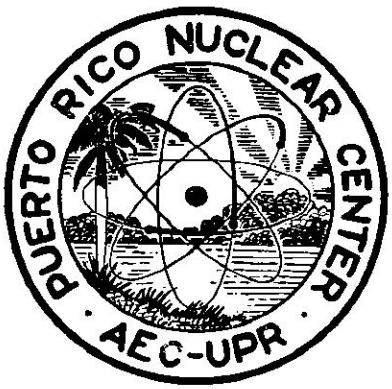
PRNC-2
(Health Physics)

HEALTH PHYSICS GUIDE

AND REGULATIONS

By J. A.Ferrer Monge



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(Health Physics)

HEALTH PHYSICS GUIDE AND REGULATIONS

by

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Puerto Rico Nuclear Center
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for
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PREFACE

This "Guide and Regulations" has been prepared so that all personnel of the PRNC and other persons associated with the institution can read them carefully and thus proceed as instructed.

Radiation protection can be afforded best when persons dealing or working with radioactive materials and sources of radiation follow good household practices and observe rules, regulations and recommendations.

It is the responsibility of supervisors to see that all persons under their jurisdiction comply in full with the rules and regulations set forth here.

CONTENTS

Section I

Organizations and Officers Associated with Radiological Safety

I. Radiological Safety Committee

A. Membership

The Radiological Safety Committee, hereafter designated R.S.C. shall consist of the following members:

1- Director of the Puerto Rico Nuclear Center - chairman
2- Director Reactor Program
3- Director Nuclear Science & Technology Program
4- A.E.C. Area Manager
5. Assistant Director San Juan Operations
6. Director Health Physics Section

B. Duties

The R.S.C. will have the following duties:

1. To review and approve, or suggest revision of proposed regulations and procedures pertaining to radiation hazard and/or contamination.
2. To review and approve proposed location of radiation areas in regard to radiation hazard.
3. To approve special regulations and conditions of a temporary character.
4. To receive reports from the Health Physics Section and review them.
5. To review radiation incidents.
6. To recommend disciplinary action when any person using radioisotopes and other radioactive material or radiation source fails to observe the safety rules, regulations and procedures as set forth in this guide.
7. To consider and take action on any other matters pertaining to radiological safety which are not duties of the Isotope and/or Technical Committees.
8. To keep records of the meetings of the committee in regard to all transactions considered under 1 to 7 and other matters.

C. Meetings

The R.S.C. shall meet as frequently as required by circumstances, but not less than once every six months. Attendance of other appropriate persons for a specific meeting may be requested through the Director's office.

II. Isotope Committee

A. Membership

This committee will consist at least of the following of whom one will be appointed chairman by the Director of PRNC.

1. One Radiochemist
2. One Radiobiologist
3. Administrative Officer or his appointee
4. Head Health Physics Section

B. Duties

The duties of this committee are:

1. To review and approve, procedures for procurement of radioisotopes and proposal for use of such material in the Puerto Rico Nuclear Center.

   Primary consideration is given to the following:

   a. assurance that the person(s) requesting the material is qualified to handle and use the radioisotope(s) requested.
   b. that suitable facilities are available to carry on the project where the radioisotope(s) is to be used.
   c. that the proposed use of the material is safe as regards to radiation hazard.

2. To keep records of all the meetings of the committee.

C. Meetings

Regular meetings shall be held every month. Special meetings may be called at the request of the chairman.

III. Technical Committee

A. Membership

1. Reactor Supervisor - chairman
2. Maintenance Supervisor
3. Health Physics Section Head
4. Other scientific personnel as required

B. Duties

1. Review experiments in the reactor facilities.
2. Review changes to reactor equipment and/or procedures.
3. To review and approve in advance proposals for use of reactor facilities.

4. Periodically review all aspects of reactor facility operations for possible hazards.
5. Submit results of reviews and recommendations to the Reactor Division Director and R.S.C.
6. Other duties as may be delegated by the Reactor Division Director.
7. To delegate such authority to the reactor supervisor as they may find appropriate.
8. To keep records of all the meetings of the committee.

C. Meetings

The committee shall meet as frequently as required by circumstances, but at least one meeting shall be held every six months.

IV. Radiation Safety Officer

The Head of the Health Physics Section is the Radiation Safety Officer. He is also a member of the R.S., Isotope and Technical Committees. The Radiation Safety Officer will delegate special duties to one or more members of the Health Physics Section Staff. As head of the Health Physics Section his responsibilities are (from the standpoint of radiation safety):

A. To review all proposed plans or projects for use of radioactive materials and make recommendations to the person(s) submitting the plan or project or to the person using the radioactive material on the appropriate use of it.
B. To review all plans for proposed use of sources of ionizing radiation not covered in A above, such as accelerators, reactors, X-ray units, etc. and make recommendations to the experimenter on the appropriate use of such sources.
C. To review all requisitions for radioactive materials and sources and insure that a suitable location, storage area, etc. is available at time of receipt.
D. To survey all incoming shipments of radioactive materials, their distribution and storage.
E. To supply personnel monitoring instruments and instruct in their use.
F. To keep records of individual radiation exposures.
G. To keep records of urinalysis.
H. To supply protective clothing and recommend use of the same as set down in this guide.
I. To determine exposure levels under working conditions including distance and time limits.
J. To survey storage and working areas as frequently as necessary.
K. To recommend methods and procedures for radioactive waste disposal and supervise the same.

L. To carry on a permanent personnel and area monitoring program.
M. To supervise decontamination.
N. To calibrate and have repaired survey instruments and personnel and area monitoring instruments.
O. To supervise the maintenance of records of receipt, transfer, disposal, etc. of radioactive material.
P. To keep records of accidents and incidents pertaining to radiation safety such as spills, loss of radioactive material, overexposures, etc.
Q. Supervise and control procedures involving issuance, stocking, collecting, laundering and disposal of protective equipment, clothing, etc.
R. To advise on the design or alteration of installations involving sources of ionizing radiation.
S. To make arrangements for the proper training and indoctrination of personnel whenever necessary.
T. To carry on research and training pertaining to Radiological Physics and Safety.
U. With the advice and approval of the R.S.C. to keep this Radiological Guide and Regulations up to date.
V. To prepare and distribute manuals, guides, or other publications pertaining to Health Physics as deemed necessary.
W. To supervise and/or direct all irradiation facilities with respect to radiation safety (e.g. uses of the facilities, procedures, etc.)

The Radiological Safety Officer is appointed by the Director and responsible to him for the fulfillment of his duties. Other duties and responsibilities not covered above are fully explained in the next sections of the guide.

IV. Medical Officer

The duties and responsibilities of the Medical Officer are indicated throughout the succeeding sections of the guide only in his relation to radiation safety aspects.

V. Other Divisions, Departments, etc.

Directors, heads, foremen, supervisors, etc., must keep the H.P.S. informed of personnel assigned to duties involving possible radiation exposure in order for the section to provide the necessary personnel monitoring instruments. Other contacts of supervisors with the Health Physics Section are discussed throughout the guide.

Section II

Permissible Exposure Levels

Table 1 gives the maximum permissible exposure levels (MPE) from external sources of ionizing radiation.

For the maximum permissible concentration of radioisotopes in water and air refer to National Bureau of Standards, Handbook 69, Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure.

The levels given in Tables 1 and the NBS handbook shall not be considered as tolerance levels and efforts shall be made to keep these levels as low as possible. (e.g. as close to background values as possible).

Table 1. RECOMMENDED LIMITS ON EXPOSURE TO EXTERNAL RADIATION

EXPOSURE	NATIONAL COMMITTEE ON RADIATION PROTECTION & MEASUREMENT	
	PREVIOUS	NEW
OCCUPATIONAL Critical organs (includes the whole body, blood forming organs, gonads, lenses of the eyes)	.3 rem/week 3 rems/quarter a 15 rems/year b	---- a ---- b 5 rems/year c 15 rems/year d
Skin (whole body)	.6 rem/week 30 rems/year b	---- a 10 rems/year c e 30 rems/year d f
Extremities (skin dose)	1.5 rems/week b	75 rems/year f
NON-OCCUPATIONAL Individuals in vicinity of controlled areas a	1.5 rems/year	.5 rem/year (average)
General populations (average exposure to gonads above background from all sources)	45 rems/0-30 yrs.	10 rems/0-30 yrs (3.3 rems/decade after age 30)
a Exposure resulting from plant operation, not including background or medical exposure	a If .3 rem/week is exceeded. b Assumes 50 workweeks per year	a It is expected that modification of the NCRP recommendations will result in the dropping of a weekly limitation. b It is expected that modification will result in the establishment of the quarterly limit at 3.75 rems. c Average dose/yr. lifetime occupational. d Maximum in one year e Double the MPD for critical organs f Assumes 50 workweeks per year.

Section III

Handling Radioactive Material

Preventive measures are the foundation of radiation protection. The preventive and safety rules given in this manual shall be employed by all personnel and enforced by the proper authorities. Laxity in following the rules set forth here will jeopardize the safety of all personnel, including the violoator. In case of doubt on any procedure the Health Physics Section shall be consulted.

I. Radioactive sources and radiation sources are divided into three Categories; Category 1 (low intensity), Category 2 (intermediate intensity) Category 3 (high intensity). (See Appendix A for definitions).

II. Intensity Levels and Zones:

In regard to intensity levels from radioactive substances or sources the following, as detected by survey and monitoring equipment, are established.

A. Radiation Area(s) and High Radiation Area(s). (See Appendix A for definition).

B. Radiation Area(s) and High Radiation Area(s) - shall be properly indicated by use of appropriate signs. Persons authorized to enter these areas shall wear personal monitoring devices (e.g. dosimeter, pocket chamber) in addition to the film badge.

III. Procurement:

Any acquisition by the PRNC of radioactive material from outside the Center, or any disposal of radioactive material from inside to outside of the Center shall be carried out through the Administrative Office.

A. The Administrative Office shall notify the Health Physics Section of the scheduled arrival of any radioactive material by filling the appropriate section of Form No. [illegible].

B. As soon as the Administrative Office receives notification of arrival, he shall notify the Health Physics Section. This section will collect, survey and deliver the material to the appropriated custodian and notify the Administrative Office of action taken. The Health Physics Section will complete the appropriate section of Form No.[illegible] and send a copy to the Administrative Office.

IV. Transfer:

Transfer of radioactive material from one storage location to another or change of custodian within the PRNC shall be reported to the HP Section before the transfer is made.

NOTICE OF INCOMING OR OUTGOING RADIOACTIVE MATERIAL

To be Filled by Administrative Office in Duplicate: No. _____

Incoming _____ Outgoing _____

1. Date of this notice _____

2. Expected date of arrival _____

3. Material _____ 4. Quantity (C, mc or uc) _____

5. Type of package _____

6. Approximate size and weight _____

7. From _____

8. To _____

9. Storage location-room No. _____

10. Delivered by (car, truck, airplane) _____

_____

To be filled by Health Physics Section:

11. Parcel - Survey _____

12. Maximum radiation _____ at (distance) _____

13. From (center or surface) _____ Maximum radiation at 1 meter _____ 14. Instrument used _____

15. Contamination _____

16. Evidence _____

17. Inst. used _____

18. Remarks (damaged parcel, no label, possible exposure to areas or persons, etc.) _____

_____

_____

19. Delivered to _____ 20. Date of survey _____

_____
Signature of Surveyor

PRNC-HPS FORM NO. 661

Transfer of radioactive material into or out of PRNC shall only be recorded and monitored by the HPS in accordance to approved procedures. This section will assist, if needed, in such transfer. Form No.662 will be filled in any of the above mentioned instances.

V. Storage:

Whether a radioactive material is kept in a temporary or permanent storage, such material shall be clearly labeled. The Health Physics Section will supply upon request the required labels for all radioactive materials or substances.

A. Permanent Storage Area - (See Appendix A for definitions).

Entrance of unauthorized personnel to this area shall be restricted by use of locks, physical barriers or any other convenient method. The Health Physics Section will affix appropriate warning signs. Barriers, when used, should be placed so that access to surrounding areas will not result in exposures greater than 7.5 mrem/hr or else a limiting time access be used. Permanent storage areas shall be maintained under the cognizance of the Health Physics Section.

B. Temporary Storage Area - (See Appendix A for definition).

Temporary areas shall be prpporly indicated by means of warning signs. These signs will be supplied by the Health Physics Section, but it is the responsibility of supervisors to carry out related regulated regulations and safety measures (See section V-A above among others).

C. Permanent and Temporary Storage Space - any person can request space for storage of radioactive materials from the authority controlling the desired space, which may or may not be the Health Physics Section. The HPS will give final approval. To apply for storage space fill out Form No. 662 in duplicate.

D. Storage Tags - tags for radioactive material in a permanent storage area shall have the following information:

No. _____

Material _____ Quantity _____ (C, mc or uc)

Date Measured _____ Last Custodian _____

Date of Storage _____

Description of source: (Such as: enclosed in glass capsule, remote tongs needed, in powder or liquid form-grams or militers, etc.)

Radiation Intensity _____ mr/hr at _____ (shielded)

HEALTH PHYSICS SECTION

Transfer Permit

1. Date: _____ 2. Requested by: _____ 3. No. _____

4. Present custodian _____

5. New custodian _____

6. Present storage location (building and room) _____

7. New storage location (building and room) _____

8. Description of material and quantity _____

9. Description of container(s) _____

_____

10. Date when transfer will be made _____

11. Assistance needed from H.P.S. _____

_____

The requester certifies that the person to whom the material described above is to be transferred (custodian) is acquainted with the material and with the radiation hazards involved in using, handling or working with such material. Furthermore the requester indicates that said person is acquainted also with decontamination and disposal procedures pertaining to the material.

Note: Use reverse side for additional space.

To be Filled Out by the Health Physics Section

Permit granted by _____

Date _____

Not valid after _____

Remarks: _____

_____

PRNC-HPS FORM NO. 662

_____ mr/hr at _____ (unshielded)

Contamination _____ c/m (alpha)

_____ c/m (beta, gamma)

H.P.S. _____ Date _____

VI. Recommendations for Handling Radioactive Materials

A. General

Protection is best afforded in three distinct ways, or a combination of them: distance, shielding, time.
It is recommended not to rush when using radioactive materials or substances, but a person should not remain exposed to radiation beyond the time required for completion of work.
The use of gloves, tongs, electromagnetic holders, remote pipetting devices, shoe covers, etc. are strongly recommended.
Whenver the intensity field is such that the devices above are not enough, shielding shall be used to further assure protection.

B. Shielding

Because of the value and common use of shielding for many operations involving use of radioactive substances or sources, certain general facts should be taken into consideration (keeping in mind that shielding problems may be very complex at times).

1. For gammas, lead (high atomic number) is the most widely used material due to its high density and relative economy.

2. For betas, plastics (low atomic number) like plexiglass and lucite are the most widely used materials. With betas Bremsstrahlung rays (secondary gammas) are produced. As a rule 1 curie of beta produces about 1 millicurie of gamma equivalent.

3. For beta-gamma sources in which Bremsstrahlung phenomena occur, a combination of plastic and lead is frequently used.

4. For neutrons, paraffin and water are the most widely used absorbers and moderators.

Section IV

Contamination and Decontamination

I. Contamination

Criteria for Contamination

Any spot, area, zone, surface, etc. exceeding the levels given in Table 2 is to considered as contaminated.

II. Preventing Contamination and Spreading of Contamination

All radioactive material shall be considered as a potential leaker. In handling or using radioactive materials or substances all items which may become contaminated should be considered as such until proved otherwise by proper monitoring. This applies especially to items used in conjunction with isotopes in class II and III in Table 3. Glassware shall be thoroughly washed and monitored after used. Washed glassware shall be stored separately from unused glassware. Any equipment, instrument, tool, etc. of doubtful cleanliness in regard to radioactive contamination that must repaired shall be monitored and approved by the Health Physics Section before it can be sent for repair.
The following rules shall be observed while working or handling radioactive material:

A. Avoid smoking, eating or drinking of any kind, use of cosmetics, etc.
B. Do not use telephone, nor handle reports, etc. while wearing gloves.
C. No solution, regardless of its nature, shall be pipetted by mouth, avoiding chance of ingesting, however, remote.
D. In case one has to leave the premises be sure to wash exposed parts of the body, in particular the hands, and check with a monitor.
E. Before leaving the premise all protective clothing or equipment such as shoe covers, gloves, coats, masks, etc., shall be left in the premises.
F. Custodians and/or supervisors are responsible for checking for radon leakage, every 3 months, all radium sources assigned to them or to personnel under their supervision and notifying the Health Physics Section.
G. Tables, laboratory surfaces, floor surfaces, etc. which may become contaminated during an experiment or in handling radioactive material, shall be covered with appropriate paper towel, absorbent paper, etc.
The Health Physics group will gladly assist in recommending materials to be used in these cases.

TABLE 2 MAXIMUM PERMISSIBLE LEVELS FOR GROSS ALPHA AND BETA/GAMMA CONTAMINATION

Contaminated Item	Alpha		Beta-Gamma	
	Smear*	Survey Meter**	Smear*	Survey Meter**
Hands and Body		150 c/m***		0.1 mr/hr 700 c/m
Protective Clothing		150 c/m		0.7 mr/hr
Hot laboratory surfaces, High Radiation Areas	<10 c/m	none detectable	200 c/m	2.5 mr/hr
Cold areas - floors, walls, furniture, closets	<10 c/m	none detectable	50 c/m	0.2 mr/hr
Gas cylinders, acid bottles, other large containers	<10 c/m	none detectable	20 c/m	none detectable
Offices, lunch rooms including offices used as such	<10 c/m	none detectable	20 c/m	none detectable
Instruments for calibration sent to H.P.S.	<10 c/m	none detectable	50 c/m	0.2 mr/hr 1000 c/m
Shoes (personal) inside	<10 c/m	300 c/m***		0.3 mr/hr 1000 c/m***
outside	<10 c/m	300 c/m***		0.6 mr/hr 1000 c/m***
Personal clothing		150 c/m		0.2 mr/hr
Shoes (Center) inside	30 c/m	300 c/m		1.0 mr/hr
outside		300 c/m		2.5 mr/hr
Radioisotopes containers leaving Puerto Rico Nuclear Center	<10 c/m	none detectable	50 c/m	up to 200 mr/hr

* smears - consist of wiping with a 2 $in.^2$ filter paper an area of approximately 100 $in.^2$. Smears are counted in a gas flow proportional counter with 50% geometry and background count of 10 c/hr.

** survey meters for alphas read in c/m and for beta-gamma read in c/m and mr/hr.

*** this is total alpha. 10% is assumed to be transferable. If contaminant is known to be transferable use 10 c/m. In case of beta-gamma this value is 1,000 c/m

TABLE 3. CLASSIFICATION OF RADIOISOTOPES ACCORDING TO THEIR RELATIVE RADIOTOXICITY WITHIN THE BODY

Hazard Class	Activity Level *			Maximum Permissible Contamination		
Class I Slight Hazard	Low	Intermediate	High	mr/hr **	mrad/hr **	c/m **
*Na^{24}, K^{42}, *Mn^{52}, Cu^{64}, *As^{76}, As^{77}, Kr^{85}, Hg^{197}	to 1 mc	1 to 50 mc	50 mc up	1.0	1.0	1000 /
Class II Moderate Hazard H^3, C^{14}, *Na^{22}, P^{32}, S^{35}, Cl^{36}, Mn^{59}, *Co^{60}, Sr^{89}, *Cb^{95}, *Ru^{103}, Te^{127}, Te^{129} I^{131}, *Cs^{137}, *Ba^{140}, *La^{140} Ce^{141}, Pr^{143}, *Nd^{147}, *Au^{198} *Au^{199}, Hg^{203}, 205	to 500 uc	500 uc to 5 mc	5 mc up	1.0	1.0	1000 /
Class III Very Hazardous Ca^{45}, Fe^{55}, Sr^{90}, Y^{91} *Zr^{95}, Ce^{144}, Pm^{147}, Bi^{210}	to 50 uc	50 uc to 500 uc	500 uc up	0.1	0.1	100 /

* Modified after Table 1. NBS HB 48.1951

** Monitoring Instruments for beta and gamma read usually in mr/hr or c/m. Instruments for beta and alpha usually read in c/m or mrep/m, but for practical purposes in radiation protection the rep and rad difference can be neglected. The rad is the officially adopted unit of absorbed dose.

/ This assumes 10% transferable alpha, beta or gamma. These values are for body contamination only. Values for group contamination other than body are found in Table 2.

H. All laboratories or other facilities making use of radioisotopes shall have a properly labeled solid wastes can and/or a liquid wastes container of the type specified by the H.P.S.

I. Equipment or materials (e.g. gas cylinders, instruments, reagent bottles, etc.) used in areas of radioactivity shall be checked by a Health Physics surveyor before they are discarded or transferred or returned to stock rooms, etc.

J. Mops and brooms used in cleaning "hot" laboratories, high level activity areas or any other area where radioactive substances are used regularly (e.g. Radiochemistry, Radiobiology labs.) shall never be used to clean other areas, nor placed together with mops and brooms used for cleaning "cold" areas, laboratories, offices, classrooms and the like.

K. Whenever a radiation area is to be vacated the Health Physics Section shall be notified. The Section shall make a survey of the area and if this is found to be contaminated above permissible levels, will request decontamination by the person or persons vacating the area. The Health Physics Section will give final approval for reoccupation of the area.

L. Spills (see Appendix A for definition) shall be reported to the Health Physics Section immediately. In case of doubt as to how to proceed, contact the Health Physics Section. Spills shall be cleaned as soon as practical. If the radioactive material is in liquid form, blot with blotting paper (not towel paper) using rubber gloves. If in powder form clean with damp paper towel. Be sure paper is not soaked wet. Wear rubber gloves. When dry, monitor and proceed with decontamination. (Part V of this same section).

M. Any glass item in a laboratory or other room where radioisotopes are present shall never be taken to the glass blowing shop. For this reason, it is suggested that glass items (e.g. beakers, glass tubing, pipettes, test tubes, etc.) in laboratories and rooms where radioisotopes are stored or used, be kept in enough quantities to meet the needs. All other glass items of no immediate use shall be stored in an appropriate place in accordance with the idea expressed above. In addition pipettes, glassware, tubing and similar items in a laboratory shall never be allowed to touch one's mouth.

N. Centrifuges shall be used very carefully to avoid spills and/or contamination. They shall never be operated with the lid open and the centrifuge tubes shall never be filled less than 1 inch from the rim when radioactive solutions are used. Note: If contaminant is an alpha emitter use your best judgement in monitoring. Portable alpha survey meters are not as efficient as other instruments. The Health Physics Section will take "smears" if requested or necessary.

III. Protective Clothing

A. Expendable clothing (see Appendix A for definition) will be issued to all personnel working in areas where contamination is possible. All expendable clothing that can be laundered shall be properly identified by a serial marking to indicate its assignment (including that used by the Health Physics Staff).

B. Some expendable clothing (e.g. paper clothing, plastic shoe covers, etc.) shall be discarded after using it once. Other expendable clothing will be discarded accordingly.

C. The Health Physics Section will supply laundry hampers or equivalent for the collection of expendable clothing to be laundered. One hamper is labeled "Cold Clothing". Garments giving under 150 c/m for alphas and less than 700 c/m for beta-gamma, when checked with a laboratory survey instrument, shall be thrown into this hamper

The other hamper is labeled "Hot Clothing". Garments reading 150 c/m or more for alphas and 700 c/m or more for beta-gamma shall be dumped into this hamper. (See table 2 "Maximum Permissible Contamination Levels").

These hampers shall be used only for fabric clothing.

Protective clothing shall be monitored by the wearer daily before leaving work.

The Health Physics group will collect these hampers at regular intervals.

IV. Contaminated Tools and Equipment

This applies to any item used in handling, transportation, machining, disposal, etc. of radioactive material that can be called tool or equipment in the conventional way.

Contaminated tools and equipment shall be considered as radioactive material and treated as such until properly decontaminated and proved to be so. Whenever tools and equipment are suspected of being contaminated, consider them as such until proved otherwise.

Whenever tools, equipment, glassware, containers, etc. are definitely contaminated, they are to be placed under water, under an operating hood or on top of blotting paper, (whichever the situation calls for), until decontaminated, but they shall never be allowed to rest directly on exposed surfaces of any kind nor shall they be stocked in a storage room or any other room on exposed surfaces, for future decontamination.

Any item that has been cleaned and decontaminated shall be monitored to assure definite decontamination.

V. Decontamination

A. Responsibility

It is the responsibility of individuals working with radioactive substances to get acquainted with decontamination procedures, particularly suited to their work and they shall be responsible to carry on these procedures and to take the necessary steps to avoid spread of contamination to other areas.

It is not the responsibility of the Health Physics Section to carry out decontamination, except when the contaminated material is such that only this department has the facilities to do it or when a serious problem of contamination may develop. In that case this department shall be notified at once to take care of the situation.

The Health Physics Section shall be consulted at any time in case of doubt to furnish advise or assistance.

B. Cuts, Wounds and Lesions

Personnel using or working with radioactive materials receiving a cut, wound or lesion shall report at once to the Medical Officer for diagnosis and treatment. The Medical Officer will notify the Health Physics Section.

If a person is actually engaged in work using a radioactive substance which may contaminate a cut, wound or skin lesion, proceed as follows:

1. Wash the injured area immediately with running water. Apply pressure while washing. The time factor is very important to reduce the amount of absorption of contaminant (if any were present).
2. Notify or have someone else notify the H.P.S. at once.
3. Secure medical attention as necessary. No person under any circumstance shall employ antiseptics or self-treatment. Any person receiving a cut, wound or skin lesion should report to the Medical Officer for clearance before working or using radioactive substances again.

C. Laboratory Equipment, Tools, Apparatus, Materials, Etc.

Whenever an item is to be decontaminated the person or persons in charge shall wear rubber gloves. In addition, an apron or coverall (whichever is best for the particular case) and shoe covers or rubber boots (whatever is best for the particular case), shall be worn. If fumes are involved in the procedures, assault or gas masks shall be worn.

Ordinarily, the majority of contaminated items can be

decontaminated by the person using these items or by some one assigned to this job (not a member of the Health Physics staff).

Decontamination of low contaminated items shall not be carried out in laboratories and working areas where teaching and/or research is done as this may create a potential hazard and/or may affect background levels.

All items in this group which are not going to be decontaminated immediately shall be properly and clearly labeled using a sticker, label or tag indicating "Radioactive Contamination" until decontaminated. Such items shall be placed in a decontamination room, expedially if bulky or in large numbers (e.g. part of a machinery, several beakers, etc.)

Wherever they are temporarily stacked they shall be placed on top of absorbent paper or blotting paper, under water, under a hood or in a well exhausted room.

As stated in part V of this section, subpart A, the responsibility for decontamination is taken over by Health Physics Section only in serious cases of contamination.

However, if a person is not familiar with decontamination procedures not covered in this guide, the assistance of the Health Physics group shall be requested. Also, if the physical character of the contaminated item is such that it can not be decontaminated with the conventional equipment and materials, the services of the Health Physics Section shall be requested.

In case of doubt always consult your supervisor and if he can not help consult the Health Physics Section.

VI. Recommendation for Decontamination

A. General

Decontamination is a complex problem depending on the type of contaminant and the contaminated material, therefore only general decontamination procedures are considered here, giving particular attention to hand and body decontamination. Table I (appendix B) presents a list of general routine decontamination procedures. The table is to be used only as a guide.

B. Personal Decontamination

In case of personal contamination the procedure outlined in Appendix B is recommended.

Section V

Personnel Monitoring

I. Types of Instruments

There are a number of personnel monitoring devices, all of which have a definite use for a particular type of work with radioactive material, or to gather specific information in regard to exposure dose received by personnel. These devices shall be worn as indicated. Failure to do so will be detrimental mainly to the wearer.

A. Film badges - these badges, made of metal, plastic or cardboard about 1-1/4 x 1-3/4 inches in size, shall be worn at all times while the person is within the controlled area (see Appendix A for definition). The badges assigned will be of 3 types.

1. Permanent badges - every permanent employee or person associated or visiting PRNC for a period of time of one year or more will be assigned a permanent film badge.
2. Temporary badges - are assigned to persons temporarily employed or associated or visiting the Puerto Rico Nuclear Center, for a period of not less than 3 months nor greater than one year (e.g. regular students, part-time employees, etc.).
3. Visitors badges - are assigned to persons employed, associated or visiting either regularly or irregularly for a period from 8* to 12 weeks.
4. Regardless of type of badge, this shall be worn with the name toward the front.
5. The badges shall be worn somewhere around the chest level, outside of all clothing. For persons engaged in special work where the hands are exposed most, wrist badges will be issued.
6. Badges shall be picked up every morning from a badge rack located in the main lobby. The rack is numbered serially to correspond with the film badge.
   Badges shall be returned to their proper place in the rack on leaving the installation.
   The film is sensitive to a certain extent to temperature, humidity and heat, therefore, the badges shall never be tampered with, taken home, left in the drawers or on top of cold or hot surfaces, etc. If this is done an erroneous reading may be recorded for the person to whom the badge was assigned.

* Persons employed, associated or visiting for less than 8 weeks may or may not use pocket chambers and/or dosimeters as determined by H.P.S.

B. Pocket dosimeters - these are self-reading fountain pen type electroscopes.

1. These dosimeters are assigned by the Health Physics Section to personnel working in radiation areas where the possibility exist of getting an exposure dose greater than 40 millirems of X or beta-gamma radiation in 8 hours (see table 1 Maximum Persmissible Exposures to External Radiation).
2. Personnel using pocket dosimeters shall be instructed by their supervisors on how to read them.
3. Pocket dosimeters shall never be handled roughly.
   Pocket dosimeters shall be picked up from the rack in the morning before starting to work. Dosimeters are placed next to the badge in the same rack used for badges, in the main lobby, in slots provided for them.
   Before leaving the installation they shall be returned to the rack.
   Pocket dosimeters are read daily by the Health Physics Section. The section will assign 2 dosimeters to a person, if there are enough available.

C. Pocket chambers - these devices are similar to pocket dosimeters, except they are not self-reading and have to be read in a special instrument in the Health Physics Section.

1. Pocket chambers are assigned by the Health Physics Section to personnel working in radiation areas where the normal exposure in 8 hours is not likely to exceed 40 millirems of X or beta-gamma radiation and to visitors, since they do not wear X-ray film.
2. Pocket chambers shall be used in the same manner as pocket dosimeters and handled, picked and returned every day as instructed for pocket dosimeters (see B 2 and 3 above).

D. Combined pocket chambers - these chambers are similar to the pocket chambers described under C above, except that in addition to being sensitive to X, beta and gamma radiation, they also detect thermal neutrons.
These chambers read in terms of millirems.

1. These chambers will be assigned by the Health Physics Section to personnel working in areas where the possibility exists of being exposed to mixed radiation (e.g. near the reactor).
2. Combined chambers shall be used like pocket chambers described under C above.
   These chambers shall be handled, picked up and returned every day as instructed for pocket dosimeters (see 2 and 3 under B above).

E. Neutron pocket chambers - these chambers are similar to those already described except that they are used to detect thermal neutrons only.

These pocket chambers also read in millirems.

1. These chambers are assigned to personnel working in areas where the possibility exist of getting an exposure of 40 mrems or more in 8 hours due to thermal neutrons.
2. These chambers shall be handled, used, picked up and returned as the other chambers described before.

F. Others - the Health Physics Section keeps a number of pocket dosimeters (self-reading) for emergency cases. There are 3 types of these dosimeters: full scale 200 mr, 5 r and thermal neutrons.

II. Issuance

The Health Physics Section will issue the proper personnel monitoring instrument(s) subject to the following:

1. It is the responsibility of supervisors to notify the H.P.S. of personnel under their supervision as well as visitors.
2. The supervisors note shall include the position (job) assigned to said personnel to facilitate issuance of the appropriate personnel monitoring instrument(s). In the case of visitors the area or areas to be visited shall be indicated.
3. The information (above) should be in the hands of the Health Physics Section at least 2 days before employee reports to work or visitor arrives.
4. Upon receipt of notice from Supervisor, the Health Physics Section will determine and issue the appropriate personnel monitoring instrument(s).

Section VI

Radioactive Waste

I. General

For practical purposes radioactive wastes are divided into three broad classes.

II. Liquid Waste

Liquid waste shall be placed in appropriate labeled bottles or containers and a tag affixed by the person in charge indicating the radioisotope(s) present.

A. Radioisotopes shall be placed in separate containers as follows:

1. Short-lived radioisotopes shall be placed in a separate container from the medium-lived and long-lived ones. Short-lived radioisotopes shall be considered those with a half-life up to 20 days; medium-lived, those with a half life from 20 days up to 140 days; long-lived, those with a half life greater than 140 days.

2. Regardless of half-life no liquid radioactive waste shall be disposed of by pouring into drains, except those designated or approved by the Health Physics Section. Furthermore the H.P.S. shall approve the disposal whatever means is employed.

3. No liquid radioactive waste, whatever its origin, will be released with an activity greater than 1×10^{-5} uc/cc. This will assure an activity not greater than 2.63×10^{-9} uc/cc of sewage.

III. Solid Waste

Dry radioactive waste such as papers, towels, Kleenex, etc. shall be placed in appropriate labeled cans. Radioactive waste containers shall never be used for deposition of uncontaminated material. The cans should be monitored as frequently as good judgement indicates by the regular user(s) and if found to exceed permissible levels the Health Physics Section should be notified so that waste may be taken to disposal or storage vaults whichever the case may be.

IV. Gaseous and Airborne Radioactive Waste

Radioactive Wastes in gaseous form shall be controlled so that their release to the atmosphere will not result in activity levels in working areas greater than the permissible levels indicated in NBS HB-69, when measured by appropriate monitors.

Section VII

Radiation Source Equipment

I. General

Accelarators, X-ray units, teletherapy units using radioisotopes as source of radiation and other equipment capable of producing radiation are to be considered as sources of hazardous radiation. The Hazards associated with such equipment is mostly external and as such Section II applies.
In addition the following regulations are to be observed.

A. Surveys

1. A survey shall be made for all energy levels at which the equipment operates.

2. A survey shall be made whenever there is a significant change in beam direction, shielding arrangement and type of target.

3. The Health Physics Section will carry on the surveys mentioned in 1 and 2 above, but it is the responsibility of supervisors to notify the section at least 2 days in advance of proposed work to be done.

B. Protection

1. High radiation intensity areas around facilities using this type of equipment are considered High Radiation Areas and regulations pertaining to such areas apply (See Section III-IIB).

2. Interlocks, mazes, warning devices (alarm systems), etc. shall be installed in such a way as to prevent entrance into the facility while the equipment is in operation which would result in an accidental exposure.

3. It is the responsibility of the person(s) in charge of these facilities to see that all safety equipment is working properly at all times and that appropriate warning signs, protective barriers, etc. are in use.

   The Health Physics Section, upon request, will furnish and post warning signs, establish physical barriers and conduct surveys whenever requested (see A-1, 2 and 3 above).

4. Any person assigned to duties with X-ray and teletherapy units must familiarize himself with the National Bureau of Standards Handbook 60 "X-Ray Protection" and sign a statement to this effect. Only those persons signing this statement shall be authorized to work with X-ray Teletherapy units.

The signed statement will be kept by the Health Physics Section.

C. Radiation Source Statement:

In accordance with the regulations set in this section, part B, sub-parts 4, Form No. 663 shall be filed with the Health Physics Section, before authorization be issued for work with X-ray and teletherapy units.

PUERTO RICO NUCLEAR CENTER

Operated by

UNIVERSITY OF PUERTO RICO

For

U.S. ATOMIC ENERGY COMMISSION

Radiation Source Equipment Statement

No. _____ (do not fill) Date _____

I, _____ , hereby certify that in accordance with Section VII-I, B 4 and C, I have read and familiarized myself with:

National Bureau of Standards, Handbook 60, "X-Ray Protection".

Also I certify that (I am, I am not) qualified to operate the facility(s) described in the above mentioned handbooks.

_____

Signature

Approved by _____

Health Physics Section

HPS FORM NO. 663

Section VIII

Protection of Construction and Maintenance Workers

Whenever construction and maintenance personnel are requested to work in a radiation area, the request for use of such personnel shall be approved by the H.P.S. To assure protection from radiation hazards, it is the responsibility of the supervisor(s) concerned to be certain that said personnel under their supervision are acquainted with the offical radiation signs and obey the instructions given thereon. Furthermore, the supervisor(s) concerned shall submit at least 2 days in advance the name (s) of construction and maintenance personnel assigned to work in radiation area(s) to the Health Physics Section in order that the section can determine the preventive measures to be used (if any) and take the necessary steps. After completion of the job the supervisor(s) will notify the Health Physics Section in order for the Section to complete its termination procedures.

If needed and/or requested, a Health Physics Section staff member will give a briefing to construction and maintenance personnel on radiological safety.

Section IX

Holidays and After Hours

The regular working hours at the Puerto Rico Nuclear Center are from 8:00 AM to 12:00 Noon and from 1:30 P.M. to 5:00 P.M. Monday through Friday, at which time the Health Physics Section and the Medical Officer offer reguler service.

Work involving use of radioactive substances and/or radiation sources on holidays and after hours (5:00 P.M. to 8:00 A.M. Monday through Friday) shall be notified at least 2 days in advance to the Health Physics Section it being the responsibility of the person(s) doing the work to insure that adequate personnel and area monitoring meters are available.

The Health Physics Section will give final approval for work to be performed on holidays and after hours.

Appendix A

Definition of Terms

I. General:

In this section a number of terms are defined from the point of view of Health Physics or Radiological Safety. These definitions are generally in complete agreement with the definitions used in other related fields, but some differ to some extent.

II. Definitions:

Airborne Radioactivity Area - any room, enclosure, or operating area in which airborne radioactive materials exists in concentrations in excess of the amounts specified in NBS Handbook 69 for 40 hour week or in concentrations which averaged over the number of hours in any week during which individuals are in the area exceed 25% of these values.

Container - any object used for temporary or permanent containment of radioactive material regardless whether the container is used or not for protection from radiation(e.g. capsules, boxes of any kind of material, jars, beakers, cans, shipping containers, etc.).

Controlled Area (Restricted) - area under the supervision of a radiation safety officer. This implies that a controlled area is one that requires control access occupancy and working conditions for radiation protection purposes. All facilities of P.R.N.C. wherever they are located are designated as controlled areas and subject of the rules, regulations and procedures given in this guide.

Critical Organ - in regard to maximum permissible exposure from external source of ionizing radiation the critical organs are: the whole body, the head and trunk, the active blood forming organs, the gonads, the lens of the eyes. In regard to the maximum permissible concentration of a radioisotope in the body in air and water the critical organ is that organ receiving the radioisotope that results in the greatest damage to the body.

Curie - is the unit of activity of radioactive substance or material. One curie is that amount of a radioactive material or substance in which the number of desintegrations per second is 3.7×10^{10} (1 C = 3.7×10^{10} d/s). One millicurie is one-thousandth of a curie (1 mc = 3.7×10^{7} d/s), and one microcurie is one-millionth of a curie (3.7×10^{4} d/s = 2.22×10^{6} d/m).

Expendable Clothing - clothing that canbe disposed off right after use if necessary (e.g. shoe covers, gloves, etc.).

Exposure Dose (R) of X or Gamma Radiation - at a certain place is a measure of the radiation that is based on its ability to produce ionization.

Health Physicist - any member of the Health Physics Section staff qualified by training and experience to carry on radiation surveys, monitoring, setting up calibration facilities, waste disposal methods and facilities, etc. and all other normal duties commonly assigned to a Health Physicist.

Health Physics Surveyor - designates a Health Physics Section member whose duty is primarily that of surveying and monitoring in regard to radiation safety.

High Radiation Area - means any area, accessible to personnel in which there exists radiation, at such levels that a major portion of the body could receive in any one hour a dose of 150 millirems.

Maximum Permissible Concentration in Air and Water (MPC_a, MPC_w) - is a value expressed in uc/cc of air or uc/ml of water, to denote the maximum permissible concentration of a radioisotope in the corresponding medium. Values of MPC are given in NBS Handbook 69.

Maximum Permissible Exposure or Dose (MPE),(MPD) - is a value, expressed usually in millirems, to denote maximum permissible exposure to external radiation allowed to persons.

MPE values shall not be considered as tolerance values and efforts should be made to maintain radiation exposures to personnel below the recommended MPE values.

These values are given elsewhere in this guide.

Permanent Storage Area - is an area solely used for storage of radioactive material or substances.

Radiation Absorbed Dose (rad) - is the unit of absorbed dose (energy imparted to matter per unit mass at place of interest). One rad is equal to 100 ergs/gm of material.

Radiation Area - means any area, accessible to personnel, in which there exists radiation at such levels that a major portion of the body should receive in any one hour a dose (absorbed) in excess of 5 millirems, or in any 5 consecutive days a dose (absorbed) in excess of 150 millirems.

Radiation Safety Officer - is used to designate the Head of the Health Physics Section.

Radiation Source - this term, although it includes radioactive substances and materials, is frequently used to designate machines or equipment that can be used as a source of radiation, like particle accelerators, X-ray diffraction machines, etc.

Radiation sources are divided into three categories defined as:

Category 1: Those sources which have such low intensity that they may be handled, unshielded for a full 8-hour day without causing greater than the permissible daily dose of 60 mrems.

Category 2: Those sources which only can be handled at distances less than 10 ft. for short times (less than 8 hr) without causing greater than a permissible daily dose of 60 mrems. This category includes intensities up to the maximum which can be handled outside of hot cells or other massive shields.

Category 3: Those sources of such intensity that they cannot be handled outside of hot cells or other massive shields.

Radioactive Substance, Material - any substance, material or item which emits or produces one or more types of ionizing radiation, whether this is an inherent characteristic or not. Radioactive standards, radioisotopes, calibration sources, are examples.

Relative Biological Effectiveness (RBE) - is the inverse ratio of the doses of two different radiations necessary to produce the same biological effect.

Roentgen(r) - is the unit of exposure dose of X or gamma radiation. One roentgen is that exposure dose of X or gamma radiation such that the associated corpuscular emission per 0.001293 gm of air produces, in air, ions carrying 1 electrotastic unit (esu) of quantity of electricity of either sign.

Roentgen Equivalent Man (rem) - is a unit of absorbed dose taking in consideration the R.E (q.v.) for different types of radiation. As used here it is the product of the absorbed dose in rads of a particular type of radiation and its corresponding REE (relative biological effectiveness) value. Its use is limited mostly to radiation safety statements in regard to maximum permissible exposure to external radiation and maximum permissible concentration in water and air to internal radiation.

Shall - as used in this guide implies an order indicating absolute necessity of following the recommendations.

Spill - as used in this guide means the loss or escape of radioactive material from a container by whatever means this loss may occur (e.g. leakage, jolting, turn over, breakage of container, etc.).

Temporary Storage Area - an area not solely used for storage of radioactive material or substances, for example, a shielded area of a laboratory, a cabinet in a room, etc.

Uncontrolled Area (Unrestricted) - area not under the supervision of a radiation safety officer.

APPENDIX B

Table I

Decontamination Procedures

General - Floors, laboratory table tops, benches and other surfaces never shall be cleaned with a dry mop, brush or any other item that can be used for cleaning. Always use a wet or oil mop, brush, paper towel, etc. to avoid a dust hazard.

Glassware	1. chromic acid cleaning solution 2. Tide or other detergent and warm water
Porcelain (with full glaze)	1. ammonium citrate, trisodium phosphate, ammonium bifluoride 2. same as glass
Stainless Steel	1. same as (2) for glassware 2. Radiac wash 3. dilute nitric acid (10%) 4. 10% solution sodium citrate or other inorganic acid 5. hydrochloric acid 6. wet abrasion
Brass	1. same as (2) for glassware 2. Radiac wash 3. brass polish 4. wet abrasion
Plastics	1. same as for (2) glassware 2. 10% solution ammonium citrate 3. organic solvents 4. 10% nitric or hydrochloric acid
Paints	1. same as (2) for glassware 2. sodium citrate 10% solution 3. organic solvents (turpentine) 4. carbon tetrachloride 5. caustic soda or potash 6. wet abrasion 7. paint
Wood	1. if not painted or otherwise covered, but treated for porosity, plane and collect shavings 2. paint

Aluminum	1. same as for (2) glassware 2. Radiac wash 3. 10% solution of organic acid 4. weak inorganic acid
Concrete and brick	1. wet abrasion 2. chiseling or complete removal This in many cases is the best 3. paint if smooth surface
Asphalt tile	1. Tide or other detergent and warm water 2. replace
Rubber tile	1. Tide or other detergent and warm water 2. Radiac wash 3. 10% hydrochloric or nitric acid 4. replace
Linoleum	1. same as for (2) glassware 2. carbon tetrachloride 3. kerosene, dilute mineral acids
Vinyl plastic tile	1. Tide or other detergent and warm water 2. 10% hydrochloric or nitric acid 3. 20% hydrochloric or nitric acid 4. replace
Ceramic tile	1. mineral acids 2. ammonium citrate or trisodium phosphate
Dust spills	Contact Health Physics Department since this requires a vaccum cleaner.

Note:

1. **If contamination is due to an alpha emitter and decontamination to the acceptable limits can not be accomplished, but is very close to it, if of short half-life, set apart until contamination is within limits; if of long half-life coat with shellac, varnish or paint if possible, in case of valuable equipment.**
2. **Inorganic acids should be used with caution. Acids fumes may be toxic to personnel and there is also the possibility of corrosion.**
3. **Organic solvents should be used with great caution as many are toxic and flammable.**

APPENDIX B

Personal Decontamination

1. Check contaminated area(s) with a survey meter.
2. Wash thoroughly contaminated area(s) with warm water and Tide, or similar detergent for about 2-3 minutes, working a good lather. Dry well with paper towel. Check contamination again. If it has been reduced, repeat step 2, two, three or four times as long as there is a reduction in contamination counts until this falls below the maximum permissible contamination level. If after two consecutive washing counts remain the same without reaching tolerance level, proceed with step 3.
3. Repeat step 2 using a hand surgical brush, being careful not to apply excess pressure so that the bristles scratch the skin. Repeat step 1. Do not wash more than three times, 2 minutes each. If no results proceed with step 4 or 4a.
4. Moisten your hands and apply citric acid crystals. Rub for about 3 minutes. Repeat 1 again. If not successful try 4a.

4a. If contamination is known to be due to fission products use titanium dioxide in step 4 instead of citric acid. However T.D. has proved good for other contaminants besides fission products. Add enough T.D. in the palm of your hands to form a paste (if not available in paste form).

Work this paste well over contaminated area(s), but be sure to prevent hardening of the paste by adding water sparingly, for about 2 minutes. Rinse thoroughly with warm water, then use water and Tide and scrub with surgical brush assuring that no paste remains under and around fingernails or it will form a hard cake which is difficult to remove.

Repeat step 1. If step 4 or 4a fails to reduce contamination below tolerance level proceed with step 5.

5a. Apply potassium permanganate ($KMnO_4$) - sulfuric acid solution (freshly made solution of equal volumes of a saturated potassium permanganate solution and 1% (or 0.2N) sulfuric acid solution) and scrub with brush for NOT more than 2 minutes. Rinse thoroughly with warm water. Repeat step 1. (Exposure to solution for more than 2 minutes may remove a layer of skin). Step 5 can be repeated up to 3 times.

If and when decontamination is satisfactory proceed with (b)

b. Wash hands thoroughly with a freshly made 5% sodium acid sulfite ($NaHSO_3$) solution to remove the permanganate stains.
c. Wash with Tide and warm water. Dry well with paper towel. If all the methods described fail to decontaminate proceed with step 6.
6. Apply lanolin or an equivalent hand cream to contaminated areas to soften skin.

Notes:

a. Apply solutions to the neck, ears and face with absorbent cotton.
b. Keep two separate 100 cc bottles, one with a saturated solution of potassium permanganate and the other with the 1% sulfuric acid solution
c. Keep several 10 gm. packets of sodium acid sulfite to dissolve in 200 cc of water.
d. Reminders: used paper towels, and brush if discarded, shall be dumped in the dry radioactive waste can.
e. Contaminated clothing shall be placed in a paper bag and dumped in the corresponding hamper, but if the clothing is very wet, place in plastic bag first.
f. Do NOT use oxalic acid NOR organic solvents for decontamination.
g. Before starting decontamination, if this is very low (as indicated by monitoring), you may carry on decontamination without any help. Keep calm all the time. Avoid spreading contamination by grasping detergent container, solution bottles, etc. with a paper towel. If help is required, whoever assists in decontamination shall wear rubber gloves.