levels with short-lived radionuclides, storage-to-decay is recommended. If contamination in the clothing cannot be decreased to a safe level, it should be treated as radioactive waste.

APPENDIX B

Table 1. Annual Dose Limitations

Location of Exposure	Radiation Workers	Members of the Public
Whole body	50 mSv (5 rem)	5 mSv (0.5 rem)
Individual organs and tissues	500 mSv (50 rem)	50 mSv (5 rem)
Lens of the eye	150 mSv (15 rem)	15 mSv (1.5 rem)

Reference: Code of PAEC Regulations, Part 3, Standards for Protection Against Radiation, 1990.

Table 2. Decontamination Methods for Specific Surfaces

Contaminated Area	Decontaminating Agent	Stringent Treatment
Wood	Hot citric acid	Scrape off the wooden surface with a plane or floor chipper and collect the particles using a small vacuum cleaner
PVC	Non-flammable chlorinated organic solvent	Replace the affected parts
Stainless Steel	Phosphoric acid & dilute nitric acid	Use HCl
Linoleum	CCl_4, kerosene	
Rubber	Dilute nitric acid	
Glass	Chromic acid cleaning solution or concentrated nitric acid	Wash with mineral acids or solution of ammonium citrate, trisodium phosphate, or ammonium biflouride
Plastic	Ammonium citrates, dilute acids, organic solvents	
Ceramic tile	Mineral acids, ammonium citrate, trisodium phosphate	Swab with a special inhibited phosphoric acid formulation containing a wetting agent
Brick & concrete	32% HCl acid	Remove the affected surface by mechanical means
Paint	CCl_4, 10% HCl acid	Remove the paint and repaint
Metal tools and machined surfaces	Dilute nitric acid, 10% soln. of sodium citrate or ammonium biflouride Very weak solutionn of inhibited phosphoric acid (1% deoxidene)	Use a vapour blast machine using very fine abrasive. If the tools are crude types (spanners, etc.) then vapour blast using a heavy abrasive is possible

Reference: International Atomic Energy Agency, Evaluation of Radiation Emergencies and accidents, Technical Reports Series No. 152, IAEA, Vienna (1974), Table LII and Manual on Decontamination of Surfaces, Safety Series No. 48, IAEA, Vienna, 1979.

Table 3. Limits for Removable Surface Contamination in Medical Institutions*

Type of Surface	Type of Radioactive Material**		
	Alpha Emitters Bq/cm^2 (μCi/cm^2)	Beta or X-ray Emitters Bq/cm^2 (μCi/cm^2)	Low-Risk Beta or X-ray Emitters Bq/cm^2 (μCi/cm^2)
Unrestricted areas	0.04 (10^{-6})	0.4 (10^{-5})	4.0 (10^{-4})
Restricted areas	0.4 (10^{-5})	4.0 (10^{-4})	40.0 (10^{-3})
Personal clothing worn outside restricted areas	0.04 (10^{-6})	0.4 (10^{-5})	4.0 (10^{-4})
Protective clothing worn only in restricted areas	0.4 (10^{-5})	4.0 (10^{-4})	40.0 (10^{-3})
Skin	0.4 (10^{-5})	4.0 (10^{-4})	4.0 (10^{-4})

* Averaging is acceptable over inanimate areas of up to 300 cm^2 or, for floors, walls, and ceiling, 100 cm^2. Averaging is also acceptable over 100 cm^2 for skin or, for the hands, over the whole area of the hand, nominally 300 cm^2.

** Beta or x-ray emitter values are applicable for all beta or x-ray emitters other than those considered low risk. Low-risk nuclides include C-14, H-3, S-35, Tc-99m, and others whose beta energies are <0.2 MeV maximum, whose gamma or x-ray emission is less than 0.1 R/h at 1 meter per curie, and whose permissible concentration in air is greater than 10-6 uCi/ml.

Reference: U.S. Nuclear Regulatory Commission, Radiation Safety Surveys at Medical Institutions, Regulatory Guide 8.23, February 1979.