INTERNAL REPORT
PINSTECH/HPD-101

CODE OF PRACTICE AGAINST RADIATION HAZARDS AT PINSTECH (Revised 1982)

M.A. MUBARAK
M. JAVED
SHAKEEL AHMAD

Health Physics Division
Pakistan Institute of Nuclear Science and Technology
Nilore, Rawalpindi
October 1982

INTERNAL REPORT
PINSTECH/HPD - 101

CODE OF PRACTICE AGAINST RADIATION HAZARDS AT PINSTECH (Revised 1982)

M.A. MUBARAK

M. JAVED

SHAKEEL AHMAD

Health Physics Division

PAKISTAN INSTITUTE OF NUCLEAR SCIENCE & TECHNOLOGY

P.O. NILORE, ISLAMABAD

(October 1982)

CONTENTS

.-.-.-.-.-.-.-.

List of Table

List of Figures

1. INTRODUCTION

It is the radiation safety policy of PAEC/PINSTECH that all radiation exposure should be kept as low as reasonably achievable (ALARA). A code of practice against radiation hazards at PINSTECH was written in 1972 which regulated the conduct of radiation work at PINSTECH. Since the radiation work at PINSTECH has greatly increased, it was considered necessary to revise the code so as to incorporate the new concepts in this field as well as to help meet the present requirements of radiation protection.

The procedures setforth in this code are mandatory and in no case should any of them be deviated except under an emergency situation which may be handled according to procedures laid down in a separate manual "Emergency Procedures at PARR-PINSTECH" (PINSTECH/HP-19).

All those supervising or performing any kind of radiation work are required to study and adhere to these procedures. Copy of this code should be kept in every radiation laboratory for ready reference.

2. ADMINISTRATION - GENERAL

2.1. Responsibility.

2.1.1 Director - PINSTECH

Being the highest authority of the institute, the Director PINSTECH is responsible to ensure that all operations at PINSTECH are so conducted that the health and safety of the individuals inside or outside PINSTECH are adequately protected. To meet these responsibilities the Director should ensure that the following actions are taken

i) Safe working conditions and equipment appropriate to the degree of radiological hazard should be provided.

ii) Only persons who are medically suitable and adequately trained or experienced should be allowed to work with radioactive material.

iii) Suitable medical casualty service should be provided.

The Director will be assisted in this regard by the Head, Health Physics Division and the Nuclear Safety Committee.

2.1.2 Health Physics Division

The Health Physics Division would be responsible to provide radiological protection services to all radiation workers at PINSTECH. The radiological protection service would include the following

a) Radiation/contamination survey of all potentially radioactive/ contaminated areas.

b) Personnel monitoring, of all radiation workers, casual workers working in radiation area and visitors.

c) Environmental monitoring of all working places where airborne radioactivity is likely to be generated.

d) Maintenance of records pertaining to all kinds of monitoring.

e) Safety evaluation of radiation facility or radiation work and assessment of radiological hazards associated with them.

f) Approval of activities which involve actual or potential exposure to radiation or release of radioactive material to environment.

g) Maintenance of inventory of sealed/unsealed radiation sources and periodic inspection of these.

h) Specify the protective clothing and equipment requirement for the work in contamination one,

i) bio-analysis for internal exposure,

j) appropriate training and instruction to radiation workers,

k) calibration of radiation monitoring instruments,

l) formulation of safety procedures with regard to safe handling of radioactive material, and radiation facilities,

m) control over the movement of radioactive material to and from radiation area,

n) advice on matters related to radiation protection.

2.1.3 Nuclear Safety Committee

The Nuclear Safety Committee has been established by the Director to assure and offer direction for the safe use of radiation/radioactive material at PINSTECH. The committee at present is comprised of the following members:

1.	Head, NED	-	Chairman
2.	Head, NCD	-	Member
3.	Head, HPD	-	"
4.	Head, NMD		"
5.	Head, CNS	-	"
6.	Head, ROG	-	"
7.	Head, Op. H.P.G.		Member/Secretary

Additional members may be co-opted as and when considered necessary.

The Nuclear Safety Committee is the final authority on all matters pertaining to radiation safety. The committee shall review all applications for the use of radioactivity or radiation producing machines at PINSTECH. Any modification or improvement, it deems necessary in the interest of radiation safety, shall be effected at the earliest possible time. In case of non-compliance with the rules set forth in this code, the committee has an authority to terminate the authorisation for the use of radioactive matter/ radiation.

The committee shall normally meet once in each quarter to discuss new developments in radiological safety. However, the Chairman may call a meeting whenever he deems necessary. Minutes of the meetings shall be recorded and distributed to the all concerned.

2.1.4 Heads of Divisions

The Heads of Divisions are responsible for conducting all activities safely. Their radiation safety responsiblities include the following :

i) Assume responsibilities for attainment of policy objectives with regard to personnel exposure, personnel and environmental contamination.

ii) Inform Health Physics of new facilities or facilities to be significantly modified.

iv) Consult Health Physics in planning all operations where exposure to radiation or radioactive material might occur.

v) Inform Health Physics, whenever, work requiring the presence of health physicist, is to be performed.

vi) Initiate Radiation/special work permits as required for operations involving radioactive materials or radiation source.

vii) Stop all work likely to result in (i) significant personnel exposure (ii) Spread of contamination (iii) environmental contamination in working area unless it is judged for specific reasons that the advantage of continuing the operation outweighs the disadvantage.

viii) Cooperate with Health Physics in assessing radiation safety through notification of unusual occurances or incidents involving radioactive contamination, over-exposure or personal injury and by providing access to and making readily available, all relevant information.

x) Assume responsibility for the adequacy of employee training in radiation safety.

xi) Inform promptly the Director/Chairman NSCP or Head, Health Physics of all personnel over expocure, unusual contamination incident or excessive releases of radioactivity to environment.

xii) Ensure that work with radiation/radioactive material and the laboratory, if unsealed radioactive material are used, are approved by NSCP.

xiii) Ensure that all persons working in laboratory are registered as radiation workers and carry personal monitoring devices appropriate to the work in hand.

xiv) Provide protective clothing to his workers doing radiation work.

xv) Maintain a record of all radiation sources and provide to Health Physicist.

xvi) Appoint a Divisional Radiation Supervisor who may act on behalf of Head of Division in matters relating to radiation safety.

2.1.5 Laboratory Incharge/Supervisor.

The supervisor of the laboratory in which work is carried out, must ensure that the work is duly approved by the committee and that the laboratory also is approved particularly if unsealed radioactive materials are handled. He must also ensure that all personnel working in the laboratory carry appropriate personnel monitoring devices. He is also responsible for providing protective clothing to the workers as recommended by Health Physicist.

2.1.6 The Individual worker

It is the responsibility of the individual worker to understand the nature of hazards associated with the work which he undertakes and to perform his work in a manner which is in accordance with the approved procedures and which is safe for himself and for other persons. He must report to his supervisor and radiological protection service of any incident or occurance involving increased radiation risk.

2.2 Approval and Registration of work.

Prior approval of Health Physicist and/or NSCP shall invariably be required for all new radiation facilities: modification to existing facilities and operating procedures; irradiation in the reactor, all waste disposal procedures: production, acquisition and disposal of radioactive materials; alterations to and maintenance of radioactive facilities, experiements and operations involving handling of radiation and radioactive materials, use of radioactive materials by PINSTECH workers outside the limits of the institute etc. Appropriate proposal to this regard shall be put up in writting well in advance to area Health Physicist who may approve them by himself or submit them to the Nuclear Safety Committee in consultation with the Head Health Physics Division.

The write-ups to be prepared with regard to above must provide the following informations :-

i) Names of the supervisor of the operation and other workers.

ii) Place and/or facility to be used for experiment/operation.

iii) Description of the experiment/operation etc. including procedures to be followed.

iv) Type of radiation and/or quantity of radio-nuclides involved.

v) Estimated quantity and nature of radioactive wastes to be produced, if any.

vi) Details of transfer operations, if any, and specifications of transfer/transport containers.

vii) Definition and evaluation of hazards involved in the operation and measures to minimize such hazards.

An approved work certificate is valid, unless specified, for two years from the date of authorization after which it will automatically become void. A new application is required if the work is to be continued.

Health Physicist may recommend for the suspension of authorization if he is not satisfied with the precautions in force or discover that the safety rules are violated. An appeal to the safety committee for reassessment may be filed by the concerned.

2.3 Approval and grading of laboratories

Laboratories in which unsealed radioactive materials are handled shall be graded on the basis of finish, location and facilities provided; the grade will get an upper limit to the quantities of radioactive materials which may be handled. Details of these quantities and outline specification for the grades are given in chapter VI. Work with unsealed radioactive material must be carried out in approved laboratories and the quantity of unsealed radioactive materials must not exceed the limit set by Health Physicist.

2.4 Medical Examination of workers.

Pre-employment and routine medical examination of all radiation workers shall be arranged by Administrator PINSTECH, who shall also maintain record of such examinations.

The routine medical examination would be directed towards special investigations of those organs and functions which are regarded as particularly vulnerable to radiation hazard in the light of class of test undertaken. The routine examination should be carried out every twelve months or as and when required by H.P./NSCP.

2.5 Medical Casualty Service.

A medical casualty service should be availabe within PINSTECH during all working hours on week-days as well as during shifts, First aid equipment should be immediately available throughout the working area. Administrator PINSTECH shall be responsible to supply the necessary medicines for the first aid boxes and replenish the depleted medicines.

3. RADIATION AND CONTAMINATION CONTROL

The handling of radiation sources or radioactive material can give rise to certain hazards which may be divided into two broad classes :

a) External hazards, and b) Internal hazards.

By adopting appropriate safety measures, suitable precautions and through careful planning of the work, the handling of radiation sources may become a safe operation and chances of exposure to external and internal hazards may be minimised or reduced to a safe level.

3.1 Control of External Radiation Hazards.

External radiation hazards may arise from the radiation reaching the body from external sources. External radiation hazards can be minimized by reducing all external radiation levels to values which are as low as practicable. This can be accomplished by adopting following measures

i) The activity of the source used should be as low as possible.

ii) The energy or penetrating power of the emitted radiation should not be greater than that necessary to accomplish the task with minimum total exposure.

iii) If possible the radioactive material in the source should be of low toxicity and in such chemical and physical form as to minimise dispersion and ingestion in the event of container being broken.

iv) The distance between the radiation source and the worker may be kept the maximum possible. Remot handling tongs may be used.

v) The time spent in the vicinity of the source should be the minimum necessary. Work with radiation sources should, therefore be planned to limit exposure by limiting the working time. Dummy runs should preferably be performed, if possible.

vi) Adequate shielding between the source and the worker may be provided. Additional shielding may be used to ensure that other persons in the vicinity or in adjoining area are appropriately protected from radiation.

vii) Radiation sources should be measured to permit individual indentification and to facilitate determination of the nature and quantity of radioactivity without undue exposure of worker.

vii) Sealed sources and/or appropriate containers should be regularly examined for contamination or leakage (smear test may be used).

ix) Radiation sources should always be handled in such a way that proper location is possible at all time.

x) The loss of radiation source should be immediately notified to Health Physicist.

xi) Sources should not be touched by hand. Appropriate tools should be used,for instance, long-handled forceps with firm grip.

xii) Radiation sources should be handled in such a way as to avoid hazards to all personnel working in the adjacent area including rooms above and below. Areas subject to high radiation levels should be clearly marked and cordoned off.

xiii) Radiation field of 2.5 mrad/hr (0.025 mGy/hr) or more in controlled areas must be marked. Health Physicist must be notified of any changed circumstances which may be expected to alter the field.

xiv) A plan of procedure must be prepared in consultation with Health Physicist for any work which may cause personnel exposure of more than 100 mrad/per hour(1 mGy/hr). Such work must be performed in the presence of a member of Health Physics Staff.

3.2 Control of Internal Hazards and Radioactive Contamination.

Radiation arising from radioactive substances within the body constitutes an internal hazard. The radioactive substance may get entry into the body by inhalation, ingestion or through wounds and broken skin.

The radioactive contamination may also result in internal radiation hazard.

Precautions against internal radiation hazards and control of radioactive contamination include the following measures in addition to those against the external ha ard.

i) Al' operations with regard to handling of unsealed radioactive; materials should be planned to limit the spread or dispersal of radioactive material.

ii) Unnecessary movement of personnel or material to and from radioactive area should be restricted/avoided.

iii) Equipment, glassware, tools and cleaning equipment for use in active area should not be used for work in inactive areas and should be suitably marked.

iv) All equipment, tools etc. must be got monitored by Health Physics personnel before taking out of contaminated area. Contaminated equipment etc. should not be taken from controlled area for repair until the level of activity has been reduced to safe limit set by Health Physicist.

v) All operations involving the production of vapour, spray, dust or radioactive gas, should be carried out in a good fume cumboard or in a glove box.

vi) Extreme care should be excercised so that any radioactive spill is confined to well defined areas.

vii) To avoid the spread of contamination in the event of breakage or spill, all work should be carried out in double containers or over large trays of stainless steel or enamel. Such trays should be lined with absorbent paper to restrict the spread of liquid.

viii) No mouth operations should be carried out in the laboratory. Pipettes must be syringe or bulb operated.

ix) Glass blowing should be avoided in the laboratory. Where such work is essential, blowing by month is not permissible.

x) Radioactive materials must not be manipulated with unprotected bare hands.

xi) Persons having open skin, wound (even if protected by bandage) must not work with radioactive materials.

xii) The use of containers, glassware, equipment etc. with sharp cutting edge should be avoided.

xiii) Eating, drinking, smoking or the application of cosmatics are not permitted in any laboratory or room where radioactive materials are used or stored.

xiv) All persons shall monitor themselves for contamination before leaving a laboratory where loose radioactive material is used or stored or suspected to be present.

xv) Any injuries, however small, sustained in radioactive area must be reported to Health Physics immediately.

xvi) If it is essential to carry out work with radioactive material after working hours, there should always be at least two persons in the laboratory.

xvii) Repairs to sinks or waste pipes should be carried out only after the approval of Health Physicist.

xviii) Waste bin for solid radioactive waste i.e. filter paper, tissue papers etc. should be provided in the laboratory by the supervisor of the laboratory. A marked container should be provided for liquid waste of high activity.

xix) On leaving the laboratory, every worker should wash his hands thoroughly, preferably scrubbing gently with a nail brush, especially around the nails. Hands should be monitored to ensure that no contamination is present.

3.3 Establishment of Controlled Areas.

Areas in which potential radiological hazards from radiation or contamination are considered to be present, shall be designated as controlled areas which shall be further classified as radiation area, contamination area or both. Areas in which sealed radiation sources are used or stored and radiation producing machines are in operation shall be classifed as radiation ones. Similarly areas in which open radioactive materials are handled shall be designated as radiation or/and contamination zones.

All controlled areas shall be marked out and warning signs posted as appropriate at entrance and inside The warning signs shall display the symbol shown in fig 1 & fig 2 which indicates the presence of ioni ing radiation or radioactive contamination or both.

Access to the controlled areas shall be restricted to regular radiation workers working in the area and to those who have special business to conduct, All the persons entering the controlled areas are required to wear radiation metering devices such as film badge or dosimeters and protective clothing.

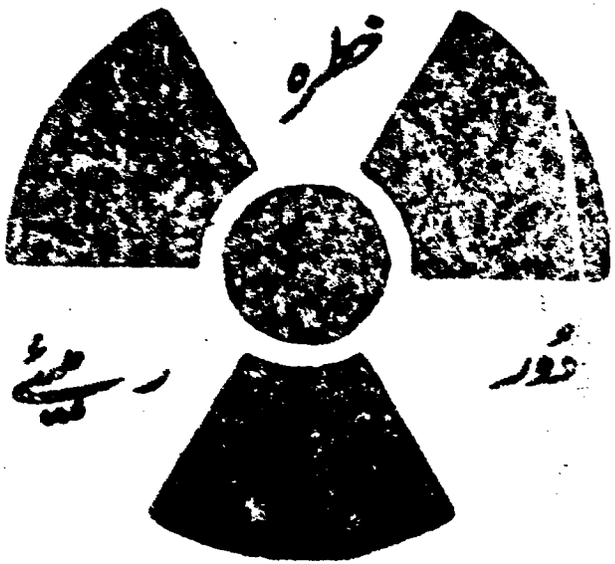
3.3.1 Controlled Areas

Following areas have been declared as controlled areas on account of external and internal radiation hazards.

I) Phase-I

(i)	Reactor Hall	Radiation area
(ii)	Rabbit Room (in the reactor hall)	Radiation-contamination area
(iii)	Sump Room (in the reactor hall)	" "
(iv)	Pump Room	" "
(v)	Radiation Source storage room	Radiation area

DANGER
RADIATION Zone



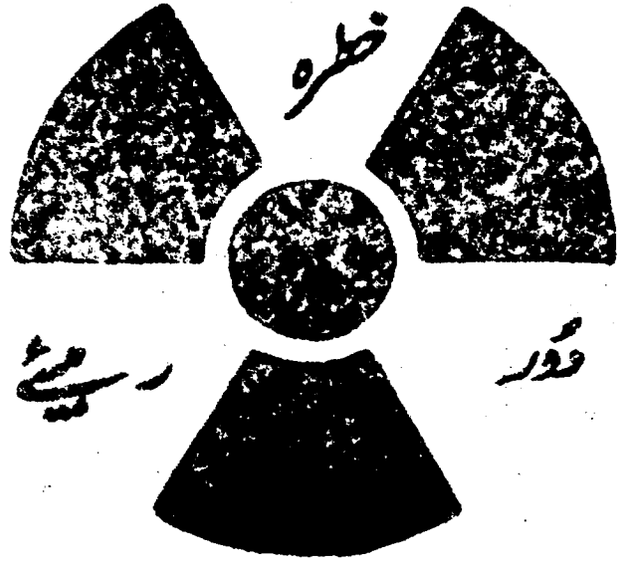
KEEP AWAY

IN CASE OF EMERGENCY NOTIFY

DUTY HEALTH PHYSICIST

Figure 1

DANGER
Contamination Zone



KEEP AWAY

IN CASE OF EMERGENCY NOTIFY

DUTY HEALTH PHYSICIST

Figure - 2

II) The Nuclear Chemistry Building

(i)	Radioisotopes Production Labs. on 1st floor.	Radiation-contamination area.
(ii)	RIPG Plant area in the basement.	" "
(iii)	Nuclear Activation Analysis Labs. on the 2nd floor.	" "
(iv)	Cobalt-60 gamma cell in the basement.	Radiation area

III) Nuclear Materials Building

(i)	All the labs. on the 1st floor.	Contamination area
(ii)	Basement (SMG)	" "

IV) Nuclear Engineering Building(Basement).

(i)	Radiography Lab.	Radiation area
(ii)	X Ray Room	" "
(iii)	Radiation sources storage Room.	" "

In addition to above mentioned areas, the other areas shall be designated as controlled areas by the area Health Physicist as and when considered necessary.

The radiation workers shall be responsible to check themselves thoroughly for radioactive contamination and perform decontamination operations, if necessary, (in consultation with Health Physicist) before leaving the contaminated areas. Similarly all materials i.e. equipments, glass ware,

papers, containers, waste materials, tools, protective clothings must be checked for contamination before they are sent out of the controlled area. Health Physics check posts have been established for this purpose at appropriate locations in each building of PINSTECH. Additional Health Physics check posts may be prescribed and established by the Health Physics both within and outside various controlled areas as and when considered necessary.

3.4 Protective Clothing

Protective clothing for radioactive work may be considered under two headings-routine and emergency. The latter includes protective clothing for purpose such as special maintenance and emergency operations.

3.4.1 Routine Protective Clothing

Routine protective clothing includes laboratory coats, overalls, aprons, rubber gloves, rubber shoes and overshoes. It is the responsibility of lab. Incharge to arrange in advance necessary protective clothing for his workers to enable them to carry out radioactive works in a safe manner.

Protective clothing appropriate to the conditions shall be worn all times in the laboratory. In all cases gloves shall be the minimum protection required. Due to the risk of contaminating other work, this rule applies even at very low levels of activity. In grade C laboratories and for most work in grade B laboratories, a normal laboratory coat or overall is sufficient. To prevent the transfer of contamination from the floor of Grade A laboratories, it is necessary to wear overshoes or separate footwear. Rubber gloves should be worn for all work with unsealed radioactive material. The surgical technique should alway be used when putting on or removing gloves, to avoid contaminating the hands and inside surface of the gloves. Gloves must alway be monitored before removal. All protective clothing worn in active laboratories must be removed before leaving and left in or immediately outside the laboratory.

Emergency protective clothings such as face mask, respirator etc. may be recommended and provided by Health Physics to be used in various active areas as and when considered necessary.

3.5 Incidents of Radioactive Contamination

Radioactive materials may be accidently released by a spill, by a failure of equipment or by rupture of sealed source. All such incidents must be reported to Health Physics at once. No attempts should ever be made to conceal such instances as they may create serious hazards to the persons concerned as well as to other workers in the Institute. Health Physics will advise about appropriate safety measures and decontamination procedure to be adopted. The decontamination will be carried out by the workers of the concerned laboratory under the supervision of Health Physics.

In certain cases where spill or release is of such a nature that requires immediate action to be taken to contain the material or limit the release, such action may be taken by the individual concerned before Health Physicist arrives. This may include the following :-

i) Persons directly contaminated by a wet spill should immediately remove affected clothing and thoroughly wash the hands and other contaminated parts of the body.

ii) If an inhalation hazard exists, all persons not involved in carrying out planned safety procedures should vacate the contaminated area immediately.

iii) After evacuation of the affected area, all the persons involved in the radioactive work should assemble in the clean area and should wait for the Health Physicist who would advise for the suitable actions to tbe taken.

3.6 Transportation of Radioactive Materials within Institute.

During transportation, the radioactive material may accidently be released to the environment and result in spread of radiation and contamination hazard. A great deal of care should, therefore, be exercised while transporting radioactive material. The following specific measures should be adopted while moving radioactive materials from one place to an other within the institute.

i) No more radioactive material should be moved than is required.

ii) Radioactive material should be transported in adequately shielded and closed containers. The container should be so designed and constructed as to prevent accidental release of the source material in case of upset.

iii) Radioactive material in liquid, gas, powder or in other dispersible solid form must be transported in suitable vessels made of non-shatterable material (such as P.V.C. or polyethylene etc.) or at least the outer containers should be of non-shatterable material.

iv) For radioactive liquid, the outer containers should be provided with absorbing material to retain all the liquid in case of breakage.

v) The transport container must be marked with sign and in transit, should bear a transportation tag showing information necessary for safety, such as nature of contents, physical condition, activity in curies (or Becquerel), dose rate on the outer surface of the container and dose rate at 1 m from the container.

vi) In case of unsealed radioactive material, the outside of the container should be free from loose contamination.

vii) All movement/transfer of radioactive material to inactive/cold areas must be effected after prior approval and clearance from Health Physics.

viii) Radioactive material other than prepared samples should not be taken into counting room.

ix) Suitable trained workers should be deputed for the transportation of radioactive material.

x) Any loss of radioactive material during transport should at once be reported to Health Physics.

xi) Contaminated waste material and the articles for decontamination should be transported in polythene bags sealed with adhesive tape.

3.7 Storage of Radioactive Materials.

Radioactive materials must always be used and stored in conditions which do not present a hazard to persons in the vicinity and are reasonably secure against theft or unauthorized tampering. In general, it is recommended that materials not in regular use should be kept in a locked storage assigned for this purpose only. The authorised personnel should be allowed to introduce or remove radioactive materials into or from the place of storage.

The place of storage should be adequately shielded, provided with suitable means of exit that can be operated from the inside and must be posted with signs bearing the radioactive symbol and the words; CAUTION-RADIOACTIVE MATERIAL. The place of storage should be inspected regularly and checked for possible contamination.

All radioactive materials or radiation sources in the storage should be clearly labelled, giving information on the nature, activity and physicial form and the name of the person responsible for the source should be included.

Where radioactive material is likely to evolve a radio-active gas or vapour the store must have separate and adequate mechanical; ventilation to the outside air. The fan must have operated for two minutes before any person enters the store.

Active residue at tracer level may be stored in glass vessels with polythene, rubber, or cork stoppers; glass or screw-on stoppers should not be used.

Thermally unstable solutions containing radioactive materials in nitric acid or other oxidizing solutions containing traces of organic material, peroxides, chlorates etc. and stable solutions with alpha activity in excess of 5mCi (18.5×10^7 Bq) or beta-activity in excess of 50 mCi (18.7×10^8 Bq) should always be stored in vented vessels. Old bottles of radioactive liquors should be opened only in a fumehood.

Containers used to transfer radioactive material to and from the stores should be designed to reduce to a reasonable level the dose received by person carrying them and should be designed to avoid a spill if they are dropped or upset.

Solutions having an alpha activity in excess of 1 μCi/ml (3.7×10^4 Bq/ml) should not be stored in thin walled glass bottles, since irradiation might weaken the glass. All glass vessels must be expected to fail without apparent cause.

Bottles containing radioactive liquids should be placed with absorbing material in the vessels large enough to hold the entire contents of the bottles in case of breakage.

Records should be kept for all stored radioactive materials which should give information on the type of material, activity time of removal and return and the name of person responsible for the material during its absence from the store. Such records should be checked to provide adequate control.

Inventories of all radioactive material should be taken every 6 months and provided to Health Physics Division.

3.8 Normal Cleaning of Radioactive Laboratories/Areas.

Normal cleaning of laboratories or areas in which work with unsealed radioactive material is carried out must not be allowed except under direct supervision of trained radiation worker specially designated for this purpose.

4. RADIOLOGICAL SURVEILLANCE

Radiological Surveillance of the working environment, surrounding area and working personnel is an essential part of the effective radiological protection programme to verify the safety measures adopted, to ensure the safe working conditions and render necessary advice, if needed, to improve the protection level.

Radiological surveillance at the institute is accomplished by performing monitoring of various kinds such as

a) Area Radiation Monitoring

b) Surface contamination monitoring

c) Air-borne Radioactivity monitoring

d) Personnel Radiation monitoring

e) Whole body counting and bioassay

f) Environmental monitoring

g) Effluent monitoring

4.1 Radiation Monitoring/Surveys

i) Areas in which radiation sources are used or stored, neighbouring areas, reactor hall and neutron generator area when in operation, shall be monitored at regular intervals.

ii) Radiation surveys shall be performed before starting a project or using radiation sources, after any significant modification of set-up and also periodically during operation.

iii) The frequency of radiation surveys shall be determined by area Health Physicist depending on the nature and scale of operations carried out in the area.

iv) All radiation Surveys shall be carried out and proper record shall be maintained by Health Physics personnel. The information so obtained may be used as a basis for planning in respect of worker's safety.

v) The laboratory/area supervisor is responsible to ensure that the area under his control is being regularly monitored and workers are aware of the radiation hazard involved in their work.

4.2 Surface Contamination Monitoring

Areas in which unsealed radioactive materials are used or stored shall be regularly monitored for surface contamination. Everything used for work with radioactive materials may be subject to wide spread contamination. This includes surface of work place or working bench, walls of fumehoods or glove boxes, floors, walls of working room, clothing, equipment, tools etc. and must be monitored for surface contamination.

Sealed radiation sources should be checked at regular intervals, at least once per year and whenever there is a suspicion of leakage, e.g. after damage or suspected damage to the source container. In addition all parts around the targets of neutron generator should be monitored before handling.

All equipment, tools etc. to be taken out of contaminated area and personnel leaving such area shall be monitored for radioactive contamination. Level of contamination on floor of working area etc., exceeding maximum permissible level of contamination as given in section VI, will be reported to area Health Physicist and the laboratory supervisor, who will arrange to decontaminate it.

4.3 Airborne Radioactivity Monitoring

Air borne radioactive contamination can be one of the major risks in the areas where radioactive aerosoles, gases, powders or dust are handled or produced. The air in such areas must be monitored for airborne radioactivity as a routine.

Such monitoring shall be performed and record shall be maintained by Health Physics personnel and may be used to assess the internal exposure and to improve the working conditions to safe level.

4.4 Personnel Monitoring

The purpose of personnel monitoring is to assess the radiation dose received by the individual working in the radioactive areas. This programme is being carried out by the Health Physics Division at the institute as well as at national level. The instruction given here must be followed with regard to personnel monitoring programme and the use of devices.

a) All persons entering a radioactive area must wear appropriate personnel monitoring device.

b) Suitable radiation dose measuring device such as film badge, thermoluminescent dosimeters, dosimeters for extremity dosimetry, pocket dosimeter shall be supplied by Health Physicist and distributed through Divisional radiation supervisor and/or Heads of Divisions who would be responsible to notify the names of workers and the nature of their work to Health Physics.

c) The film badge should be worn on the trunk preferably on the lapel or waistband and outside any protective clothing. Additional film badge may be worn on the wrists or other parts of the body if advised by Health Physicist.

d) When not in use personnel monitoring devices should be stored in areas where they would be protected from radiation.

e) Personnel monitoring film badge or thermoluminescent dosimeter should not be worn during non-occupational exposure such as medical X-ray.

f) The film badges are normally issued for a period of one clendar month. The radiation workers must ensure that the films in their badges are changed on the first working day of every month.

g) The film badges must not be left in a radioactive area and/or carried out-side the premises of the Institute. The film badge should not be deliberately exposed to high temperature, chemical fumes, excessive moisture or high radiation fields.

h) The film inside the film badge must never be tampered with in any way. Puncturing of the film or the wrapper by any means must be avoided.

i) The film badge must be returned to Health Physics immediately for evaluation if contamination of the badge or excessive exposure to radiation of the worker concerned is suspected.

j) The film badges issued to individuals must be carried on the person. They must not be used to check radiation dose in a fixed position (e.g. at a bench); special film badges may be obtained for this purpose from Health Physics.

k) Pocket dosimeters will be provided by Health Physics for use in addition to the film badges as an additional precaution if high dose rates are probable. They must not be considered as substitutes to the film badges. Such dosimeters should be handled very carefully. They must not be subjected to dampness or mechanical shock.

4.5 Bioassay

The radiation workers performing operations with the radioactive material in powder or gaseous form are likely to get radioactivity incorporated into their body by inhalation, and ingestion etc. The radiation exposure due to internally deposited radionuclide will be determined periodically by either whole body counting or monitoring of excreta such as urine (Bioassay) or by scanning a particular organ. The following procedure should be adopted in the case of bioassay:

a) The names of the individuals whose urine sample would be required for bioassay, shall be notified by the Health Physicist through respective divisional radiation supervisor and/or Head of Division.

b) The individual concerned shall provide his twenty four hours urine sample to Health Physics for analysis.

c) The bottles/containers assigned for this purpose shall be collected by the individual from Health Physics check post.

d) After the 24 hours urine sample has been collected the bottle shall be handed over to the same Health Physics check post.

e) These bottles must be stored in a clean area and should not be taken in any potentially contaminated area or handled with contaminated hands.

In case of an incident resulting in widespread contamination in lab. environment, the workers shall be asked to provide urine samples for immediate analysis.

In addition to above, all the workers handling radioactive material in powder or gaseous form shall be required to undergo whole body counting for gamma emitters and for actinides in the lungs at least once a year or as and when deemed necessary from safety point of view.

4.6 Environmental Monitoring

Environmental monitoring programme shall include the measurement and identification of radioactivity in various media such as air, surface water, vegetation, rain water, soil, milk and various items of human diet etc.

Continuous monitoring of the air shall be carried out to ensure the effectiveness of safety measures taken to check release of radioactivity either in the working areas or to the environment.

Similarly surface water, vegetable, soil, milk etc. shall be periodically collected and analysed for radioactive contamination.

Appropriate measures as recommended by Health Physicist and/or Nuclear Safety Committee, PINSTECH, will be adopted whenever the contamination level in any of the sampling media exceeds the limits set out in section VI.

4.7 Effluent Monitoring

The gaseous radioactive effluent from reactor and N.C.D. laboratories, after removing as much particulate radioactivity as possible shall be discharged through the stack where it will be monitored before discharging to atmosphere.

The radioactive liquid effluent from the reactor, NCD and NMD laboratories shall be collected in hold up tanks located in various areas of the institute. Before discharging, the liquid effluent shall be monitored for radioactive contamination and shall be stored in the storage tanks, if contamination level exceeds the values given in section VI or otherwise drained to seepage pits in radioactive waste disposal area.

5. CLASSIFICATION OF RADIONUCLIDES AND GRADING OF RADIOCHEMICAL LABORATORIES

Precautions to be taken in the handling of unsealed radioactive materials depend on the degree of radiotoxicity, on the quantity of substance being used, on the nature of the operation and the built-in safety aspects of the facility in use. This section deals with the classification of radionuclides and grading of laboratories from safety point of view.

5.1 Classification of Radionuclide

Radiotoxicity refers to the potential of an isotope to cause damage to living tissue by absorption of energy from the disintegration of the radionuclide introduced into the body.

The radionuclides can be classified in one of the following four groups of radiotoxicity per unit activity :

Group - 1 - Very high radiotoxicity

Group - 2 - High radiotoxicity

Group - 3 - Moderate radiotoxicity

Group - 4 - Low radiotoxicity

Table 1 : Provides the classification of radionuclides according to relative radiotoxicity per unit activity.

TABLE 1 Classification of Isotopes According to Relative Radiotoxicity.

Group 1 (Very High Toxicity)								
^{210}Pb	^{210}Po	^{223}Ra	^{226}Ra	^{228}Ra	^{227}Ac	^{227}Th	^{228}Th	^{230}Th
^{231}Pa	^{230}U	^{232}U	^{233}U	^{234}U	^{237}Np	^{238}Pu	^{239}Pu	^{240}Pu
^{241}Pu	^{242}Pu	^{241}Am	^{243}Am	^{242}Cm	^{243}Cm	^{244}Cm	^{245}Cm	^{246}Cm
^{249}Cf	^{250}Cf	^{252}Cf						
Group 2 (High Toxicity)								
^{22}Na	^{36}Cl	^{45}Ca	^{46}Sc	^{54}Mn	^{56}Co	^{60}Co	^{89}Sr	^{90}Sr
^{91}Y	^{95}Zr	^{106}Ru	$^{110}Ag^{m}$	$^{115}Cd^{m}$	$^{114}In^{m}$	^{124}Sb	^{125}Sb	$^{127}Te^{m}$
$^{129}Te^{m}$	^{124}I	^{126}I	^{131}I	^{133}I	^{134}Cs	^{137}Cs	^{140}Ba	^{144}Ce
^{152}Eu(13 yr)		^{154}Eu	^{160}Tb	^{170}Tm	^{181}Hf	^{182}Ta	^{192}Ir	^{204}Tl
^{207}Bi	^{210}Bi	^{211}At	^{212}Pb	^{224}Ra	^{228}Ac	^{230}Pa	^{234}Th	^{236}U
^{249}Bk								

Group 3 (Moderate Toxicity)

^{7}Be	^{14}C	^{18}F	^{24}Na	^{38}Cl	^{31}Si	^{32}P	^{35}S	^{41}A
^{42}K	^{43}K	^{47}Ca	^{47}Sc	^{48}Sc	^{48}V	^{51}Cr	^{52}Mn	^{56}Mn
^{52}Fe	^{55}Fe	^{59}Fe	^{57}Co	^{58}Co	^{63}Ni	^{65}Ni	^{64}Cu	^{65}Zn
$^{69}Zn^{m}$	^{72}Ga	^{73}As	^{74}As	^{76}As	^{77}As	^{75}Se	^{82}Br	$^{85}Kr^{m}$
^{87}Kr	^{86}Rb	^{85}Sr	^{91}Sr	^{90}Y	^{92}Y	^{93}Y	^{97}Zr	$^{93}Nb^{m}$
^{95}Nb	^{99}Mo	^{96}Tc	$^{97}Tc^{m}$	^{97}Tc	^{99}Tc	^{97}Ru	^{103}Ru	^{105}Ru
^{105}Rh	^{103}Pd	^{109}Pd	^{105}Ag	^{111}Ag	^{109}Cd	^{115}Cd	$^{115}In^{m}$	^{113}Sn
^{125}Sn	^{122}Sb	$^{125}Te^{m}$	^{127}Te	^{129}Te	$^{131}Te^{m}$	^{132}Te	^{130}I	^{132}I
^{134}I	^{135}I	^{135}Xe	^{131}Cs	^{136}Cs	^{131}Ba	^{140}La	^{141}Ce	^{143}Ce
^{142}Pr	^{143}Pr	^{147}Nd	^{149}Nd	^{147}Pm	^{149}Pm	^{151}Sm	^{153}Sm	$^{152}Eu^{m}$(9.2h)
^{155}Eu	^{153}Gd	^{159}Gd	^{165}Dy	^{166}Dy	^{166}Ho	^{169}Er	^{171}Er	
^{171}Tm	^{175}Yb	^{177}Lu	^{181}W	^{185}W	^{187}W	^{183}Re	^{186}Re	^{188}Re
^{185}Os	^{191}Os	^{193}Os	^{190}Ir	^{194}Ir	^{191}Pt	^{193}Pt	^{197}Pt	^{196}Au
^{198}Au	^{199}Au	^{197}Hg	$^{197}Hg^{m}$	^{203}Hg	^{200}Tl	^{201}Tl	^{202}Tl	^{203}Pb
^{206}Bi	^{212}Bi	^{220}Rn	^{222}Rn	^{231}Th	^{233}Pa	^{239}Np		

Group 4 (Low Toxicity)

^{3}H	^{15}O	^{37}A	$^{58}Co^{m}$	^{59}Ni	^{69}Zn	^{71}Ge	^{85}Kr	$^{85}Sr^{m}$
^{87}Rb	$^{91}Y^{m}$	^{93}Zr	^{97}Nb	$^{96}Tc^{m}$	$^{99}Tc^{m}$	$^{103}Rh^{m}$	$^{113}In^{m}$	^{129}I
$^{131}Xe^{m}$	^{133}Xe	$^{134}Cs^{m}$	^{135}Cs	^{147}Sm	^{187}Re	$^{191}Os^{m}$	$^{193}Pt^{m}$	$^{197}Pt^{m}$
^{232}Th	Th-Nat	^{235}U	^{238}U	U-Nat.				

a From ICRP Publication 5 (1964).

5.2 Grading of Laboratories

The various laboratories at the institute shall be graded as one of the following three types (i) Type A (ii) Type B, (iii) Type C, of which "A" is the highest in terms of finish and facilities required for safety.

The type of laboratory shall be determined by the Health Physicist and/or Nuclear Safety Committee. The Table 2 sets out the amount of unsealed radionuclide which may be safely handled in a laboratory of a given standard.

Table 2: Grading of Laboratories for Handling of Radionuclides.

Class of Radionuclide (Radiotoxicity)	Type A High Level Radiochemical Laboratory.	Type B Radiochemical laboratory.	Type C Chemical Laboratory (Hood Operation)
Very High	> 10 mCi	10 mCi max	10 µCi max
High	> 100 µCi	100 mCi max	100 µCi max
Moderate	> 1 Ci	1 Ci max	1 mCi max
Slight	> 10 Ci	10 Ci max	10 mCi max

5.3 Modifying Factors

The quantities mentioned in Table 2, refer to normal wet chemical operations which include most quantitative and qualititative analysis. Because physical form and complexity of the procedures to be followed can either increase or decrease the degree of hazard in handling unsealed radioisotopes, certain modifying factors must be applied to the values in Table 2.

Due regard must be paid to the circumstances affecting each individual case and Health Physicist must be consulted before increasing the quantity of radicactivity to be handled.

Table 3 : Operational Factors to Modify Table 2

Type of Operation	Modifying Factor
(i) Storage (Stock solution)	x 100
(ii) Very Simple Wet Operation	x 10
(iii) Normal chemical operation	1
(iv) Complex wet operation with risk of spills	x 0.1
(v) Simple dry operation	x 0.1
(vi) Dry and dusty operation	x 0.01

Certain labelled organic compounds, particularly those containing hydrogen, carbon, sulphur, phosphorus and iodine may be metabolized in a different way from the elemental radionuclides and may therefore present a greater hazard. An additional modifying factor of 0.1 should be applied in respect of such compounds.

5.4 Ventilation

Proper ventilation is generally required for all kinds of chemical laboratories and particularly for radiochemical laboratories where unsealed radioactive materials are handled.

The designing of ventilation system should include the following features

i) The ventilating air should be passed only once through the radioactive area. The air intake and exhaust position should be well separated to avoid any recirculation. The air flow should always be from clean areas to contaminated areas. The flow of air within radioactive areas should be from areas having lesser contamination risk to areas of higher contamination risk.

ii) Before discharging to atmosphere, the exhaust air should be passed through a filter system 99.95 % efficient to remove particles of > 0.3 micro and if necessary, it should be filtered through charcoal filters.

iii) Control of ventilation system shall be located in an area that will be readily accessible in the event of an accident.

iv) The number of air changes in a radioactive laboratory shall be maintained at the rate of 10 per hour. This figure may be increased or decreased for some areas depending upon the nature of the operation to be carried out.

v) The air velocity across the front face of a fumehood with the window in the normal working position must be at least 0.75 linear m/Sec (150 linear ft/min)

vi) A negative pressure of 25 to 50 mm w.g. shall be maintained in glove boxes and hot cells.

vii) In radioisotopes production plant area, the corridors shall be kept at negative pressure of at least 10mm. w.g. with respect to outside. The plant room shall be kept at negative pressure of 10 mm w.g. with respect to corridors. The hot cell shall be kept at negative pressure of 25 to 50 mm with respect to working area.

6. MAXIMUM PERMISSIBLE LEVELS OF RADIATION

All the workers in the institute using radio-nuclides or nuclear radiation must comply with dose equivalent limits and radioactive contamination limits set out in this Code of Practice.

6.1 Dose Equivalent Limits

Table 4 present a summary of dose equivalent limits for individual radiation worker.

Table 4: Effective Dose Equivalent limits.

Tissue or Organ	Annual Limit rem	(SV)
Whole Body	5	(0.05)
Gonads	20	(0.2)
Breast	30	(0.3)
Red Marrow	40	(0.4)
Lung	40	(0.4)
Thyroid	50	(0.5)
Bone (Endosteum)	50	(0.5)
Remainder	50	(0.5)

Necessary arrangements should be made to ensure that the annual occupational exposure of pregnant woment should not exceed three-tenths of the dose-equivalent limits.

Certain relaxations of the dose equivalent limits would be permitted for men under conditions of a planned emergency, but these should be used only under guidance from the Health Physicist.

6.2 Quality Factor

Most of the Health Physics instruments measure doses in "rads" which is a unit of absorbed dose. In order to convert the measured dose in rads, into the biologically significant dose equivalent in rems, it is

necessary to multiply by the quality factor appropriate to the radiation. Table 5 gives the quality factors for different kinds of radiation:

Table 5 Quality factors for different kinds of radiation.

Radiation	Quality Factor
X-rays, γ-rays, Electron and β particle.	1.0
Neutrons(according to energy)	3 to 10
Protons (according to energy)	1 to 3
Heavy recoil nuclei, fission fragments and heavy particles from accelerator	20
Alpha particles	20

6.3 Limits of Internal Contamination

Internal contamination may result from inhalation or ingestion of radioactive material or in some cases from direct absorption through skin. Special attention must be paid to prevent the spread of radioactive contamination in the working environment and to limit the internal contamination so that maximum permissible doses are not exceeded.

The derived air concentration (DAC) and derived ingestion concentration $(DIC)_w$ of radionuclides should not exceed the limits set forth by ICRP. Values of DAC vary enormously, ranging from 10^{-12} $\mu Ci/Cm^3$ for Plutonium-239 to 10^{-6} $\mu Ci/Cm^3$ for certain lesser toxic radionuclides. The Health Physicist may be consulted for DAC and $(DIC)_w$ of any radionuclides, if needed.

6.4 External Radiation Levels

(a) Working Areas

The external radiation levels in all working areas shall be kept minimum possible and shall not normally exceed the following limits:

Controlled areas	2.5 mrad/hr (25 μGy/hr)
Uncontrolled areas	0.25mrad/hr (2.5 μGy/hr)

The areas having a radiation field of 2.5 mrad/hr (25 μGy/hr) to 25 mrad/hr (250 μGy/hr) shall be restricted for entry and a special work permit from Health Physics shall be needed for work to be carried out. The areas having radiation level more than 25 mrad/hrs (250 μGy/hr) shall be barricated and locked. Entrance shall be allowed only on emergency basis.

(b) Transfer/Transport Containers

The maximum radiation levels with respect to all transfer/ transport containers, packages, bags, items of equipment etc. to be removed from radioactive areas should not exceed the following limits:

200 mrad per hour (2 mGy/hr) at the surface of the pakage

10 mrad per hour (10 μGy/hr) at one meter from the centre of the package.

6.5 Surface Contamination Levels

(a) Controlled Areas

The maximum permissible levels of loose contamination permitted in controlled areas shall be as follows:

Table 6. Maximum Permissible Levels of Surface Contamination ($\mu Ci/cm^2$)

Surface	Alpha emitters		Beta emitters	
	Class-I	Class II to IV	E max ≥ 0.2Mev	E max < 0.2Mev
Floors, Walls, ceiling, inanimate objects	10^{-5}	10^{-4}	10^{-4}	10^{-3}
Skin	10^{-5}	10^{-5}	10^{-4}	10^{-3}
Clothing	10^{-4}	10^{-3}	10^{-3}	10^{-2}

(b) Uncontrolled Areas:

The level of contamination in non-active areas or on parts of body, personal clothing, personal effects and all items of furniture etc., to be taken out of radioactive areas shall not exceed the following limits:

Alpha contamination (Transferable)	Nil
Alpha contamination with Group-1 alpha emitters (Fixed)	10^{-5} µCi/cm^2 (.37 Bq/Cm^2)
Alpha contamination with Group-2 to 4 alpha emitter (Fixed)	10^{-4} µCi/cm^2 (3.7 Bq/cm^2)
Beta-gamma contamination	10^{-4} µCi/cm^2 (3.7 Bq/cm^2)

Contamination levels may be averaged over 0.1 m^2 (1000 cm^2) for floor, walls and ceiling or 0.03 m^2 (300 cm^2) for other inanimate objects. For skin contamination, levels may be averaged over the whole of one hand (taken to be 300 cm^2) or 0.01 m^2 on the other parts of the body. Contamination levels inside total or partial enclosures (i.e. fumehoods, glove boxes) within a controlled areas may exceed those above, but should be kept as low as reasonably achievable.

7. RADIOACTIVE WASTE

Radioactive wastes can give rise to a serious source of internal and external radiation hazards if they are not properly handled. Adequate arrangements should therefore be made for the proper collection and safe disposal of all kinds of radioactive wastes generated at the institute.

7.1 Nature and Classification of Radioactive Waste.

The radioactive waste produced in various processes involving radioactive material can, on the basis of physical form, be of three types, (a) liquid wastes (b) solid waste, (c) gaseous wastes.

Keeping in view the facilities available at PINSTECH, the liquid wastes can be classified into three categories according to the following activity levels.

i)	Category 1:	Low Level Waste -	less than 10^{-5} $\mu Ci/cm^3$ (0.37 Bq/cm^3)
ii)	Category 2:	Medium Level Waste -	10^{-5} to 10^{-3} $\mu Ci/cm^3$ (0.37 to 37 $Bq/^3cm$)
iii)	Category 3:	High Level Waste -	10^{-3} to 10^{-1} $\mu Ci/cm^3$ (37 to 3.7×10^3 Bq/cm^3)

The solid wastes can be divided into the following four categories on the basis of radiation dose at the surface and the type of activity present.

i)	Category 1:	D $\leq$ 10 mr/hr (100 μGy/hr)	Contaminated with β-γ emitters only
ii)	Category 2	D $\leq$ 200 mr/hr (2 mGy/hr)	-- do --
iii)	Category 3	D $>$ 200 mr/hr (2 mGy/hr)	-- do --
iv)	Category 4	10^{-2} $\mu Ci/cm^3$ (3.7×10^2 Bq/cm^3)	Contaminated with α-emitters.

Gaseous effluents, the concentration of which is higher than $10^{-10}\mu Ci/cm^3$ (3.7×10^{-6} Bq/cm^3) would be treated as gaseous radioactive waste.

The following measures should be adopted to safely handle the problems of radioactive waste disposal.

7.2 General Precautions

a) An estimate of the quantity and radioactive content of all radioactive wastes expected to be generated during an operation should be made and plans for handling and disposal of such wastes should be prepared in advance in consultation with Health Physics.

b) All radioactive wastes should be secured and/or disposed off as soon after generation as practicable.

c) The wastes should always be labelled and kept at a place reserved in the working area for this purpose alone.

d) The wastes containing short-lived radionuclides may be stored within a radioactive area so that they may decay to a safe level before they are disposed off. Such storage should however be practiced in accordance with the usual requirements for containment.

e) The wastes should not be removed from a radioactive area except after notification to Health Physics.

f) No radioactive wastes should be disposed off with non-radioactive drains without the permission of Health Physics.

7.3 Liquid Wastes

Radioactive liquid wastes of various activity-levels are produced in the regeneration of primary demineralizer, in the processing of radioactive samples, radioisotopes and radioactive material carried out in NCD and NMD laboratories.

7.4 Solid Wastes

Solid waste will be comprised of every contaminated thing which comes under the definition of solid. The following measures should be adopted for the collection and disposal of such wastes.

a) Suitable cans shall be provided in all working places where radioactive wastes may originate.

b) All type of contaminated wastes such as gloves, tissue papers, rags etc. shall be deposited in the radioactive waste bins lined with removable polythene bags to facilitate removal of the waste without contamination.

c) Items having sharp points or cutting edges such as needles, pins, blades, broken pieces of glass etc. should not be disposed off in such containers.

These should instead, be completely wrapped in papers and collected in separate polythene bags which must be marked accordingly.

d) The polythene bags should be sealed with adhesive tape before they are removed from radioactive area.

e) The external contamination on all packages/bags of waste to be removed from a radioactive area should be lower than the levels given in section-VI of this code of practice. All such packages should bear labels giving the names, approximate quantity of radionuclide contained in them and dose rate at the surface of package.

f) Container/packages/bags of radioactive waste to be stored or placed within a working area should be shielded, if necessary, in such a way that the radiation level at the surface of container, or package does not exceed 10 mrad/hr (100 μGy/hr) and the level in the working area is less than specified in section VI of this code of practice.

g) The contaminated items, waste material and unprocessed irradiated samples of radioactive material having long lived radionuclides and radiation level in excess of 200 mrad/hr (2 mGy/hr) shall be fixed in cement and packed in containers made of mild steel/stainless steel. Such containers shall be burried in the pits located in Burial Ground.

h) Appropriate records of the waste disposed off and stored, shall be kept by Health Physics.

8 DECONTAMINATION

The personnel, their clothing, equipment and work places may become contaminated with radioactive materials during routine operations in a radioactive area. It is the responsibility of the concerned radiation workers to ensure that decontamination operations in accordance with the following instructions are performed so as to reduce contamination at least to the levels specified in Section VI of this Code of Practice.

Each Laboratory Supervisor should have the following items available in his laboratory :-

a) Sheets of filter papers,

b) Tissue papers,

c) Sanitory gauze, cotton, bandages,

d) Soft and hard brushes,

e) Soap solution

8.1 Decontamination of Personnel

8.1.1 Internal Contamination

Internal contamination of personnel must immediately be reported to Health Physics. The following measures should nevertheless be taken by the worker concerned immediately (in the first seconds or minutes) before the Health Physicist arrives.

a) In the event of probable in-take of radioactive material through the nose or the mouth, the worker should try to eliminate radioactive material which might still be remaining in the nose and the mouth by blowing, coughing and gurgling. Vomiting may also be induced, if possible, to eliminate radioactive material which may have been swallowed.

b) In case of contaminated small open wounds, cuts, punctures etc. the wound should be immediately washed under running water and bleeding should be encouraged for a short time.

c) Decontamination of the eyes should be done by irrigation of the eyes with a copious amount of water.

Chemical or medical preparations of any kind must not be used under any circumstances for the above purposes except under medical supervision.

8.1.2 External Contamination

Decontamination of external parts of the body should be done as quickly as possible by washing (repeatedly if necessary) with soap and water available in change rooms/ monitor lobbies. The following points may be borne in mind in this connection.

a) The washing may be helped by scrubbing with a soft brush only in such way as not to abrade the skin.

b) The washings should not be repeated if there is an indication of damage to the skin

c) The use of organic solvents; acid or alkaline solutions should be avoided.

d) Special attention should be paid to creases, folds, hair and such parts of the hands as fingers, nails, inter-finger space and the outer edges of the hands.

e) While decontaminating the face, special care should be taken not to contaminate the eyes or lips.

f) Care should be taken to avoid the spread of contamination to uncontaminated parts of the body and to avoid internal contamination.

g) Contamination which resists washing and which is more than the levels specified in Section VI of this Code of Practice should be reported to Health Physics.

h) Contaminated personnel may be required to take baths if considered necessary by Health Physics.

8.2 Decontamination of Equipment

8.2.1 General Considerations

a) A decision to decontaminate material must take into account the continuing value of the material compared with the cost of decontamination.

b) Where the half-life of the contaminant is short the material should be sealed in polythene bags suitably marked and stored for decay of activity rather than attempting any decontamination.

c) The contaminated material must be sealed in polythene bags and/or contained in suitable vessels whenever it is to be taken out of an active area.

d) Cleaning tools and materials used in the area in which decontamination operations are performed should not be removed or used elsewhere without careful decontamination and monitoring.

e) The object of decontamination operations should be to achieve the safe levels of contamination specified in Section VI of this Code of Practice. If these levels cannot be achieved the material should not be re-used and should be regarded as radioactive waste.

8.2.2 Glassware and Tools

a) The cleaning of contaminated glassware and tools should be done as soon as possible after their use (so as to prevent the contamination from getting fixed). A well ventilated place or hood set side preferably within a radioactive area should be used for this purpose.

b) Glassware may be cleaned by normal chemical agents such as chromic acid solution, concentrated nitric acid , ammonium citrate, penta sodium triphosphate and ammonium bifluoride.

c) Uptake of radioactive substances by glassware may be reduced by a preliminary treatment with corresponding inactive material.

d) Metal tools and similar equipment may be washed with a detergent with brisk brushing to dislodge trapped contamination.

e) Immersion of equipment in solutions of the non-radioactive isotopes of the contaminant may also be tried although this is a slow procedure.

f) The solution arising from decontamination should be regarded as radioactive waste.

8.2.3 Working Areas, Benches, etc.

a) Wet methods of cleaning should be used as far as practicable as the use of dry methods may create a dust hazard. For porous materials however, vacuum cleaning with proper filteration of the rejected air may be attempted.

b) Paint work may be cleaned with soap and water or, in extreme cases, removed with paint remover.

c) Stainless steel may be treated with sulphuric acid or, as a last resort, by hydrochloric acid.

d) The radiation and/or contamination from surfaces having fixed contamination may be controlled by painting particularly when alpha or soft-beta-emitters are involved.

e) If after attempted decontamination, safe levels as specified in Section VI of this Code of Practice cannot be achieved and/or adequate protection cannot be assured the contaminated premises should be abandoned and posted with suitable warning signs.

8.2.4 Clothing and Similar Items

a) Contaminated clothing should not be released to public laundry without the approval of Health Physics.

b) In the case of short-lived radioactive contamination, the item should be sealed in polythene bags suitably marked and stored for decay of activity.

c) Clothing and similar items as stated above which cannot be decontaminated to a safe level will be regarded as radioactive waste.

d) Contaminated clothings should be segregated into batches of differing degree of contamination to avoid cross-contamination.

e) If the clothing etc. cannot be decontaminated to a safe level it should be treated as radioactive waste.

REFERENCES

1. Safe Handling of Radionuclides. IAEA Safety Series No. 1

2. Basic Safety Standards For Radiation Protection. IAEA Safety Series No. 9.

3. The Provision of Radiological Protection Service. IAEA Safety Series No. 13.

4. International Commission on Radiological Protection, "Recommendations" ICRP Publication - 26 (1977).

5. Code of Practice Against Radiation Hazards At PINSTECH - (PINST/HP-11), M.A. Mubarak, Abdul Aziz, Anwar Ali.

6. Radiological Health Handbook, U.S. Department of Health.