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IRRADIATION PROCESSING DEPARTMENT

RADIATION CONTROL
STANDARDS AND PROCEDURES

Issued By

RADIOLOGICAL ENGINEERING
PROCESS AND REACTOR DEVELOPMENT
RESEARCH AND ENGINEERING OPERATION

December 14, 1956

HANFORD ATOMIC PRODUCTS OPERATION
RICHLAND, WASHINGTON

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<i>S. H. Hulet</i>	<i>3672</i>	<i>105-K8</i>	<i>JUL 10 1958</i>	
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SUBJECT

REPRODUCTION OF AEC MANUAL CHAPTER 0524, PART III

STANDARDS FOR RADIATION PROTECTION

AEC Appendix 0524

III. GUIDANCE FOR EMERGENCY EXPOSURE DURING RESCUE AND RECOVERY ACTIVITIES

A. Purpose

The emergency action guidance promulgated in this part provides instructions and background information for use in determining appropriate actions concerning the rescue and recovery of persons and the protection of health and property during periods of emergency.

B. General Considerations

1. The problem of controlling exposure to radiation during rescue and recovery actions is extremely complex. Performing rescue and recovery operations requires the exercise of prompt judgment to take into account multiple hazards and alternate methods of accomplishment. Sound judgment and flexibility of action are crucial to the success of any type of emergency actions. Although the guiding principle is to minimize the risk of injury to those persons involved in the rescue and recovery activities, the control of radiation exposures should be consistent with the immediate objective of saving human life, the recovery of a deceased victim, and/or the protecting of health and saving of property.*
2. To preclude the possibility of unnecessarily restricting action that may be necessary to save lives, these instructions do not establish a rigid upper limit of exposure but rather leave judgment up to persons in charge of emergency operations to determine the amount of exposures that should be permitted to perform the emergency mission.
3. The official in charge must carefully examine any proposed action involving further radiation exposure by weighing the risks of radiation insults, actual or potential, against the benefits to be gained. Exposure probability, biological consequences related to dose, and the number of people involved are the essential elements to be evaluated in making a risk determination.

*The determination as to whether radiation dosage received in emergency actions will be chargeable to the radiation exposure status of the persons will be made on an individual case basis.

4. These instructions recognize that accident situations involving the saving of lives will require separate criteria from that of actions required to recover deceased victims or saving of property. In the latter instances, the amount of exposure expected to be received by persons should be controlled as much as possible within occupational limits.

C. Field Office Managers in Accordance with Subsection 0524-034:

1. shall review and approve emergency plans for rescue and recovery operations.
2. may authorize contractors to take all appropriate measures in emergency situations.
3. normally shall not allow the recovery operation personnel to exceed the occupational exposure standards specified in part I and annex I of this appendix for the recovery of deceased victims; however, in special circumstances may approve a waiver of these limits.

D. Emergency Situations

Specific dose criteria and judgment factors are set forth for the three categories of risk-benefit considerations, i.e., actions involving the saving of human life, the recovery of deceased victims, and the protection of health and property.

1. Saving of Human Life

- a. To preclude the possibility of unnecessarily restricting action that may be necessary to save lives, judgment shall be left to persons in charge of emergency operations to determine the amount of exposures that should be permitted to perform the emergency mission.
- b. Attempts to rescue victims of a nuclear incident should be regarded in the same context as any other emergency action involving the rescue of victims, regardless of the type of hazard involved.
- c. Where there is reasonable expectation that an individual is

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STANDARDS FOR RADIATION PROTECTION

alive within the affected area, the course of action to be pursued should be determined by the person onsite having the emergency action responsibility.

- d. The amount of exposure for this type of emergency action shall be determined by the person onsite having the emergency action responsibility. He should immediately evaluate the situation and establish the exposure limit for the rescue mission accordingly. His judgment should be based upon:

- (1) evaluation of the inherent risks by considering:

(a) the reliability of the prediction of radiation injury. This reliability cannot be any greater than reliability of the estimation of the dose. Therefore, consideration should be given to limits of error associated with the specific instruments and techniques used to estimate the dose rate. This is especially crucial when the estimated dose approximates 100 rems or more.

(b) the exposure expected in performing the action shall be weighed in terms of the effects of acute external whole body exposure and entry of radioactive material into the body.

- (2) current assessment of the degree and nature of the hazard, and the capability of reducing inherent risk from that hazard through appropriate mechanism such as the use of protective equipment, remote manipulation equipment, or similar means.

e. In the course of making a decision to perform the action, the risk to rescue personnel should be weighed against the probability of success of the rescue action.

f. Any rescue action that may involve substantial personal risk should be performed by volunteers, and

each emergency worker shall be advised of the known or estimated extent of such risk prior to participation.

2. Recovery of Deceased Victims

a. Accident situations involving recovery of deceased victims require criteria separate from those for saving lives. Since the element of time is no longer a critical factor, the recovery of deceased victims should be well planned. The amount of radiation exposure received by persons in recovery operations shall be controlled within existing occupational exposure guides.

b. In those situations where the bodies are located in areas inaccessible because of high direct radiation fields, and where the recovery mission would result in exposure in excess of occupational exposure standards contained in this part, special remote recovery devices should be used to retrieve the bodies.

c. In special circumstances where it is impossible to recover bodies without the entry of emergency workers into the area, the individual in charge of the recovery mission may determine it necessary to exceed the occupational exposure standards contained in this part. The planned exposures of an individual participating in the recovery should not exceed 12 rem total for the year or 5 (N-18) whichever is the more limiting.

3. Protection of Health and Property

a. Where the risk (probability and magnitude) of the radiation hazard either bears significantly on the state of health of people or may result in loss of property, so that immediate remedial action is required, the following criteria should apply:

- (1) When the person in charge of emergency action onsite deems it essential to reduce a hazard potential to acceptable levels or to prevent a substantial loss

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AEC Appendix 0524

of property, a planned exposure up to but not to exceed 12 rem for the year or 5 (N-18) whichever is more limiting may be received by individuals participating in the operation.

However, the person in charge of emergency action at the incident scene may elect under special circumstances to waive these limits and permit volun-

teers to receive an exposure up to but not to exceed 25 rem.

- (2) Where the potential risk of radiation hazard following the nuclear incident is such that life would be in jeopardy, or that there would be severe effects on health of the public or loss of property inimicable to the public safety, the criteria for the saving of human life shall apply.

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PREFACE

General

This manual contains the "Radiation Control Standards" and "Radiation Control Procedures" which have been established to provide the necessary control over radiation exposures within Irradiation Processing Department. Provision is also made for including, in the form of "Bulletins", other radiological information of general interest to IPD personnel.

Special attention is directed to the use of the words "shall" and "should" throughout this manual. "Shall" is used where compliance with the stated policy is considered necessary or mandatory to meet accepted standards of protection; "should" indicates requirements that are to be applied or adhered to when possible.

Any questions as to the proper interpretation of material contained in this manual, or any suggestions as to revisions or additions should be directed to the Radiological Engineering Operation.

The Standards

The purpose of the standards is to establish firm radiological limits within which the Irradiation Processing Department will operate, and to outline our radiation control program in sufficient detail to insure uniform and consistent application throughout all IPD facilities.

The standards have been formulated so as to meet the requirements of, and to present detailed methods of accomplishing the intent of, HAPO Radiation Protection policies. Changes in Radiation Control Standards may be made from time to time, as more and better information becomes available.

The Radiation Control Standards are intended to apply to all persons who are working under IPD Management authority. In addition, standards 1.1, 1.2, and 1.3 apply to IPD personnel regardless of where they may be working.

All supervisory personnel within the department are responsible for obtaining compliance on the part of personnel under their supervision.

Any planned deviations from these standards shall have the prior approval of Radiological Engineering, Research and Engineering Operation. Emergency or unplanned deviations shall be promptly reported to Radiological Engineering.

The Procedures

Radiation Control Procedures are intended to prescribe the best method of accomplishing an objective within the limitations of the Radiation Control Standards. A procedure may be changed at any time provided the suggested change is generally agreeable to management involved, and is consistent with department policies and the Radiation Control Standards.

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HANFORD ATOMIC PRODUCTS OPERATION
RADIATION CONTROL CHANGE AUTHORIZATION
 IRRADIATION PROCESSING DEPARTMENT

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5-31-65

SUBJECT

EXTENSION OF RADIATION CONTROL CHANGE AUTHORIZATIONS

The conditions set forth in the change authorizations shall remain in force until the Radiation Control Standards are replaced.

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9-1-64	1.2 Personnel External Exposure Under Emergency Conditions
9-1-64	1.3 Removal of Personnel from Radiation Work and Return
9-1-64	1.6 Radiation Exposure Received at Off-Site Locations
9-8-64	2.1 Personnel Internal Exposure
9-8-64	3.1 Contamination Checks of Personnel
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9-14-64	4.2 Special Work Permits and Radiation Work Procedures
9-14-64	4.5 Controlled Equipment
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9-14-64	9.2 Reactor Shielding
9-14-64	9.3 Radioactive Sources
9-15-64	10.1 Dose Rate Monitoring
9-17-64	10.7 Radiation Occurrences and Incidents
10-15-64	8.2 Underground Radioactive Waste Disposal Facilities

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RCCA EXPIRES

12-31-64

SUBJECT

PERSONNEL EXTERNAL EXPOSURE LIMITS

REFERENCE SECTION: Operational Controls

Part 1

HAPO badge periods have been changed from four weeks and 13 changes per year to monthly periods of four or five weeks to give three badge changes each quarter and 12 changes per year.

The term "four-week badge period" should therefore read "monthly badge period."

Part 5

The improved measurement program developed by the Radiation Protection Operation, HL, has eliminated the need for retention of exposure estimates as permanent records. Exposure estimates may still be desirable on a short-term basis, but any record of them need only be retained until the measurement record has been cleared, which is about 90 days.

The last two sentences of this section which read: "A cumulative record of these estimates shall be maintained as a secondary radiological record. On completion, these records shall be forwarded to Exposure Evaluations & Records, HLO, for inclusion in the individual exposure history dossiers." -- may therefore be disregarded.

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SUBJECT

PERSONNEL EXTERNAL EXPOSURE LIMITS

Basis

The basic HAPO policy on permissible exposures is established by the Radiation Protection Operation, Hanford Laboratories Operation in conformance with applicable regulations issued by the AEC, recommendations of the National Committee on Radiation Protection and Measurements, and the International Commission on Radiological Protection.

This policy is as follows:

1. Human exposure to ionizing radiation shall be kept as low as practical.
2. The basic HAPO exposure limits (described below) shall be applicable to all persons subject to HAPO radiation protection controls.

The basic HAPO exposure standards are stated in terms of the dose received by the critical organs; specifically the active blood-forming organs, lens of the eyes, gonads, and skin. The direct measurement of the radiation dose received by the blood-forming organs, the gonads, and the lens of the eyes is obviously impossible. For this reason, operational controls based on available measurements have been established at such a point that we will know with reasonable certainty that the basic HAPO exposure standard has been met.

It is the responsibility of the management of each facility to initiate such control procedures as may be appropriate to the facility and the work to assure that the intent of this standard is met.

Standard

Basic HAPO Exposure Standards

Occupational exposure as a result of ionizing radiation from a source external to the human body shall not exceed:

1. 5 rem multiplied by the number of years between the person's age and age 18, including not more than 3 rem in any 13 consecutive weeks to the whole body, head and trunk, active blood-forming organs, lens of the eyes, or gonads, due to radiation of sufficient penetrating power to affect a significant fraction of the critical tissue;
2. 10 rem multiplied by the number of years between the person's age and age 18, including not more than 6 rem in any 13 consecutive weeks to the skin of the major portion of the body, due to radiation of very low penetrating power (half-value less than 1 mm of soft tissue);
3. 75 rem/year, including not more than 25 rem in any 13 consecutive weeks to the hands, forearms, feet or ankles.

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SUBJECT

PERSONNEL EXTERNAL EXPOSURE LIMITS

Accidental or Emergency Exposures

Information on accidental and emergency exposures appears in RCS 1.2.

Medical Exposures

Radiation exposures received during medical examinations will not be included in the record of occupational radiation exposure of the person.

Minimum Age for Radiation Workers

Persons under 18 years of age shall not be assigned Radiation Zone Work.

Prior Employment Record

When any person accepts employment in radiation work, it shall be assumed for purposes of controlling subsequent exposures that he has received his age-prorated dose up to that time unless: (1) satisfactory records from prior radiation employment show the previous exposures; or (2) it can be satisfactorily demonstrated that he has not been employed in radiation work.

Operational Controls

1. The following exposure limitations will normally be applied throughout HAPO to assure that HAPO Radiation Protection Standards are met:
 - a. The whole body penetrating dose should not be permitted to exceed 1 rem in any regular four week badge period, or 5 rem including 3 r in any calendar year.
 - b. The whole body skin dose should not be permitted to exceed 2 rem in any regular four week badge period, or 10 rem in any calendar year.
 - c. The extremity dose should not be permitted to exceed 8 rem in any regular four week badge period, or 40 rem in any calendar year.
 - d. Application of the four week badge period shall be such that the basic HAPO exposure standards above are not exceeded.
2. Any planned exposure of personnel in excess of operational control limits shall be cleared through the Radiological Engineering Unit.
3. Radiological Engineering shall be notified of any accidental exposure of personnel in excess of operational control limits.
4. The details of all cases of exposure of personnel in excess of operational control limits shall be documented.
5. The radiation dose to each individual entering a Radiation Zone shall be estimated as described in procedures elsewhere in this manual. A cumulative record of these estimates shall be maintained as a secondary radiological record. On completion, these records shall be forwarded to Exposure Evaluations & Records, HLO, for inclusion in the individual exposure history dossiers.

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SUBJECT

PERSONNEL EXTERNAL EXPOSURE UNDER EMERGENCY CONDITIONS

REFERENCE SECTION: B. Emergency Dose Limitations

The dose limitations established in this section have for sometime been recognized as too limiting for practical application. An expression of guidance by the AEC allows for more realistic values.

Parts 1 and 2

These two parts should be changed to read:

"Where a human life can be saved, a person making an emergency mission should limit his dose to less than 100 rem. Where the dose approaches this maximum, it is important that the method used to measure and limit the exposure be accurate. Where a substantial loss of property can result, the dose received by an individual taking preventative action shall be limited to less than 12 rem.

During recovery action following an emergency, including recovery of deceased victims, individuals shall maintain their exposure within basic HAPO Exposure Standards (RCS 1.1). This does not limit them to the listed operational control values."

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PERSONNEL EXTERNAL EXPOSURE UNDER EMERGENCY CONDITIONS

B. Emergency Dose Limitations

1. For emergencies involving the saving or protecting of an individual, exposures up to twelve times the operational controls listed in Radiation Control Standard 1.1 may be received.
2. For unusual circumstances involving vital equipment, exposures up to three times the operational controls listed in Radiation Control Standard 1.1 may be received.
3. No more than 50% of these doses may be contributed by neutrons.
4. Women shall not be authorized for planned exposures greater than the operational controls stated in Radiation Control Standard 1.1.
5. Under no circumstances shall an individual be deliberately twice exposed to an emergency dose.

C. Action at Time of Accident or Emergency

1. If the condition which caused the emergency still exists, personnel shall leave the affected area immediately and isolate it against uncontrolled entry.
2. Operating supervision and radiation monitoring shall be notified without delay.
3. Emergency exposures greater than normal operational controls shall be allowed only for situations requiring direct action to save or protect an individual or an item of vital equipment. The operating supervisor in charge should direct the emergency exposures.
4. Medical treatment measures shall take precedence over contamination control measures in cases of severe body injury.
5. The manager of the operating group, Industrial Medicine, Radiological Engineering, and the Hanford Laboratories Operation Exposure Evaluations and Records Operation shall be notified without delay of any accidental or emergency exposures estimated to exceed 1 rem, and of any evidence of internal exposure such as contaminated injuries, highly contaminated nasal smears, the presence of highly contaminated air, or suspected ingestion of radioactive materials. The emergency call lists are as follows:

	ORDER	NAME	WORK PHONE	HOME PHONE
Industrial Medicine	1	100-B Area First Aid	2-4403	
		100-D Area First Aid	2-5503	
		100-F Area First Aid	2-5603	
		100-H Area First Aid	2-5403	
		100-K Area First Aid	2-4503	
	2	200-W Area First Aid	2-7703	
	3	P. A. Fuqua	6-4414	Wh-4-5180

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SUBJECT

PERSONNEL EXTERNAL EXPOSURE UNDER EMERGENCY CONDITIONS

Basis

In case of an accident or emergency, immediate action should be directed primarily toward preserving life and minimizing effects of injuries. Personnel involved must be relied upon to take appropriate action to accomplish this objective. When radiation or radioactive materials are involved, action deemed appropriate may require exposures in excess of normal occupational controls. Such exposures should, of course, be taken as judged necessary by those involved to accomplish the primary objective.

Subsequent action should be taken employing pre-established procedures and equipment insofar as possible, wherein due consideration has been given to minimizing radiation exposures to people. In establishing limits for personnel occupational exposures, the National Committee on Radiation Protection has made allowance for the fact that emergencies could arise requiring the planned exposures of personnel to an extent greater than that normally desirable, for the purpose of saving or protecting an individual or an item of vital equipment.

The following standard describes the limitations which are to be applied to personnel exposures in emergency situations in the Irradiation Processing Department.

Standard

A. General

1. Action in an accident or emergency involving radiation or radioactive materials shall be to minimize the radiation exposure of people, employing pre-arranged procedures and equipment wherever practicable.
2. Each person in a Radiation Zone is responsible for being aware of and complying with radiation protection requirements.

Each person working in the vicinity of radiation sources should be generally aware of the kinds of emergencies that might occur and the action he should take. He should promptly notify the appropriate operating or radiation monitoring group whenever a condition is noted that might jeopardize personnel or property.

3. The group responsible for local radiation monitoring and the appropriate operating group jointly are responsible for preparing general plans of action and for providing equipment to cope with emergencies which are within their jurisdiction. The procedures and available equipment shall be made known to each person at the facility appropriate to his expected action in an emergency.

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RADIATION CONTROL STANDARD
IRRADIATION PROCESSING DEPARTMENT

DOCUMENT NO.
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1-9-63	

SUBJECT

PERSONNEL EXTERNAL EXPOSURE UNDER EMERGENCY CONDITIONS

Use the call list supplied as an attachment to RCS 10.8, "Radiological Communications."(1)

6. In criticality type incidents, no access closer than 50 feet to the suspected area shall be made without the express authorization of the Supervisor, Radiological Engineering Unit, Research and Engineering Section.
7. The execution of emergency action shall not be delayed because of the lack of a written procedure.
8. Protective apparel appropriate to the emergency, and which minimizes the possibility of internal deposition of radioactive materials, should be worn wherever possible (e.g., masks, coveralls, helmets, fire fighting gear, etc.).
9. Re-entry should be limited to the locations where the dose rates are known or can be measured with monitoring instruments available.
10. The best available personnel monitoring devices shall be used, including film badges.
11. Personnel exposures resulting from an emergency situation shall be estimated and recorded.
12. The details of all cases of exposure of personnel in excess of operational control limits shall be documented.

1. Call lists revised 6-15-64.

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9-1-64

RCCA EXPIRES

12-31-64

SUBJECT

REMOVAL OF PERSONNEL FROM RADIATION WORK AND RETURN

REFERENCE SECTION: Standard

Parts 1 and 2

Terminology has changed, since the issuance of this standard:

The "4 week badge period control" is now the "monthly badge period control."

The "Current 4 week control period" is now the "current monthly control period."

The position title "Radiation Analyst" is now "Supervisor, Radiation Monitoring."

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RESEARCH AND ENGINEERING SECTION

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MANUFACTURING SECTION

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PRODUCTION FUELS SECTION

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REMOVAL OF PERSONNEL FROM RADIATION WORK AND RETURN

Basis

The basic HAPO policy on permissible exposures is established by the Radiation Protection Operation, Hanford Laboratories Operation in conformance with applicable regulations issued by the AEC, and recommendations of the National Committee on Radiation Protection and Measurements, and the International Commission on Radiological Protection.

Operational controls have been devised to implement this HAPO policy, and may be found in IPD Radiation Control Standard 1.1. A case where an operational control is exceeded is an indication of failure to maintain adequate control over personnel exposures.

It is essential that personnel who may have taken a significant amount of radioactive material into the body be kept from work that might result in increasing this burden.

Standard

1. Employee May Have Exceeded 4 Week Badge Period Control

The employee shall be removed from radiation work until his actual status, as indicated by the dosimeters, is determined by the local radiation analyst; if it is determined that the employee has exceeded a control, or that he is so close to a control that further radiation exposure might cause him to exceed a control, he shall be removed from radiation work for the duration of the current 4 week control period.

2. Employee May Have Exceeded a Calendar Year Control

The employee shall be removed from radiation work until his actual status, as indicated by his badge totals, is determined by the radiation analyst; if it is determined that the employee has exceeded the control, or that he is so close to the control that further radiation exposure might cause him to exceed the control, he shall be removed from radiation work for the duration of the current calendar year.

3. A Routine Bioassay Result is High Enough to Require Careful Study to Determine Whether an Individual Has a Deposit of Radioactive Material Approaching the Permissible Concentration

The individual involved shall be removed from radiation work until such time as the analytical results have been evaluated.

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SUBJECT

REMOVAL OF PERSONNEL FROM RADIATION WORK AND RETURN

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4. An Individual is Involved in an Occurrence Wherein a Significant Amount of Radioactive Material May Have Been Taken Into the Body

The individual involved shall be removed from radiation work until such time as the magnitude of the problem can be determined. The employee shall not return to radiation work until bioassay or whole body counter results are known to be insignificant, or in case high results are obtained, until approval is granted by Industrial Medicine through the Radiation Protection Operation.

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SUBJECT

TIMEKEEPING

Basis

To obtain required estimates of the dose received by an individual engaged in radiation work, two factors must be determined; the dose rate, and the duration of exposure. The accuracy of the dose determination is dependent upon the accuracy with which each of the factors is determined. Accurate timekeeping is essential when work is performed at high dose rates. Consideration should be given to experience and competence in the selection of timekeepers for high dose rate work.

The standard below outlines timekeeping requirements which are necessary to insure that dose determinations are made with sufficient accuracy to prevent exposure in excess of that planned.

StandardI. Timekeeping Requirements

- a. For Radiation Zone work which may be expected to result in personnel whole body penetrating dose rates greater than 300 mrem/hr, a timekeeper shall be required in constant communication with the work site, and preferably at the work location. Whenever possible, the timekeeper should devote his full attention to timekeeping, and should not perform other operational functions while so engaged.

Each worker shall be responsible for informing the timekeeper prior to the start of the work, of the dose which he is to receive during the course of the job. The timekeeper shall not allow an individual to remain in the work zone unless he has supplied this information.

An employee shall leave the Radiation Zone immediately upon notification by the timekeeper that the employee's planned dose has been received.

- b. For Radiation Zone work which may be expected to be performed at whole body penetrating dose rates less than 300 mrem/hr, timekeeping requirements shall be established by supervision prior to the start of the job.
- c. In case a separate timekeeper is not provided, each employee entering the Radiation Zone shall be responsible for his own timekeeping.

II. General

- a. Personnel engaged in establishing dose rates shall not at the same time serve as timekeepers, except for keeping their own time as in (Ic) above.

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SUBJECT

TIMEKEEPING

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- b. Close communication between the monitor and the timekeeper shall be maintained. The method to be used in communicating dose rate information to the timekeeper shall be determined in advance of the work.
- c. Timekeeping equipment such as electric-timers, stopwatches, communication systems, and timekeeping machines shall be provided by the operating group of the facility involved.
- d. Whenever it becomes apparent that timekeeping has been ineffective, exposure to personnel shall cease until doses received are evaluated and adequate time-keeping is provided.

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SUBJECT

PERSONNEL DOSIMETERS

STANDARDA. RECORD MEASUREMENT DOSIMETER REQUIREMENTS

1. Within a plant area or radiation zone, each person shall wear his Hanford Beta-Gamma Film Badge continuously.
2. In a zone where the average neutron dose rate exceeds 1 mrem/hr and the occupancy time is long enough to exceed a 1 mrem dose, each person shall wear an assigned Hanford Neutron Film Badge. These zones will be identified by procedure and/or posting.
3. Any person whose work will cause him to receive a hand dose of 1 rem during the monthly badge period shall wear a Hanford Finger Film Dosimeter while in a radiation zone.

B. CONTROL DOSIMETER REQUIREMENTS

1. Pocket dosimeters and other devices required to maintain interim control of radiation doses received shall be specified by radiation procedure for individuals working in radiation zones.
2. Each person in a job position where the annual X- or gamma-ray exposure exceeds 1 R, or a person who will exceed 100 mR dose during a calendar week, shall wear a Hanford Pocket Dosimeter while in a radiation zone.

C. WEARING PERSONNEL DOSIMETERS

1. The film badges and pocket dosimeters shall be worn on the front of the torso above the waist and finger films on any finger of the dominantly used hand. The dosimeters are to be positioned so that one does not shield another.
2. Dosimeters are to be protected from radioactive contamination, but the Hanford Beta-Gamma Film Badge should be masked by no more than the outer layer of clothing or an equivalent mass thickness of material.

D. LOSS OF PERSONNEL DOSIMETERS

When the loss of a personnel dosimeter is recognized, the person shall:

1. report it to his functional supervisor,
2. remain outside radiation zones until he has a replacement dosimeter.

The supervisor is responsible for investigating the loss of the dosimeter and requesting radiation monitoring service assistance. The local radiation monitoring service is to provide the necessary assistance in determining the amount and type of dosimeter measurement lost and to see that the proper correction is made to the exposure measurement records.

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SUBJECT

PERSONNEL DOSIMETERS

SUPERSEDES ISSUE DATED

5-10-61

BASIS

Personnel radiation dosimeters are worn by personnel exposed to radiation at HAPO:

1. To provide an evaluation of exposure for each individual as a condition of employment in accordance with contractual obligations of the General Electric Company.
2. To assist in maintaining individual exposure within the HAPO operational control limits.
3. To provide frequent routine evaluation of personnel exposure for work planning and scheduling.
4. To provide early notification of off-standard conditions so that corrections can be made.

Two basic types of personnel monitoring devices are currently used. One type utilizes photographic film which is sensitive to radiation: the beta-gamma film badge, the wrist badge, and the finger ring are examples of this type. Small ionization chambers are the second type. The pocket dosimeters or gamma pencil is an example of this dosimeter.

The standard specifies the locations and manner in which personnel dosimeters shall be worn so as to produce quality results and to prevent, insofar as possible, loss of readings due to mishandling. Heat, pressure, and excessive moisture can alter film results and shock can alter pencil results.

The external exposure measurement program provides a continuous exposure record for each individual so that results missing for record measurement dosimeters must be re-evaluated to provide a complete record. Other missing results should be re-evaluated to be sure exposures are under control.

For continuity of external exposure measurement program, the detailed procedures are presented in RCP 1.5. (RCP 1.5 covers exchange, loss, temporary badge issue, etc.) Radiation Control Procedure 1.6 gives the detailed procedure for Manufacturing's pocket dosimeters.

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RGCA EXPIRES

12-31-64

SUBJECT

RADIATION EXPOSURE RECEIVED AT OFF-SITE LOCATIONS

REFERENCE SECTION: Standard

Part A-1

"Exposure Evaluation and Records Operation, HLO (phone 3384)" should read "External Dosimetry Operation, HL (phone 3368 or 3384)."

Part A-5

"Exposure Evaluation and Records Operation, HLO" should read "Exposure Evaluator, RPO, HL."

Part B-1

"Exposure Evaluator, Exposure Evaluation and Records Operation, HLO" should read "Exposure Evaluator, Radiation Protection Operation, HL."

Part B-2

"Exposure Evaluations and Records Operation, HLO" should read "Exposure Evaluator, Radiation Protection Operation, HL."

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RADIATION EXPOSURE RECEIVED AT OFF-SITE LOCATIONS

Basis

In order that HAPO personnel radiation exposure records may reflect the true radiation status of an individual, it is necessary that exposures received by employees while off-site be measured and recorded.

Standard

A. Exposure Received While Visiting Other Sites On Company Business

Any individual in IPD, planning to visit another site where he may be exposed to radiation or radioactive materials shall:

1. Obtain an off-site film badge from the Exposure Evaluation and Records Operation, HLO, (phone 3384) prior to departure. Allow at least twenty-four hours for the badge to be prepared.
2. Wear the off-site badge during any exposure to radiation or radioactive materials while at other projects, in addition to any personnel monitoring devices which may be required at the other projects.
3. Conform to local radiation protection standards when these standards are not in conflict with HAPO standards.
4. On the first working day after return to HAPO, turn in the off-site badge to the local radiation analyst.
5. Provide such personal bioassay samples as are requested by the Exposure Evaluation and Records Operation, HLO.

B. Exposure Received During Temporary Duty With The Armed Forces

Any IPD employee who may temporarily enter the Armed Forces to attend encampments or training periods shall:

1. On the first working day after return to HAPO notify the Exposure Evaluator, Exposure Evaluation and Records Operation, HLO, as to the nature of any radiation exposure received and to whom to write to obtain the complete exposure record for the period.
2. Provide such personal bioassay samples as are requested by the Exposure Evaluations and Records Operation, HLO.

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PERSONNEL NEUTRON EXPOSURE MEASUREMENT

Standard

NEUTRON BADGE

Each person who enters a field of neutrons where it can be anticipated that he could receive more than a 1 mrem neutron dose shall wear a neutron badge.

NEUTRON DOSE

A. Reporting

1. Each person is responsible for recording his neutron dose on the Neutron Exposure Register.
2. The dose shall be reported:
 - a. whenever a neutron badge is worn,
 - b. on the day received,
 - c. in mrem units,
 - d. as zero when the dose is less than 1 mrem.

B. Calculation

The neutron dose shall be evaluated by multiplying the dose rate by the time of exposure. Each person is responsible for knowing his own dose rate, time of exposure, and calculated dose.

C. Records (IPD)

The Neutron Exposure Register with the recorded neutron doses is a permanent radiation monitoring record to be filed and retained.

1. Each entry shall be identified by name, payroll number, neutron badge number, and date.
2. The Register sheets shall be identified by 105 reactor building and dates of the period covered.

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PERSONNEL NEUTRON EXPOSURE MEASUREMENT

SUPERSEDES ISSUE DATED

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3. The period covered by the Register shall correspond to the neutron badge period.
4. Radiation monitoring should maintain surveillance of the Register as to the accuracy of the entries.

D. Records (HAPO)

The neutron dose for each individual shall be transmitted to the External Dosimetry Operation, RPO, HL, on their Neutron Exposure Report form.

1. Each entry shall contain the person's total neutron dose for the badge period, identified by his name, payroll number, and badge number.
2. The report shall be identified by reactor, period covered, and date submitted.
3. The report shall be reviewed for accuracy and signed by the Radiation Monitoring Supervisor for the reactor.
4. The report should be submitted within one week after the last day of the badge period.

NEUTRON DOSE RATE

A. Zone Rates

1. The neutron dose rate shall be established for all fields of neutrons greater than 1 mrem/hr to which people are exposed.
2. The average neutron dose rate established for a zone should represent as closely as possible work conditions, but in no case shall it be below the average of the maximum and minimum.

B. Surveys

1. Neutron dose rate zones shall be established annually and confirmed by a neutron check survey monthly.
2. If the reactor shield has been disturbed in any way, the adjacent zone shall be neutron checked before personnel enter.
3. When a neutron check differs by more than 20 per cent from the established rate, all rates for the zone shall be re-evaluated and re-established.
4. When the neutron dose rates are established for a location, the reactor power level shall be above 90 per cent of its maximum.

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SUBJECT

PERSONNEL NEUTRON EXPOSURE MEASUREMENT

C. Dose Rate Records

Neutron dose rates established for neutron zones are to be recorded.

1. Routine surveys of the neutron allowance zones shall be recorded in the Routine and Repetitive Survey record which should include a dose rate contour mapping of the zone.
2. A dose rate survey made for an entry into a nonroutinely entered neutron zone shall be recorded in the Radiation Survey Reports.

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SUBJECT

PERSONNEL NEUTRON EXPOSURE MEASUREMENT

BASIS

This Standard is to provide a method for obtaining personnel neutron exposure measurement which extends the capabilities of the Hanford Neutron Film Badge Dosimeter and is compatible with the Hanford Radiation Measurement Program.

The neutron film measures fast neutrons above 0.8 Mev. Because fast neutrons are encountered in broad spectrums, the sensitivity of the film varies depending on what portion of the spectrum is above 0.8 Mev. In the vicinity of the IPD reactors the energy spectrum is mostly below 0.8 Mev making the film relatively insensitive. Since the neutron dose rate can be measured to the desired degree of sensitivity with a Hanford Double Moderated BF_3 , the dose rate combined with the duration of exposure provides the necessary information to calculate the neutron dose. The film badge serves as an indicator of the level of dose received.

Radiation Control Procedure 1.4, "Neutron Measurements and Records," is a guide to the mechanics of implementing and carrying out the requirements of this Standard.

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RCCA EXPIRES

12-31-64

SUBJECT

PERSONNEL INTERNAL EXPOSURE

REFERENCE SECTION: Basis

Adequate recognition has not been given to whole body counting as a means of detecting and measuring internally contained radionuclides. The following should be added to the Basis Section:

"Because of the type of radioactive contamination available for internal ingestion within IPD facilities, whole body counting becomes the primary method for internal dose determination. Bio-assay sampling is still necessary, but it plays a secondary or backup roll."

REFERENCE SECTION: Standard

Part 2

To attain timely radiological technical guidance following an occurrence, the second sentence in Part 2 should read: "The information shall be communicated immediately in compliance with RCS 10.8. (Also, see Call List - RCS 10.8 Attachment.)"

Part 4

To clarify the intent here, especially when one considers radionuclides of short half life, the first four words "In any case where" should read "While."

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PERSONNEL INTERNAL EXPOSURE

Basis

The total radiation dose received by an individual is composed of the dose received from external sources and any dose contributed by internally deposited radionuclides.

Small amounts of radioactive materials are normally present in the body. Additional small amounts which may be inhaled or ingested during radiation zone work can be identified and measured by means of bioassay and whole body counting techniques. These techniques are extremely sensitive, therefore special care must be taken not to introduce contamination into the specimen or into the equipment and this is why most samples are taken at home. The cooperation of all groups involved in bioassay sampling is necessary to assure that accurate and sensitive evaluation is secured. A sample may be lost or spoiled in processing, or the sampling may be contaminated, in spite of rigid precautions. In these cases, resampling is necessary.

The determination of the effective dose to the body from either a single radioisotope, or a mixture of radioisotopes is obtained only after a very detailed analysis of bioassay samples. These studies are performed by the Radiation Protection Operation, Hanford Laboratories Operation.

Employees are routinely sampled on hiring in, periodically during their employment, and upon termination. The frequency of routine sampling of a given individual is based upon the probability of his receiving significant deposition of radioactive material in the performance of his assigned work. The probability of plutonium deposition is vanishingly small in the IPD areas, and the probability for significant fission product deposition is remote under ordinary circumstances.

In addition to routine bioassay samples, special samples will be taken in any case where radioactive materials may have been taken into the body as the result of an occurrence.

In IPD, it is our policy to avoid any significant deposition of radioactive materials in personnel by the use of radiological protective clothing, respiratory protective equipment, personnel contamination surveys, air and water sampling programs, and surface contamination control.

Standard

1. The exposure potential from internally deposited radionuclides shall be evaluated at least once a year for all IPD for personnel who routinely enter radiation zones.
2. In any case where an individual is involved in an occurrence wherein deposition of radioactive material is possible, a prompt evaluation of the internal exposure potential shall be made. Supervision responsible for radiation protection shall

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request such evaluations directly from the Exposure Evaluator, Radiation Protection Operation, Hanford Laboratories Operation (Building 3705, Phone 3625, 3645).

3. The body burden of the radionuclides shall be limited to the maximum permissible body burden listed in Appendix A, HW-25457.
4. In any case where an individual's body burden of radionuclides exceeds 50% of the Appendix A values, further planned exposure to the offending, or biologically similar nuclide shall be prohibited.
5. In any case where an individual's body burden of radionuclides exceeds 10% of the Appendix A values, the individual's allowable annual external dose may be reduced to compensate for the internal dose, as directed by Radiation Protection Operation, Hanford Laboratories Operation.
6. Supervision shall be promptly informed by Radiological Engineering in any case as in 3, 4 or 5 above.
7. The recorded dose from deposited radionuclides shall be as confirmed and computed by the Radiation Protection Operation, Hanford Laboratories Operation.

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SUBJECT

RADIATION ZONE INJURIES

Basis

Significant internal exposure of personnel may result when radioactive material enters the body through a break in the skin. Plutonium, and certain fission products are especially hazardous. A relatively small amount taken internally can cause exposure above the permissible limit. Other isotopes are hazardous, but to a lesser degree, because of more rapid decay, faster elimination from the body, or deposition in less vital parts of the body.

In any case of personal injury, the general welfare of the injured is the primary consideration. In a contaminated injury of minor nature, the deposition of radioactive material could be a much greater hazard to the individual than the effects of the injury itself; but if the injury is of a serious nature, involving broken bones, severe bleeding, unconsciousness, shock, intense pain, or other symptoms that indicate severe injury, deposition hazards are usually of less importance than immediate care of the injury.

In case of an injury which has occurred in a contaminated area, consideration must be given to preventing deposition of the contamination in the body through any skin breaks, and to avoiding spread of contamination to the First Aid Station or other medical equipment. Therefore, a prompt personal contamination survey of the injured, especially in the area of the wound, is necessary.

Flushing the wound with clean water while massaging toward the wound will minimize the potential for deposition of any contamination which may be present in the wound. If advisable from a medical point of view, these techniques should be employed whenever surveys indicate that a wound is, or probably is, contaminated.

Controls must also be established to insure that adequate protection is afforded to existing skin breaks before personnel begin radiation work.

Standard

1. Any case of an injury in a Radiation Zone shall be immediately reported to supervision, personnel qualified in radiation monitoring, and to the Industrial Medicine Operation.
2. The degree of compliance with normal contamination control procedures shall be dependent upon the medical severity of the injury. If the injury is of a serious nature, contamination control shall be limited to that required to prevent spread of contamination to medical facilities or spread of gross contamination into the wound. If the injury is of a relatively minor nature, normal contamination control procedure should be followed as closely as possible.

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SUBJECT

RADIATION ZONE INJURIES

3. A contamination survey shall be made of the injury, and where possible, the object causing the injury and any protective clothing or other materials which have been pierced by the object in inflicting the injury.
4. If surveys indicate that the wound is or possibly may be contaminated, the wound should be flushed with clean water, except when such action will unduly delay necessary medical treatment. Any further decontamination of open wound shall be performed by Industrial Medicine personnel.

Approval for Persons Having Skin Breaks to Perform Radiation Work

1. Persons having skin breaks shall perform radiation work only with the specific prior approval of the individual's supervisor, and the concurrence of supervision responsible for radiation protection. They shall insure that the degree of protection afforded the skin break is adequate in view of the nature of the work to be performed by the injured person. Skin breaks shall include unhealed wounds, open cracks from chapping, and other injuries such as lacerations, abrasions, punctures, blisters, or burns.
2. The supervisor should consult the First Aid Nurse if information as to the nature of the injury or the dressing is required.
3. It should be made clear to the individual, that since the approval to perform the Radiation Zone work is contingent upon the protection afforded the wound, the individual is expected to make every effort to maintain any dressings in satisfactory condition during the course of the work, and to leave the zone immediately if the degree of protection afforded the wound becomes inadequate.

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CONTROL OF EXPOSURE TO RADIOAEROSOLS

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Exposure Recognition and Evaluation

Where it has been observed that a person may have received a significant exposure, there shall be sufficient analysis to define and record the exposure. Such exposure is indicated by (1) air sample showing personnel exposure above ECV, (2) positive nasal smear greater than 1,000 c/m above background MW-GM, and (3) loose contamination above 15,000 c/m about the head and shoulders of a person who has worn no mask. The exposure shall be recorded on a Radiation Occurrence Report. Radiological Engineering, Research and Engineering, shall receive immediate notification to be able to recommend steps to be taken in obtaining as complete an evaluation as necessary. When Radiological Engineering is not available, the Exposure Evaluator, Radiation Protection Operation, Hanford Laboratories, shall be notified.

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SUBJECT

CONTROL OF EXPOSURE TO RADIOAEROSOLS

Standard

The average weekly concentration of radionuclides breathed by an individual shall be maintained below the MPC_a recommended by the National Committee on Radiation Protection, Radiation Protection Standards, HW-25457.

Operational Control

Exposure to beta-emitting radioactive airborne particulate contamination, which has longer than a one-hour half life, should be maintained below an average of 3×10^{-8} $\mu\text{c}/\text{cc}$ for a 40-hour work week throughout the IPD reactor facilities. Exposure to higher concentrations is allowable for time periods of less than an eight-hour shift so long as the over-all average for the shift is below the MPC. Such exposure is limited to an Exposure Control Value (ECV) of 24×10^{-8} $\mu\text{c-hr}/\text{cc}$ (i.e., 3×10^{-8} $\mu\text{c}/\text{cc}$ $\times$ 8 hours = 24×10^{-8} $\mu\text{c-hr}/\text{cc}$) which is graphically shown in Figure 1.

Masks

The assault mask, well fitted to the face, shall be considered as 90 per cent effective and the ECV increased by a factor of ten.

The supplied air mask and chemox mask shall be considered 99 per cent effective and the ECV increased by a factor of 100.

Other Radionuclides

All of the alpha-emitting radionuclides and beta-emitters, Sr⁹⁰, Ce¹⁴⁴, I¹²⁹, Pb²¹⁰, Ac²²⁷, Ra²²⁸, Pa²³⁰, Pu²⁴¹, Bk²⁴⁹, have MPC_a too restrictive for the Exposure Control Value limitation. When these radionuclides are present, other than in the fission product, activation product or natural atmospheric mixtures, exposure shall be limited to the NCRP recommended MPC presented in the Radiation Protection Standards.

FIGURE - 1
 RESPIRATORY PROTECTION
 EXPOSURE CONTROL VALUE

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 CONTROL OF EXPOSURE TO RADIOAEROSOLS

Basis

The purpose of this Standard is to guide respiratory protection for personnel exposure to airborne radioactive particulate material. Airborne contamination seldom remains constant and is changed by many factors, but it does correlate to work performed and controls imposed. Respiratory protection requirements should be established before work is started based on the past record of airborne contamination for such work and on the controls to be imposed by a knowledgeable and competent individual.

Exposure Control Value (ECV)

The Exposure Control Value (ECV) presented in the Standard represents the maximum exposure to airborne contamination that should be sustained during a single shift. The ECV (24×10^{-8} $\mu\text{c-hr/cc}$) was derived by multiplying the MPC (3×10^{-8} $\mu\text{c/cc}$) by the eight hours of a shift. It can be used to arrive at an allowable exposure time or concentration. If it is known that the concentration to which a person will be exposed is 6×10^{-8} $\mu\text{c/cc}$, then it would be permissible to extend the exposure time up to four hours ($\frac{24 \times 10^{-8}}{6 \times 10^{-8}} = 4 \text{ hr.}$). If it is known a person will be in a zone for only two hours, then it would be permissible under the ECV to be exposed to a level of 12×10^{-8} $\mu\text{c/cc}$ ($\frac{24 \times 10^{-8}}{2} = 12 \times 10^{-8}$ $\mu\text{c/cc}$).

MPC for Reactor Facility Radioaerosols

The MPC for composite mixtures and individual radionuclides frequently encountered with IPD reactor facilities are shown in Figure 2. Fairly fresh (less than ten days decay) mixtures of activation product and fission product form the bulk of the radioaerosols to which people are most frequently exposed. It should be noted that after 100-day decay the composite MPC's for activation product and fission products have reached lows of 4×10^{-8} $\mu\text{c/cc}$ and 3×10^{-8} $\mu\text{c/cc}$. The lowest value 3×10^{-8} $\mu\text{c/cc}$ is the basis for the ECV (Exposure Control Value).

The residence time in the human body for reactor facility radionuclides is reasonably short. This is best demonstrated by the fact that the effective half lives are measured in hours, days, and sometimes weeks. To maintain a

FIGURE - 2

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significant body burden of such radionuclides, they must be replenished at frequent intervals. Exposures frequent enough to maintain any reasonable level of body burden are not created by present working conditions at the reactor facilities. This adds a certain element of conservatism to the total system.

Inert Gas and Short Half Life Radionuclides

The very short half life (less than one hour) and chemically inert gas radionuclides, because of their small volume and short residence time, create an insignificant internal exposure as compared to the external exposures they generate. Because of this, no MPC values are recommended for the materials and respiratory protection consideration is given in a separate Standard, RCS 2.4.

Masks

Inhalation of aerosols while wearing a mask occurs from the leakage where the mask fits to the face. Every time inhalation takes place, a negative pressure is created inside the mask, even the supplied air masks used in IPD, causing an influx of air through the filter and at any leak points. The assault mask filter is very efficient, removing over 99.9 per cent of the aerosols, but with a poorly fitted mask half the air may enter by leakage by-passing the filter. Even with a well fitted mask, one which seals tightly to the face where the filter is stoppered, about five per cent of the air will bypass the filter.

Control of Radioaerosols

Although the use of a mask reduces exposure to radioaerosols, it also restricts both vision and breathing to hamper one's physical capabilities. The man wearing a mask slows his work pace correspondingly because of the limitations and his susceptibility to accident. As a result, exposure to external radiation is increased. Full consideration to both radiological and other safeguards must be taken into account when respiratory protection requirements are being considered. Other methods of preventing or cleaning the air of radioaerosols are available which may prove much more desirable than masks as a means of respiratory protection. Such methods as sealing or bagging a source, creating a flow of air toward the source away from people, filtration of the air from the source should not be overlooked.

Other Radionuclides

Radionuclides normally not present at the production reactors are the result of research and experimental work. They may be created by special irradiations or be transported into the reactor facilities on request. Their presence may be hidden because they arise from an impurity of a primary irradiation of some other material. The MPC for most of these radionuclides is no more restrictive than the general IPD control concentration of 3×10^{-8} $\mu\text{c/cc}$; however, a few are significantly more restrictive. The radionuclides that fit this classification have been listed in the Standard for ready reference. These unusual radioactive materials are limited in amount and location, but each must be treated on an individual basis with its own hazard analysis. Operating groups are to be aware of

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the presence of these radionuclides and have appropriate restrictions established. Awareness of all types of radioactive sources and how to deal effectively with them is a monitoring responsibility.

Exposure Recognition

Exposure to radioaerosols means the ingestion of a certain amount of this material. Present working conditions at the reactor facilities keep this to an insignificant level but when a significant amount has been ingested it should be evaluated, measured, and recorded. A guide to the need for further evaluation comes through air samples, personnel contamination surveys, and nasal smears. The air sample which indicates people have been exposed above ECV is one criteria. A second comes from personnel contamination surveys which shows the person to have loose particulate contamination on him or his clothing indicating an encounter with airborne contamination. The third from nasal smears, past experience has shown that smears in excess of several thousand counts per minutes (MW-GM) occurred with ingestions better than one per cent of MPBB but when smears were below a thousand counts per minute, ingestion was less than one per cent.

Exposure Evaluation

The extent to which an evaluation is carried in defining an exposure is dependent on the information received at each step. Some of this information is readily available at the time of exposure but becomes more and more difficult to determine with the passage of time. The Radiation Protection Operation, HL, is responsible for maintaining records of radiation exposure and determining that they are adequate. To be able to do this in the case of inhalation exposure and yet not create a burdensome evaluation program, they must receive timely information to be able to adequately advise those administering the radiation monitoring service as to the type and extent of evaluation necessary.

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SUBJECT

RESPIRATORY PROTECTION - GAS ACTIVITY

BasisNoble Gases From Fuel Elements

Radioactive gases are formed as fission products in the fuel elements. Fuel elements which have been operated at high power levels may, on rupture, release a portion of this gas into the cooling water while in the reactor, or into the storage area after discharge from the reactor. Various Xenon and Krypton isotopes have been identified in the mixture. These noble gases are highly radioactive immediately after release from the reactor.

In a large cloud of noble gases, the order of significance of the doses to various parts of the body is as follows (from most significant to least significant):

1. External whole body dose
2. Dose to the bronchial epithelium (lining of the bronchial tubes)
3. Dose to the lungs
4. Dose to body fats

Although some noble gases decay into radioactive strontiums and cesiums, it can be shown that the concentration of these descendants is relatively unimportant as compared with the external dose in a large cloud. In a very small gas cloud, the concentration of these descendant materials would be of somewhat greater importance in comparison with the external dose, but in the great majority of situations encountered in the Irradiation Processing Department, would not be expected to become the limiting consideration.

In case of personnel exposures to very small gas clouds, such as would exist immediately after a bubble of gas is released in the storage area, the dose to the bronchial epithelium becomes of relatively greater significance, and may become the limiting factor in extreme cases. If the work to be performed may involve exposure to small bubbles of gas, Chemox or fresh air protection should be worn.

In the case of a large radioactive gas cloud which is free of radioactive particulate material, the doses to the body fats, lungs and bronchial epithelium will all be within established limits, provided the external doses are limited as described in Radiation Control Standard 1.1. Therefore, in any case where it can be shown that the airborne activity is due to noble gases, and radioactive particulate material is not present in significant amounts, and a very small gas cloud is not involved, no respiratory protection need be worn. This will be the case with most fuel element gas clouds which occur in the storage areas. It is possible that fission product particulate material may be carried off by the noble gases from a ruptured fuel element; but, only in extreme cases involving a major breakup of a fuel element, would this be expected to be a significant hazard in the storage area. In grossly contaminated areas such as the

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discharge area, we must be very cautious in assuming that the airborne activity is due to noble gases alone; radioactive particulate material will probably be present in significant amounts.

Noble Gases From Effluent Water

Since reactor cooling water always contains dissolved air, (and, therefore, traces of Argon, Xenon, and Krypton), during reactor operation, radioactive noble gases are always present in association with the effluent water. In fact, the activity of the radioactive material released from effluent water (known as "effluent vapor") is almost entirely due to these radioactive noble gases. These gases may be released from the effluent system through vents or leaks in the effluent piping, or at the inlet of the retention basin. Normally, considerable dilution with nonradioactive air or decay will have taken place before the vapors are released to areas where personnel can be exposed to them.

Reactor Gases

Gases are utilized within the reactors to provide a method of transferring some of the heat generated in the fission process, and to remove moisture from inside the reactor. For technical reasons, gases other than air are used here at HAPO.

The coolant gases are maintained at a positive pressure, with respect to the atmosphere, to prevent entry of air into the reactor, since air contains trace amounts of Argon, Xenon, and Krypton, which become highly radioactive when irradiated. Occasionally, during an outage, air will get in while the pressure is reduced. For a short period after startup, and especially if the ventilation system is not adequate, high dose rates may be encountered in the vicinity of even relatively small gas leaks. The circulating gas itself becomes radioactive to a degree depending upon its impurities and exposure to neutron flux. It may carry radioactive material from the reactor, depositing it in the lines, pumps, and other portions of the gas circulation system.

The biological hazard associated with any given reactor gas sample cannot be accurately evaluated, unless the composition of the sample is known. The composition can vary greatly at different times, depending on the amount of air in the reactor gas, and the quantity and identity of the various impurities carried from the reactor. For this reason it is not possible to attain control over personnel exposures to reactor gases by means of a maximum permissible concentration. For want of a better approach, the radiation level existent in the gas cloud is used as an indication of the need for Chemox or fresh air respiratory protection.

Two errors are inherent in this approach:

1. The amount of noble gases, particularly radio-argon, in the reactor gases, varies from time to time, being especially high after air has been allowed to get into the reactor as the result of maintenance work. Increasing the amount of air in the reactor will cause the dose rate in the gas to increase greatly without causing any significant increase in personnel breathing

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RESPIRATORY PROTECTION - GAS ACTIVITY

hazards. When the gas purity is high, the personnel breathing hazard is relatively greater as compared with the dose rate measured in the gas.

2. The breathing hazards associated with a gas cloud are dependent on the composition and the concentration of radioactive material in it, but not upon the size of the cloud. The dose rate from the cloud is, however, dependent upon the size of the cloud as well as the other factors. In a large cloud, the dose rate will be large as compared with the breathing hazard; reducing the size of this cloud would cause a proportional reduction in the dose rate, while the breathing hazard of the gas would be unchanged.

The hazard of exposure to a large cloud of low purity reactor gas will therefore be interpreted conservatively, if the dose rate from the gas is used to indicate the magnitude of the breathing hazard; a small cloud of high purity reactor gas with a very low dose rate may present a significant breathing hazard and, therefore, will require a more continuous interpretation.

Experience has shown that under the conditions existing in the reactor buildings, if fresh air or Chemox respiratory protection is worn for all entries into all gas clouds giving a dose rate of 25 mrad/hr, no significant deposition of radioactive material will result.

Because of the two complicating factors of gas purity and cloud size, some caution is required in the case of small clouds of high purity gas. It is desirable, whenever the situation permits, to wear Chemox or fresh air type respiratory protection for exposure to any detectable amount of reactor gas.

Standard

Noble Gases From Ruptured Fuel Elements or Reactor Effluent Water

The exposure of personnel to noble gases will not be controlled by the use of respiratory protection, as in the case of reactor gases or airborne particulate material. The control of personnel exposure to noble gases shall be accomplished on the basis of the external dose rates. The presence of noble gases does not in itself require that respiratory protection be worn.

In emergency situations (as outlined in Radiation Control Standard 1.2) which may involve noble gases to the extent that the external dose from the noble gases may exceed the normal working limits, Chemox or fresh air respiratory protection should be worn.

Reactor Gas Atmosphere

Chemox or fresh air masks shall be worn for any entry into a cloud of reactor gas giving a corrected field dose rate of 25 mrad/hr or greater.

Respiratory protection is not mandatory when the corrected field dose rate is less than 25 mrad/hr. However, exposure of personnel to detectable amounts of reactor gas without Chemox or fresh air protection should be discouraged.

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SUBJECT

RADIOLOGICAL RESPIRATORY PROTECTIVE EQUIPMENT

Basis

Respiratory protective equipment is worn by personnel working in Radiation Zones for the purpose of preventing the inhalation and possible deposition of airborne radioactive particulate matter and gases. The wearing of a mask does not in itself insure protection against these materials; the mask and canister must be in good mechanical condition, and fitted properly to the face to provide any significant protection to the wearer.

Masks may be divided into two general types: filter masks and independent air supply types. Filter masks are effective against airborne particulates, aerosols and mists, but not against gases or welding fumes since they operate on the principle of filtration. Examples of filter type masks used in the Irradiation Processing Department are the Army assault mask, and the MSA multi-use mask. Examples of independent air supply types are fresh air masks and the MSA Chemox mask.

The two major problems involved in the use of masks are obtaining a satisfactory face-fit, particularly over glasses, and maintaining the mechanical efficiency at a satisfactory level. Since one mask is usually worn by many different persons during its useful life, sanitation and health must also be considered. The following standard is established to insure that the quality of radiological respiratory protective equipment used in the Irradiation Processing Department is maintained at such a level as to provide the necessary degree of protection to personnel.

Standard

1. Only masks which have been approved by Radiological Engineering, Research and Engineering Section, shall be worn for radiological respiratory protective purposes in the Irradiation Processing Department.
2. All radiological respiratory protective equipment shall be processed by the Central Mask Facility.
3. Modifications or repairs to radiological respiratory protective equipment shall be made only by the Central Mask Facility.
4. Each person shall check the fit of the mask to insure a proper facefit before entering the Radiation Zone. In cases where a proper facefit cannot be made, the individual shall not enter the Radiation Zone.
5. In cases where a facefit cannot be made over glasses, and the glasses are necessary to safe vision, the employee involved shall not enter the Radiation Zone.

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Standard

6. If an adequate facefit cannot be obtained over long beard stubble, or over a beard, the individual shall not enter the Radiation Zone.
7. Personnel shall not remove the mask from the face for purposes of conversation or visibility while in a Radiation Zone. In case of shortness of breath, the mask may be removed in the zone, provided that the individual involved leaves the zone immediately.
8. After a mask has been removed, it may be reworn by the same individual provided the facepiece is surveyed before it is reworn to insure that the inside of the facepiece is free of contamination.

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SUBJECT

CONTAMINATION CHECKS OF PERSONNEL

REFERENCE SECTION: Standard

Part 1

Under certain circumstances, a hand-shoe counter serves as a satisfactory substitute for the more all inclusive survey that can be made with a portable GM referred to as a personnel survey. To clarify this point, this part should read:

- "1a. A person leaving a contaminated radiation zone shall be surveyed for beta-gamma contamination on his person and clothing with a GM-type instrument or equivalent (personnel survey). The hand-foot counter is a GM-type instrument and a check with this instrument meets the criteria where it is specified by radiation work procedure.
- b. Within the 105 exclusion area any person present shall receive a personnel survey before eating or leaving. A hand-shoe count satisfies this requirement."

Part 2 and 4

The word "Special" which refers to radiation has been removed from radiation protection terminology, so "SWP" should be removed from the text, since it is replaced by "RWP" which is already present in the appropriate places.

The word "five-fold" should read "hand-shoe counter."

Part 6

The intent is for dose rates from contaminated protective clothing to be detected and eliminated before they contribute a significant dose and to do it by the most practical means available. This part should be changed to read:

"Where there is sufficient smearable contamination present to increase the limiting dose rate to a person if it becomes attached to his protective clothing, protective clothing surveys shall be made at frequent intervals. It shall be frequent enough to prevent such a source from contributing a significant local dose (a local dose whose equivalent exceeds the whole body gamma dose). As soon as it is detected, such a source of radiation dose shall be removed."

Part 8 (Addition)

Because contamination detectability with a portable GM is greatly increased by audible observation of this count rate, the following is to be added as a new part to the Standard:

"Ear phones or speakers shall be used with GM instruments for personnel surveys."

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MANUFACTURING SECTION

ACCEPTED

PRODUCTION FUELS SECTION

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CONTAMINATION CHECKS OF PERSONNEL

Basis

Procedures which have been established to prevent the spread of contamination to personnel have proved to be generally effective, but, in spite of our best efforts to avoid it, personnel contamination does occur. Personnel contamination checks are made for the purpose of detecting this contamination as soon as possible, to prevent its ingestion or spread to clean areas. As a general rule, the more contamination checks that are made by personnel working in and around contaminated zones, the better will be our control. Experience has shown that most personnel contamination, resulting from work in low level contaminated zones, is to the hands or shoes. Therefore, in many cases following work in low level contaminated zones, a check on the hand and foot counter is sufficient.

Any employee has the right to use a portable GM survey meter to check himself for contamination and should be encouraged to do so. If an employee does not know how to operate the GM, he may get instructions from, or have the check performed by a person qualified in radiation monitoring.

In grossly contaminated zones, there is a much higher probability of personnel contamination on all parts of the body. In other zones, soft beta contamination which cannot be detected on the hand and shoe counters may be present. In these cases, the SWP or RWP may require that as the individual leaves the Radiation Zone, he is to be given a special contamination check by a person qualified in radiation monitoring.

The standard below outlines the requirements for personnel contamination checks within the Irradiation Processing Department.

Standard

1. Each individual who enters a Radiation Zone shall take a hand count immediately after leaving the zone. Each individual working or visiting in the 105 building or other building in which Radiation Zones are maintained, shall take a hand count before eating, and before leaving the building.
2. All personnel shall be encouraged to check themselves and their clothing for contamination. These checks shall not substitute for any special contamination checks required by the SWP or RWP, or for the five-fold check.
3. In any case where skin or personal clothing contamination is found or suspected, a complete check of the person and his clothing shall be made by a person qualified in radiation monitoring.

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SUBJECT

CONTAMINATION CHECKS OF PERSONNEL

4. In cases where the SWP or RWP states that a personnel check by a person qualified in radiation monitoring is required, personnel shall not leave the Radiation Zone change station until this check has been made.
5. Each individual who performs work of such a nature that he might have become contaminated in a Radiation Zone known to be contaminated with soft beta emitters, shall be checked with an instrument sensitive to the soft beta involved, immediately after leaving the zone, by a person qualified in radiation monitoring.
6. When work is performed in areas in which high levels of contamination are present, high local skin exposures may be received if radioactive material is deposited on the protective clothing and is not immediately detected and removed. Therefore, during the course of radiation work in such locations all personnel in the zone shall be given frequent clothing checks. Protective clothing which becomes contaminated should be removed immediately, if the level of contamination is such that it significantly contributes to the dose rate of the person wearing it.
7. Personnel and their personal clothing shall meet the contamination limits below before they are released to go home, except with the specific approval of supervision responsible for radiation protection.
 - a. If the contaminant is known to be absorbed noble gases only,

< 500 c/m beta-gamma per HGM probe area
 - b. Otherwise,

< 100 c/m beta-gamma per HGM probe area
< 500 d/m alpha per 100 square centimeters

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SUBJECT

PERSONAL EFFECTS WORN IN CONTAMINATED ZONES

REFERENCE SECTION: Standard

Part II

To clarify the intent of this part and remove conflicting statements, the title and first sentence should be changed to read as follows:

"II. Nonreimbursable Personal Effects in Contaminated Work Zones

Only those personal effects specified in Part I are eligible for reimbursement should they become contaminated in a contaminated work zone. It should be recognized that the following items are nonreimbursable: wristwatches, rings, cigarette lighters, wallets, pens and pencils, and articles of personal clothing not listed in Part I."

Part IV (Addition)

In addition to material given in this Standard, an IPD policy and the procedure for implementing it is given in the OPG's, so the following part should be added:

"IV. Policy and Procedure

Organization and Policy Guide 8.21 "Contaminated Personal Property" spells out IPD's policy and states the procedure for handling such items, including personal effects which become contaminated in contaminated work zones."

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SUBJECT

PERSONAL EFFECTS WORN IN CONTAMINATED ZONES

Basis

The possibility of personnel or their personal effects becoming contaminated cannot be completely eliminated by the use of protective clothing. It must be expected that a certain amount of contamination spread to individuals, and their effects will occur in spite of best efforts to prevent it. At the same time, the transportation of contamination off site must be avoided if possible. To attain necessary control, items of personal equipment that become contaminated should either be decontaminated to releasable levels, or confiscated.

Occasionally personal effects which are necessary to the individual working in a radiation zone may become contaminated as the result of an unusual situation, despite reasonable precautions taken by the employee. The occasion also might arise where personal effects become contaminated outside established contaminated work zones, through no fault of the employee. In both of these cases, the contaminated effects are turned over to the company for disposal. Certain common items of personal equipment are not required by the individual in the performance of radiation work, and the company cannot reasonably be expected to reimburse employees for these items. The following standard describes those personal items for which reimbursement will be made, when they are confiscated because of contamination, and those items for which reimbursement shall not be made.

StandardI. Personal Effects Permitted in Contaminated Work Zones

If personal effects, as listed below, become contaminated through no fault of the employee, and decontamination is not successful, reimbursement will be made on the basis of the depreciated value of the item as agreed upon by the employee and his supervisor.¹

A. Contaminated work zones for which "no personal outer clothing" is specified on the written procedure or permit:

1. Underwear - to include undershirt and shorts or one-piece garment
2. Shoes
3. Socks
4. Prosthetic appliances, and/or glasses, hearing aids, etc., or other effects necessary to the safety of the employee entering the zone.

¹ Revised 5/10/61 to clarify basis for reimbursement in line with OPG #8.21.

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B. Contaminated work zones for which "one pair of coveralls over outer clothing" is specified on the written procedure or permit:²

1. All personal effects listed under "A" above
2. Trousers
3. Shirt
4. Belt or suspenders

C. Contaminated outdoor work zones, during cold weather:

When work is performed in outdoor contaminated zones during cold weather, supervision responsible for radiation protection may approve the wearing of personal clothing, as necessary, to provide protection from the cold. This clothing should be worn under the required protective clothing, and approval of responsible supervision must be obtained in each case.

II. Personal Effects Not Permitted in Contaminated Work Zones

The following items are not to be worn in established contaminated work zones and are not subject to reimbursement should they become contaminated when worn into these zones:

1. Wristwatches
2. Rings
3. Cigarette lighters
4. Wallets and contents thereof
5. Fountain pens and pencils
6. Suit or sport coat, sweaters, vests, and ties
7. All other items of jewelry and personal property not listed in "A" or "B" above

When items in 1 through 7 above are taken into established contaminated work zones, it is done at the employee's own risk.

Supervision of the operating group shall provide a repository for the safe keeping of personal effects such as those noted above.

III. Personal Effects Worn Outside Contaminated Work Zones

Personnel will be reimbursed for loss of personal effects which become contaminated outside established contaminated work zones, if the contamination results through no fault of the employee. Reimbursement will be made on the basis of the depreciated value of the items.¹

² Revised nomenclature 5/10/61.

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SUBJECT

RADIOLOGICAL PROTECTIVE CLOTHING

REFERENCE SECTION: Basis and Standard

The obsolete nomenclature of "SWP clothing" should be changed to read "protective clothing" throughout the entire Standard, and where it appears between parentheses as a definition, it should be deleted from the text.

Page 1

Because of the Plant Laundry linen service type operation where they purchase all the routinely used protective clothing Radiological Engineering has found maintenance of an approved list of radiological protective clothing unnecessary. The last sentence on Page 1 should be changed to read,

"Protective clothing other than that issued by Protective Equipment Decontamination, HFO (Plant Laundry), requires specific approval from Radiological Engineering. The using group shall initiate the request for approval."

Other plant issue clothes have been misappropriately used in place of radiological protective clothing, so the following should be added:

"White plant issue clothing shall serve no other purpose than as a radiological protective garment. Blue coveralls and cotton garments of colors other than white shall not be used in place of radiological protective clothing."

Part: Containers

Experience has shown that "high level contaminated clothing" is very occasional and not routine. Change the last word in the first sentence from "likely" to "present."

Remove items 1 through 5 following "These zones shall include:"

Part: Plant Laundry Segregation Requirements

Laundry is usually monitored by the bag full and without ill effect. Add. "A bag of laundry with a dose rate at all points of less than 6 mrad/hr @ 6" may be sent to the laundry without special marking or handling."

Add. "A bag of laundry with a dose rate between 6 mrad/hr and 50 mrad/hr @ 6" shall be handled like clothing contaminated between 50 mrad/hr and 1 rad/hr.

And. Where the dose rate from the bag is greater than 50 mrad/hr @ 6", the offending garments shall be disposed of as contaminated waste."

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SUBJECT

RADIOLOGICAL PROTECTIVE CLOTHING

Basis

The fundamental purpose of Radiological Protective Clothing (also known as SWP clothing) is to provide a barrier between contamination existing in a work zone, and personnel who enter the zone.

Protective clothing which would afford the wearer perfect protection from contamination would be airtight, and as a consequence, very uncomfortable. For this reason, protective clothing provided for use in IPD does not afford complete protection from contamination, but satisfactory results may be obtained, provided the wearer recognizes the limitations of the clothing, and conducts himself accordingly.

Protective clothing requirements are established on the assumption that the worker will exercise reasonable care to avoid becoming contaminated. If used properly within its limitations, protective clothing will afford a high degree of protection; if used carelessly, very little protection will be afforded. Even minor damage, such as a small hole in a glove, may make an item unfit for further use. Each person should carefully inspect the clothing he intends to wear to be sure that it will provide the necessary degree of protection, and should also avoid unnecessary damage to the clothing while he is using it. SWP clothing is expensive, and the help of everyone is needed to prolong its life.

After use, SWP clothing may be contaminated and must be treated as such to prevent the spread of contamination from the clothing to clean areas. To provide the necessary control, used SWP clothing is kept under Radiation Zone control until laundered.

Even though the clothing is surveyed for contamination after laundering, a small amount of residual contamination may remain in the fabric. For this reason, all used SWP clothing must be controlled throughout its life, and on disposal. The following standard outlines a system for wearing and handling SWP clothing which experience has shown will provide adequate protection to radiation workers at a reasonable cost.

Standard

Only those items of Radiological Protective Clothing (SWP clothing) which have been approved by Radiological Engineering, Research and Engineering Section shall be used within the Irradiation Processing Department, for protecting personnel from contamination in Radiation Zones. Approvals shall be of two types; approvals for general use of the item, and approvals for short-term use for field test purposes. A list of approved items of radiological protective clothing shall be maintained and issued by Radiological Engineering.

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SUBJECT

RADIOLOGICAL PROTECTIVE CLOTHING

Standard

The operating group of each facility in which Radiation Zones are established shall be responsible for providing sufficient quantities of various items of protective clothing in usable condition, for all Radiation Zone work performed within that facility.

Radiological protective clothing shall be marked or otherwise identified so as to be easily distinguishable from clothing used for non-radiation zone work.

All radiological protective clothing shall be controlled as potentially contaminated. A complete survey shall be made by a person qualified in radiation monitoring before any item is released for off-plant use.

Wearing Radiological Protective Clothing

Personnel shall not wear radiological protective clothing in lunchrooms, offices, or in other non-contaminated areas posted "No Protective Clothing Allowed" without the specific approval of operating supervision.

Radiological protective clothing shall be worn only for the purpose of protecting personnel from contamination; it shall not be worn for non-radiation zone purposes. The protective clothing specified on the SWP or on the RWP shall be the minimum worn by any person entering the Radiation Zone.

Each individual shall inspect the various items of protective clothing which he plans to wear, for such defects as holes, tears, and missing parts. When a defective item is found it should be placed in a receptacle provided for this purpose and not returned to the clothing supply bins.

Protective clothing shall be worn in the intended manner, with buttons buttoned and other closures properly made, to provide, as nearly as possible, a complete barrier to contamination.

Damage to Protective Clothing

All personnel shall exercise reasonable care in handling and removing radiological protective clothing, so as to minimize wear and damage.

In any case where the protective clothing is torn, punctured or otherwise damaged while in a Radiation Zone, person involved shall leave the Radiation Zone promptly, and obtain a personal contamination survey from a person qualified in radiation monitoring.

In case a body injury is associated with the clothing damage, the clothing involved shall be segregated and retained for detailed surveys.

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SUBJECT

RADIOLOGICAL PROTECTIVE CLOTHING

Standard

Removal of Protective Clothing When Leaving a Radiation Zone in Which One Layer of Clothing is Required

On leaving a Radiation Zone in which one pair of coveralls is required, all protective clothing shall be removed at the stopoff pad and placed in the container provided, except when the job involves transporting materials out of the zone. In this case, the individual may continue to wear the coveralls and gloves. The shoe covering shall always be removed, and the coverall cuffs turned up, to prevent shoe or floor contamination.

Removal of Protective Clothing When Leaving a Radiation Zone in Which Two Layers of Clothing are Required

On leaving a Radiation Zone in which two layers of clothing are required, all protective clothing shall be removed at the appropriate stopoff pads and placed in the containers provided, except when the job involves transporting materials out of the zone. In this case the individual may continue to wear the inner-coveralls and inner-gloves. The shoe covering, hood, outer-gloves, and outer-coveralls shall always be removed.

Rewearing Radiological Protective Clothing

Protective clothing may be reworn by the same individual provided that the protective clothing is surveyed by a person qualified in radiation monitoring prior to rewearing, and found to be free of smearable contamination, and reading less than 3000 c/m fixed contamination per HGM probe area.

Containers

Cardboard cartons bearing the radiation symbol and marked "High Level Contaminated Clothing", and a supply of clean gloves shall be provided at job sites where high level contamination is likely. These zones shall include:

1. Rear face.
2. Front face during tube replacement or extensive pushpole work.
3. Experimental levels during sample recovery, or test hold facility removal and replacement.
4. Top of reactor during ball recovery operations or other work involving rod removal.
5. Any work inside the 107 basins, such as sludge cleanout.
6. Any other zone specified by supervision responsible for radiation protection.

A hamper or other suitable container shall be provided at the exit of each contaminated Radiation Zone.

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Standard

Laundry Pickup and Sorting

"High level contaminated clothing" cartons which have been used shall be removed from the Radiation Zone at the end of the shift during which they were used. Monitoring shall be provided for any handling of these containers or their contents. After necessary exposure evaluations have been made the clothing may be released for disposal, with monitoring as required.

All bags and hampers containing clothing worn during the course of high level contamination work and all clothing worn during a shutdown shall be picked up and bagged, with monitoring by a person qualified in radiation monitoring.

Plant Laundry Segregation Requirements

Clothing contaminated to less than 50 mrad/hr may be sent to the laundry without special marking or handling.

Clothing contaminated to greater than 50 mrad/hr but less than 1 rad/hr at surface may, if desired, be sent to the laundry for special handling. This clothing shall be wrapped and marked showing contamination levels. The 200-W laundry shall be notified by the operating group in advance of shipment, and the shipment shall be made under control of a Radioactive Shipment Record.

Clothing contaminated to levels above 1 rad/hr shall be disposed of as contaminated waste. (The contaminated portion may be cut out, provided necessary repairs can be made.)

Periodic checks of used protective clothing shall be made to insure that the above limits are adhered to.

Radiological protective clothing shall be decontaminated only by the 200-W laundry facility.

Disposal of Defective Clothing

Protective clothing which is damaged to the extent that it is no longer fit for use shall be segregated and returned to the laundry facility for repair or disposal.

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RADIATION ZONES

Basis

A Radiation Zone is defined as an area or item of equipment where the persistent radiation level exceeds 1.0 mrem per hour, where significant surface contamination is present, or where airborne contamination exceeds the applicable maximum permissible concentration.

Radiologically, it would be desirable to contain all detectable contamination and radiation within Radiation Zones. However, such extreme control would not only be costly and unrealistic, but would not be necessary in order to attain a satisfactory degree of protection to personnel.

One of the purposes of the Radiation Zone concept is to provide a mechanism for limiting the casual, unplanned (nonradiation zone) exposure of personnel working in IPD plant areas. Such exposures are undesirable, not because they are not measured, but because they are not necessarily received as a consequence of performing needed work and may represent needless exposure. Also it is administratively impractical to include such exposures in the exposure estimates totals which are the primary means of assuring that personnel do not exceed short term control limits. A reasonable limit to casual dose would appear to be about 1/10 of the annual permissible dose of 5 rem. In certain specific cases where the 1 mr/hr limit would result in severe inconvenience or severe cost, it may be feasible, because of low personnel occupancy, to raise this 1 mr/hr limit without significantly increasing the possibility of personnel casual exposure exceeding about 500 mrem per year, or the resulting uncontrolled exposure causing an individual to exceed short term control limits.

The maximum permissible concentrations established for airborne activity are based on exposure for 40 hours per week for an extended period of time; that is, they are continuous occupational exposure values. In determining the concentration of airborne radioactive materials, air samples are obtained over a period of time, usually between 10 minutes and an hour, thus an instantaneous concentration determination is not feasible using present air sampling methods. In view of the above facts, the airborne activity concentration limit shall be considered to be the average concentration over a period of up to one hour insofar as establishing a Radiation Zone is concerned.

The contamination level which can be tolerated without Radiation Zone control depends on the accessibility of the item or area to personnel, its portability and the nature of the contaminant. Fixed equipment or locations within the exclusion area can be adequately controlled at a slightly higher level than can moveable equipment or locations and equipment outside the exclusion area.

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Because of the problems involved in determining size, composition, half life, and true activity of particles, a realistic limit for particulate ground contamination cannot be established at the present time. In outlying areas where there is little traffic, random particles will normally constitute no hazard to personnel, provided the contamination is fixed to the extent that it cannot be transferred to personnel or their clothing, and the dose rate to the critical organs does not exceed 1 mrad/hr. Ground contamination in areas of high traffic flow such as walks, roads, etc. should be kept as low as practicable.

This standard describes criteria which shall be applied in IPD in establishing Radiation Zones, together with the fundamental rules of conduct for personnel entering Radiation Zones. This standard does not cover release of personnel and their personal equipment (see RCS 3.1 "Contamination Checks of Personnel"), nor portable or non-installed material and equipment (see RCS 5.1 "Release of Material from Radiological Control").

A. General Rules

Standard

1. A valid Radiation Work Procedure or Special Work Permit is required for any entry into a Radiation Zone except by qualified personnel performing radiation monitoring work, or in case of an emergency as described in Radiation Control Standard 1.2.
2. Entries to, and exits from, contaminated Radiation Zones shall be made through an established change station.
3. All personnel entering a Radiation Zone shall observe the following requirements:
 - a. Prescribed personnel meters shall be worn by each individual in a Radiation Zone.
 - b. Smoking, chewing, or eating shall be prohibited within a Radiation Zone.
 - c. A hand and foot count shall be the minimum requirement for contamination survey on leaving a Radiation Zone.
 - d. Exposure received in any Radiation Zone shall be recorded on the Exposure Estimate Card.
4. All Radiation Zone exit surveys shall be performed by a person qualified in radiation monitoring in conformance with established procedures; questionable cases shall be referred to the Radiation Analyst for a decision.
5. All permanent Radiation Zone Boundaries shall be redetermined on at least an annual basis.

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RADIATION ZONES

B. Radiation Levels

1. Radiation Zones shall be established as necessary to assure with reasonable certainty that the casual (nonradiation zone) occupational exposure of personnel is limited to 500 mrem per year.
2. Radiation levels above which Radiation Zone controls will be required are as follows:

Normally,	1 mrem per hour at any point
Where severe inconvenience or cost would result from strict application of the above limit, as in transient exposures from noble gas clouds, etc., and provided occupancy of the plant area as a whole is such that no more than 10 mrem casual exposure will be received by an individual in a 40 hour week, and provided the concurrence of the radiation analyst is obtained,	5 mrem per hour at any point
In the case of outlying, low personnel traffic ground areas where random particulate contamination is present.	Radiation levels as above, except that only readings obtained at 2' or more above the ground need be considered.

C. Surface Contamination Levels

1. Radiation Zones shall be established as necessary to assure, with reasonable certainty, that personnel, their personal effects, and equipment do not become contaminated with radioactive materials while outside Radiation Zones.
2. Contamination levels above which Radiation Zone controls will be required are as follows:

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Beta-Gamma

<u>Item or location</u>	<u>Smearable as determined by Standard Smear Survey Technique</u>	<u>Direct reading per HGM probe area (or where soft contami- nation is possible, per MW probe area</u>
Buildings, including all installed equip- ment within exclu- sion area	200 c/m	600 c/m
Buildings, including all installed equip- ment outside exclu- sion area	100 c/m	200 c/m
Contamination levels above may be increased by a factor of 5, if the con- tamination is known to be from noble gases only (i.e., "effluent vapor").		
Ground areas in- cluding all installed equipment	No significant potential for contamination of vehicles, personnel and their effects during the course of normal work	Contamination level limited by resulting dose rate (see B2 above)

Alpha

Alpha surveys need not be made unless there is some reason to suspect that alpha emitters may be present without beta-gamma emitters also being present (i.e., cask pad, incoming vehicles used for radioactive shipments, etc.).

All items and locations	500 d/m smearable as determined by Standard Smear Survey Technique	500 d/m direct reading (per 100 sq cm)
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SUBJECT

RADIATION ZONES

D. Airborne Contamination

1. Radiation Zones shall be established as necessary, to assure with reasonable certainty that no significant deposition of radioactive materials will occur in personnel working outside Radiation Zones.
2. The average concentration of airborne radioactive materials above which Radiation Zone controls will be required are as follows:

Fission products or unidentified mixtures	$1 \times 10^{-9} \mu\text{c/cc}$
Corrosion products	$1 \times 10^{-7} \mu\text{c/cc}$
Other particulates	Applicable MPC as listed in HAPO Radiation Protection Standards, HW-25457, Appendix A
Noble gases	Limited only by radiation levels (see B2 above)

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12-31-64

SUBJECT

RADIATION ZONES

REFERENCE SECTION: A. General Rules

Part 1

The term "Special" where it references radiation is a carry-over from the Manhattan Project days, and is to be discontinued.

Remove "or Special Work Permit" from this sentence.

Part 3

Several terms need to be changed to meet present practices which are quite acceptable.

- b. Add the word "contaminated" so this sentence reads: "... within a contaminated radiation zone."
- c. The instrument used is called a Hand-Shoe Counter so the words "hand and foot" should be changed to read "hand-shoe."
- d. Exposure Estimate Cards are no longer mandatory so the end of the sentence "... on the Exposure Estimate Card" should be deleted and replaced with "by gamma pencil and neutron register."

Part 4

As indicated in the Basis, this item is covered in Standard 3.1, so it should be removed here.

REFERENCE SECTION: D. Airborne Contamination

Part 2

The revised limits on airborne contamination are given in Standard 2.3 and do not bear repeating here. Continuous exposure to such concentrations could result in a dose equivalent of as much as 5 rem in a year. To be consistent, it should be limited to 500 mrem in a year as designated.

To meet these changes, this part should read: "Radiation zoning will be established where airborne contamination exceeds 10 per cent of the limits established by RCS 2.3, "Control of Exposure to Radioaerosols."

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RESEARCH AND ENGINEERING SECTION

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MANUFACTURING SECTION

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PRODUCTION FUELS SECTION

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RADIATION CONTROL STANDARD
IRRADIATION PROCESSING DEPARTMENT

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4.2

12/14/56

New

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SUBJECT		

SPECIAL WORK PERMITS AND RADIATION WORK PROCEDURES

All entries to Radiation Zones will be governed by either a Special Work Permit or a valid Radiation Work Procedure. SWP's are agreements between all groups involved in a specific Radiation Zone job. They are therefore approved and signed by authorized management personnel of Radiation Monitoring, the operating group, and the service groups concerned.

RWP's are procedures established by Radiation Monitoring and the operating group for specific jobs of a routine nature, or for all work in a specific zone. These procedures may be used by any person within the Irradiation Processing Department whose organizational component is listed on the form.

Radiation Monitoring prescribes the radiation protection and control measures on these forms. The operating group is responsible for the control of Radiation Zone entries and the conduct of personnel within the zones. The operating group normally initiates all SWP's and maintains current and available copies of the RWP's. Since these two forms are basic tools for radiation control, it is imperative that all personnel be familiar with their use and contents before performing work in a Radiation Zone.

Written authorization, in the form of an SWP or a RWP shall be required for the entry of any person (except Radiation Monitoring personnel) to a Radiation Zone.

A Radiation Work Procedure may be issued by an operating Manager to cover any job for which a detailed operating procedure has been prepared, within a Radiation Zone or Zones in a facility under his control; or for all work within a single specified Radiation Zone in a facility under his control.

The Radiation Work Procedures shall be prepared on a form approved by the Supervisor, Radiological Engineering, Research and Engineering Operation.

Each Radiation Work Procedure shall be approved by the Radiation Monitoring Operation Manager and by the Manager of the operating group in the facility involved. Acceptance signatures beyond this by other components who may use the RWP are optional.

The operating Manager shall be responsible for the control of Radiation Zone entries made under the provisions of the Radiation Work Procedure, and for obtaining compliance with the provisions of the procedures.

BM-5300-017 (10-56) AEC-GE RICHLAND, WASH.

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SPECIAL WORK PERMITS AND RADIATION WORK PROCEDURES

SUPERSEDES ISSUE DATED
New

Standard

Each Radiation Work Procedure shall contain the following information:

1. Names of groups whose personnel are authorized to work under the provisions of the Radiation Work Procedures.
2. The time period for which the procedure is valid.
3. The specific location or locations in which work may be performed under the provisions of the procedure.
4. A detailed description of the nature and extent of the work which may be performed under the provisions of the procedure.
5. A description of the radiation hazards which may be encountered during the course of the described work in the Radiation Zone.
6. Monitoring requirements.
7. Protective clothing and equipment requirements.
8. Instructions for conduct during the performance of the work, and at the completion of the job.

All valid Radiation Work Procedures shall be kept readily available to all personnel in the facility. Since the Radiation Work Procedures are subject to periodic revision, each person performing work under the provisions of a Radiation Work Procedure shall read and understand its provisions before he enters the zone, and shall comply with the provisions in all respects.

One copy of each Radiation Work Procedure and subsequent revision shall be forwarded to the Supervisor, Radiological Engineering.

Special Work Permit

All entries to Radiation Zones which are not covered by a valid Radiation Work Procedure must be covered by a Special Work Permit, which is prepared for each specific job to be done, and issued by responsible supervision of the operating group.

The SWP shall be completed on a form approved by the Supervisor, Radiological Engineering, Research and Engineering Operation. The SWP's issued by a given operating group shall be numbered serially beginning with (1), on the first day of each calendar month. Each SWP shall be approved by Radiation Monitoring Supervision and by responsible supervision of all personnel who are to perform work under its provisions. The Radiation Monitoring Operation Supervisor shall prescribe the radiation protection and control measures and instructions which are to be incorporated in the permit.

The Operating Manager shall be responsible for the control of Radiation Zone entries made under the provisions of the SWP, and for obtaining compliance with the provisions of the permit.

In cases where the job outlined on the SWP is of greater duration than one shift, the SWP may be extended by the signatures of authorized persons, to cover a maximum of three consecutive shifts. SWP's shall be terminated by the signature of operating supervision at the end of the period for which it is valid. Upon termination, the

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SUBJECT
SPECIAL WORK PERMITS AND RADIATION WORK PROCEDURES

SUPERSEDES ISSUE DATED
New

Standard

SWP's shall be forwarded to the appropriate radiation monitoring group.

Each SWP shall contain the following information:

1. Names of the groups whose personnel are authorized to work under the provisions of the SWP.
2. The date on which the SWP was issued.
3. The SWP number.
4. The specific location or locations in which work may be performed under the provisions of the SWP.
5. A detailed description of the nature and extent of the work which may be performed under the provisions of the SWP.
6. Monitoring requirements.
7. Protective equipment requirements.
8. Instructions for conduct during the performance of the work, and at the completion of the job.
9. Signatures of management personnel authorized to approve the conditions imposed by the SWP.

All active SWP's shall be kept readily available to personnel performing work under the provisions of the SWP. As in the case of RWP's, each person performing work under the authority of an SWP shall read and understand its provisions before he enters the zone, and shall comply with the provisions of the permit in all respects.

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RCCA ISSUE DATE

9-14-64

RCCA EXPIRES

12-31-64

SUBJECT

SPECIAL WORK PERMITS AND RADIATION WORK PROCEDURES

The term "Special" where it references radiation is a carry-over from the Manhattan Project days, and is to be discontinued.

Since the general revision of Radiation Work Procedures for Manufacturing in 1962, the Special Work Permit form was replaced with the Radiation Work Procedure form. The new RWP form now serves a dual function previously served by the RWP and the SWP forms. The basic system remains unchanged. Throughout the text and title of this standard, remove the words "SWP" or "Special Work Permit" and replace them, where appropriate, with "RWP" or "Radiation Work Procedure."

At the time the new procedure form was developed, it was judged unnecessary to require a listing of groups who are authorized to work the RWP.

Item 1 on page 2 and item 1 on page 3 - "Names of groups whose personnel are authorized to work under the provisions of the Radiation Work Procedures/SWP" are to be removed.

The new authorized form is BM-5900-010 (1-63) "Radiation Work Procedure" and should be added to this section.

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RESEARCH AND ENGINEERING SECTION

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SUBJECT

RADIOLOGICAL SIGNS AND SYMBOLS

Basis

Since the presence of radiation cannot be detected by the human senses, it is essential that all potential Radiological Hazards be identified and posted in such a manner that they are recognizable as such, by any person who may approach them. To this end, a standard symbol and standard warning colors have been adopted.

Many types of signs, tags and tapes are used by the Irradiation Processing Department to warn personnel of radiological hazards, and others will be devised in the future as special needs arise. This standard is intended to describe the proper use of the symbol and the colors, to insure that our posting is as uniform and meaningful as possible. The standard also describes what are considered to be the minimum requirements for the satisfactory posting of Radiation Zones, and other sources of radiation within or temporarily out of Radiation Zones.

Standard

I. SPECIFICATIONS

A. The Symbol

1. The symbol shall be oriented with one vane directly downward.
2. The symbol shall be as large as possible consistent with the medium used.
3. The symbol shall be proportioned as follows:

B. The Colors

1. Symbol and words (if any) - Magenta
2. Background - Lemon yellow
3. A color shall be acceptable if it is within the Munsell Book of Color limits listed below:

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SUBJECT

RADIOLOGICAL SIGNS AND SYMBOLS

StandardB. The Colors (cont'd)

Magenta				Lemon Yellow			
Hue	Color	Value	Chroma	Hue	Color	Value	Chroma
10.0	P	3 or 4	Not less than 6 <u>limit</u>	2.5	Y	Not less than 8	Not less than 8
1.3	RP	4.2	14.5 <u>Mid-point</u>	5.3	Y	8	12
5.0	RP	3 or 4	Not less than 6 <u>limit</u>	7.5	Y	Not less than 8	Not less than 8

4. These colors shall not be used together for purposes other than the identification of radiological hazards.
5. The paint used should be of such a color and quality as to remain within the Munsell limits stated above during five years of exposure to the weather. Sunlight bleaches the midpoint magenta to a light blue after two or three years. The useful life of an outdoor sign can be increased by using as dark and as red a magenta as the limits will allow.

C. The Wording

1. All signs used for posting Radiation Zone boundaries shall bear the words "Radiation Zone".
2. Signs used for posting fences or barriers around buried material where the area involved is not otherwise a Radiation Zone, shall bear the message "UNDERGROUND" rather than "Radiation Zone".
3. Signs, tags or tapes used for purposes other than Radiation Zone boundary posting, should not bear the words "Radiation Zone"; they should instead have an explanatory message (or space for message) such as:

"Contact RM Before Opening"
 "Gamma Source"
 "Stay 3 Feet Away"
 "Underground"
 "High Radiation Level"

II. THE WARNING DEVICESA. Signs

1. Each sign shall contain at least one radiation symbol, as large as is possible considering the size of the sign.

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SUBJECT

RADIOLOGICAL SIGNS AND SYMBOLS

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Standard

A. Signs (continued)

2. In cases where no printed message is provided, the sign shall have sufficient blank space for a message to be inserted.
3. At least two, and preferably four, mounting holes should be provided to allow the sign to be firmly mounted.

B. Tags

1. Tags printed on one side only shall not be used -- both sides of the tag shall be yellow.
2. Each side of the tag shall contain a blank space for the entry of pertinent information.

C. Labels

1. Gummed labels should not normally be used for permanent posting. They are useful however for temporarily posting local sources or packages.
2. Space should be provided on the label for the insertion of an explanatory message.

D. Tapes

1. Radiological tapes may be encountered either in the form of an adhesive tape for sealing cartons, or as a cloth tape or plastic rope for use in posting Radiation Zone boundaries.
2. Adhesive tapes should be lemon yellow with standard radiation symbols printed in magenta at short intervals along the tape. A blank space between symbols for the insertion of a brief message, is desirable.
3. Tapes or ropes having stripes of magenta and yellow but no symbols, are satisfactory for radiological posting only if accompanied by signs bearing the radiation symbol.

E. Pre-printed Cartons

1. Cartons to contain radioactive waste or other radioactive material shall be marked on at least two sides with a lemon yellow area containing the magenta radiation symbol.
2. Cartons marked "Radioactive Waste" should not be used to contain other non-waste radioactive materials, or non-radioactive material.

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SUBJECT

RADIOLOGICAL SIGNS AND SYMBOLS

Standard

E. Pre-printed Cartons (continued)

3. Containers for non-waste radioactive material should be provided, with a space for the insertion of an appropriate message under the magenta symbol.

III. RADIOLOGICAL POSTING

A. General

1. Each radiological hazard or zone shall be posted in such a manner as to warn personnel approaching from any possible direction.
2. Every symbol in view should warn of an existing radiological hazard; warning signs shall be removed promptly when no longer required.

B. Radiation Zone Posting

1. Permanent Radiation Zones shall be circumscribed by a barricade, consisting of walls, doors, fences or chains. Radiation Zone boundary signs shall be mounted along this barricade in such a manner that at least one sign is visible from any ordinary angle of approach.
2. Temporary Radiation Zones shall be circumscribed by a barrier consisting of at least one strand of rope or tape supported by temporary standards. Such a temporary barricade should not normally be expected to be adequate for longer than one month. Radiation Zone boundary signs shall be mounted along this barricade in such a manner that at least one sign is visible from any ordinary angle of approach.

C. Posting of Specific Sources

Any locations or items of equipment in a Radiation Zone which involve personnel dose rates significantly greater than the general dose rates existing in the zone or hazards unusual to the zone, should be posted with approved signs or tags. An explanatory message should always be provided to indicate why the warning sign is there, or what precautions are to be taken. Some examples of useful messages are:

"High radiation level"

"Stay _____ feet away"

"Contact RM before opening (or entering)"

"RM monitoring required"

"RWP void beyond this point"

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SUBJECT

CONTROLLED EQUIPMENT

Basis

One method employed by the IPD for the disposal of radioactive wastes, is by dispersal to the atmosphere and to the Columbia river. This method of disposal is safe from a radiological point of view as long as the concentration of the radioactive material is kept within specified limits, and the material is not later reconcentrated to exceed these limits.

Certain equipment, such as air and water filters, settling basins, and ion exchange tanks, tend to accumulate and concentrate contamination from the air or from the river water as a consequence of their normal operation.

Radiation and contamination levels associated with equipment of this type are normally not high enough to require that the equipment be placed on Radiation Zone Status. To permanently establish Radiation Zones in which no radiation hazard exists the great majority of the time only tends to discredit the significance of Radiation Zones.

Occasionally, due to unusual river or atmospheric conditions, this type of equipment may become contaminated to such an extent that Radiation Zone control of inspection or servicing is clearly warranted.

The purpose of this standard is to establish a system which will provide Radiation Zone control over such equipment when required, but which will at the same time avoid the establishment of permanent Radiation Zones which are not required.

Standard

1. Equipment which as a consequence of its normal operation may concentrate contamination to the extent that it presents a radiation hazard to personnel inspecting or servicing the equipment, shall be designated as "Controlled Equipment".
2. All equipment designated as "Controlled Equipment" shall be posted with sign containing the following information:

Controlled Equipment
Radiation Monitoring Approval
Required for Servicing or Inspection

3. Supervision responsible for radiation protection may grant long term approval for the performance of specific work by a specific group on specific items of equipment. In such cases, the Radiation Analysts' instructions regarding the establishment of a Radiation Zone, or the need for a survey prior to the work, shall be incorporated in the applicable operating procedures of the group involved.

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SUBJECT

CONTROLLED EQUIPMENT

Standard

4. If the equipment is known or found to be contaminated to such an extent that personnel contamination, or personnel dose rates in excess of 1 mrad/hr, will be encountered during servicing or inspection, the equipment shall be established as a Radiation Zone and the work shall be performed under the authorization of a valid SWP or RWP.
5. If, at the completion of the work, conditions no longer justify the retention of Radiation Zone control, the equipment should be released to Non-Radiation Zone Status.

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SUBJECT

CONTROLLED EQUIPMENT

The accumulation of contamination in these locations may reach levels of several thousand c/m (portable GM), but because of the low hazard value of the radionuclides present and the low concentration of activity (d/m per gram of inert material), it does not become radiologically significant. Since the count rate is detectable, it does create an annoyance. Experience has shown posting of these locations as radiation zones to be unnecessary; however, wearing of radiological protective clothing is acceptable, and radiation surveys and hand-shoe counts will assure people that everything is under control. A reasonable amount of control is still necessary, but this may be delegated through facility management.

REFERENCE SECTION: Standard

Since experience has shown the controls to date have been excessive, parts 1, 2, 4, and 5 can be deleted.

Part 3

Preface this paragraph with the following sentence: "The management of the operation responsible for the facility shall exert the controls necessary to insure adequate cognizance of the contamination present."

"Radiation Analyst" should read "Supervisor, Radiation Monitoring" and "Radiation Zone" should read "controlled zone."

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RESEARCH AND ENGINEERING SECTION

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MANUFACTURING SECTION

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SUBJECT

RELEASE OF MATERIAL FROM RADIOLOGICAL CONTROL

Basis

Radiological controls in the form of radiation zone status, or shipment on RSR or SRSP, are established over all materials involving significant radiation or contamination levels in order to control contamination spreads and casual exposure of personnel.

Equipment which is free of radioactivity should be released from radiological control whenever practical to maximize the accessibility and usefulness of the equipment.

Items bearing small amounts of fixed contamination but which contribute no significant dose rate may not deserve strict radiological controls if they do not constitute a personnel hazard, but they should always be identified as a potential nuisance.

The following standard presents criteria for releasing material and equipment from radiological control. These criteria will provide convenience in material handling without sacrificing contamination control or personnel safety.

StandardA. Radiological Release Survey Requirements

1. The following materials shall be surveyed by a person qualified in radiation monitoring in accordance with established procedures (see RCP 4.6).
 - a. All materials prior to their removal from a contaminated radiation zone, regardless of their destination or intended future use.
 - b. All nonradiation zone materials which by their nature or use tend to accumulate radioactive materials (such as air filters), prior to their movement.
 - c. Any materials which by their use may have become activated, prior to their movement.
 - d. All materials for shipment within HAPO which are covered by a special contamination control procedure (see RCS 7.1, 7.1.1, 7.1.2, etc.).
 - e. All materials to be shipped off plant which, in the opinion of supervision responsible for radiation protection, might reasonably be expected to have become contaminated during its use.
2. Any questionable cases shall be referred to the radiation analyst for a decision.

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SUBJECT

RELEASE OF MATERIAL FROM RADIOLOGICAL CONTROL

B. Release With No Restrictions

Any material (except personnel and their personal effects) is considered free of contamination, and may be released with no restrictions if the following conditions are met:

Smearable

< 100 c/m β - γ - (as determined by the standard)
 < 500 d/m α - (smear survey technique, see RCP 4.6)

Direct reading

< 200 c/m β - γ - per HGM probe area, (or where soft beta is possible, per Mica window GM probe area)
 < 500 d/m α - per 100 sq. cm

Inaccessible surfaces

It is reasonable to assume from the design and usage that the inaccessible surfaces could not have become contaminated without the accessible surfaces having become contaminated as well.

Absorption or occlusion within the material

Low possibility of absorption or occlusion within the material as a result of its use or as a consequence of decontamination which may have been performed.

Such a release is indicated by the radiation release label (54-3000-022). This label should be affixed to materials to be shipped to other HAPO facilities. It gives assurance to the recipient that proper consideration has been given to the radiological status of the material.

Borderline cases shall be referred to the radiation analyst for a decision.

C. Release as "Tagged Equipment"

Materials which do not meet the requirements for a release with no restrictions (unconditional release) but which meet the limits shown below do not constitute a hazard to personnel, although they may in some cases constitute a nuisance. Such materials may be released from radiological controls, in the 100 Areas only, provided a tag is attached which describes the type of radiation and the levels involved, and bears the statement "does not constitute a personnel hazard", and the signature of the person authorizing the release.

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SUBJECT

RELEASE OF MATERIAL FROM RADIOLOGICAL CONTROL

Limits:Smearable

No smearable contamination ($< 100 \text{ c/m } \beta\text{-}\gamma$, $< 500 \text{ d/m } \alpha$ as determined by standard smear survey technique).

Direct reading

Normally $< 600 \text{ c/m } \beta\text{-}\gamma$ per HGM probe area (or where soft β is possible, per MWGM probe area), or as established by the radiation analyst in a specific case,

and
 $< 2000 \text{ d/m } \alpha$ per 100 cm^2 Pu known to be absent
 $< 600 \text{ d/m } \alpha$ per 100 cm^2 Pu not known to be absent

For movements within the 100 Areas, an RSR or SRSP is not required, and the material need not be stored in an established radiation zone.

When the tag is removed, or the material shipped outside the 100 Areas, radiological controls shall be reestablished.

D. Non-releasable Material

All materials not meeting the above requirements (except personal watches with luminous dials) shall be retained under radiological control.

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SUBJECT

RELEASE OF MATERIAL FROM RADIOLOGICAL CONTROL

REFERENCE SECTION: B. Release With No Restrictions

Part: Direct Reading

Where the radioactive contamination is not Sr^{90} , Ca^{45} , Zr^{95} , Bi^{210} , or Ra^{226} , the release limit is 0.3 mrad/hr measured with an unshielded probe in contact with the contaminated surface. The water plant equipment concentrates a mixture of contamination which does not contain these nuclides. Interpreting the water plant mixture activity for a surface dose rate with a GM gives 1000 c/m equivalent of 0.3 mrad/hr.

To recognize this, the following should be added to this part:

"< 1000 c/m β - γ per HGM probe area for water plant equipment of the water supply system from 181 up to and including the 190 Annex."

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RESEARCH AND ENGINEERING SECTION

ACCEPTED

MANUFACTURING SECTION

ACCEPTED

PRODUCTION FUELS SECTION

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SUBJECT

STORAGE OF CONTAMINATED TOOLS AND EQUIPMENT

Basis

The performance of maintenance work in contaminated zones and within the reactors results in the spreading of contamination to tools and equipment. The unconditional release of this material after each use is unnecessary provided controls are maintained over the contamination levels and storage of these tools, to insure that contamination is not spread from them and that personnel do not receive significant dose rates from them.

StandardDecontamination

After use in a radiation zone, all tools shall be decontaminated before they are surveyed for release to storage. The minimum decontamination effort shall be wiping the tool with a damp cloth to remove loose contamination. Tools used inside the reactor, and other grossly contaminated tools and equipment, shall be decontaminated to as low a level as practical.

Decontamination efforts should be stopped at the point where the dose received in further decontamination effort will exceed the dose received in the use of the tool, or where the cost of decontamination exceeds the value of the tool.

Blue Tool Room

Common hand tools which are used in conjunction with work in all radiation zones may be stored in the blue tool room. Tools stored in the blue tool room should be marked with blue paint for identification purposes.

Each tool shall be wiped off to remove any loose contamination present, and surveyed before it is placed in the blue tool room for reuse.

Tools which have been used in radiation zones contaminated with soft beta emitters shall be surveyed with a Samson survey meter or mica window GM instrument. All other tools may be surveyed with a normal HAPO GM instrument.

The activity on tools stored in the blue tool room shall not exceed 2 mrad/hr at surface as measured with a Samson, or equivalent, or 6000 c/m at one inch as measured with a portable GM.

The radiation level at the radiation zone boundary around the tools shall be maintained at no greater than 5 mrad/hr.

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STORAGE OF CONTAMINATED TOOLS AND EQUIPMENT

No specific authorization shall be required to obtain these tools, and to transport them to the zone in which they are to be used. The tools shall be wrapped before movement between radiation zones.

Canvas gloves shall be the minimum protective clothing requirement in all cases while handling these tools.

Hot Tool Storage

Tools which are not used exclusively within one radiation zone, and which do not meet the requirements for storage in the blue tool room, shall be stored in an area or room which is established as a radiation zone. The boundaries of this zone shall be maintained at a level no greater than 5 mrad/hr. Specific authorization by SWP or RWP shall be required for entry to this zone, and for transporting tools from this location to the work location.

No tools or equipment stored in this zone shall read greater than 400 mrad/hr at surface. The gamma dose rate at any point in the storage zone should not exceed 50 mr/hr.

Tools used in one radiation zone only, should be stored in or near the zone of use. Such tools shall read less than 400 mrad/hr at surface, and should not result in a gamma dose rate significantly greater than the gamma background in the zone. The boxes or boards containing these tools shall be posted with a warning that high level contamination is present on the tools.

Outdoor Storage

All material or equipment contaminated to > 1000 c/m smearable shall be totally enclosed in a weatherproof container before being stored in any outdoor radiation zone. This includes material for storage above ground level at the burial grounds. (For the control of material in cribs, trenches or pits, see Radiation Control Standard 8.1.)

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SUBJECT

STORAGE OF CONTAMINATED TOOLS AND EQUIPMENT

The level of smearable contamination on tool or equipment surfaces is a vital factor of contamination control. The present Standard indicates this but an upper limit is needed to guide tool handling in questionable cases. Ordinarily, it is expected that the tools will be maintained well below the limit.

REFERENCE SECTION: Blue Tool Room

Blue tool rooms are no longer universally used, but blue tools have proven a satisfactory method of accounting for radiation zone tools.

The title of this part should be changed to read "Blue Tools."

The first five paragraphs of this part should be removed and replaced with

"Tools painted blue are identified as being contaminated and for use in radiation zones only. The beta-gamma radioactivity on a stored blue tool shall not exceed 6000 c/m @ 1" or 1000 c/m by standard smear."

REFERENCE SECTION: Hot Tool Storage

Add to this section: "Smearable contamination on a tool stored in Hot Tool Storage shall not exceed 50 mrad/hr from the portion used to handle or manipulate it, or 400 mrad/hr from those portions which are expected to have direct contact with contaminated materials."

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SUBJECT

OUTDOOR STORAGE OF CONTAMINATED MATERIAL

Basis

Storing contaminated material out of doors, exposed to the weather, may result in widespread contamination outside Radiation Zone areas. The following standard is established to prevent the spread of contaminations by this means.

Standard

All material or equipment contaminated to > 1000 c/m smearable shall be totally enclosed in a weatherproof container before being stored in any outdoor Radiation Zone. This includes material for storage above ground level at the burial grounds. (For the control of material in cribs, trenches or pits, see Radiation Control Standard 8.1).

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SUBJECT

ON-SITE SHIPMENTS OF RADIOACTIVE MATERIAL AND EQUIPMENT

Basis

The operation of the Hanford Atomic Products Operation involves the movement of considerable quantities of radioactive materials including process materials, radioisotopes, tools, contaminated clothing and radioactive wastes.

Shipments of radioactive materials, whether within a plant area or to another plant area must be carefully controlled to safeguard personnel from uncontrolled exposure to radiation, and to prevent the possible spread of radioactive contamination to roadways, vehicles and personnel. This standard is designed to provide controls over radioactive material while in shipment, similar to the controls provided over fixed equipment by Radiation Zones and SWPs.

StandardA. GENERAL

1. The group initiating the shipment shall be responsible for obtaining radiation surveys to determine radiological conditions, prior to the movement of the material, and for complying with any special requirements which may be established.
2. Any materials found to be free of radioactivity may be shipped to any destination by any means without radiological restrictions.
3. Materials released as tagged equipment (as described in RCS 5.1) may be shipped within and between the 100 Areas with only the prior knowledge and concurrence of the recipient; an RSR or SRSP is not required; the radiological release label shall not be used; Radiation Zone storage of these materials is not required.

Shipments of these materials outside the 100 Areas shall be controlled as described below.

4. All materials other than the above will be shipped as radioactive material.

B. BASIC RULES APPLYING TO ALL ON-SITE MOVEMENTS OF RADIOACTIVE MATERIALS

1. The beta-gamma film badge shall be worn by an employee who will be exposed to radiation levels of 1 mrem/hr or greater from the material during the movement.

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2. The material should be loaded and/or barricaded in such a manner that the dose rate to personnel in transit is less than 6 mrem/hr.

The dose rate at the point of closest approach to the material should normally be less than 50 mrem/hr. The point of closest approach should be considered to be the surface of the shipping container, unless the RSR specifically prohibits entry to the truck bed during the shipment, in which case the edge of the truck bed may be considered the point of closest approach.

3. In all cases, materials shall be packaged or contained to the extent that there is no possibility of contamination spread.
4. The material shall constitute a transient Radiation Zone during shipment and shall be so identified.
5. Private vehicles shall in no case be used to transport radioactive materials within HAPO.
6. The shipment, or the vehicle on which it is loaded, shall not be left unattended enroute.
7. In case of a spill or accident enroute, personnel shall move to a safe distance from the shipment, but at the same time remain close enough to warn others who approach the scene. The nearest or most readily available Radiation Monitoring group shall be notified as soon as possible.
8. No repairs or adjustments shall be made to the material or its container while enroute without a valid SWP for the work, except in the case of a bonafide emergency.
9. Upon arrival at the destination, the material shall be placed in, or established as, a Radiation Zone, and posted accordingly.
10. Employees engaged in the preparation of material for shipment, or in the actual movement of radioactive material, are responsible to see that the necessary precautions are taken and that the requirements of this standard are observed.
11. Supervision responsible for radiation protection in the facility originating the shipment shall be responsible for insuring that controls are adequate to minimize the casual exposure of personnel during shipment.

C. MOVEMENT OF RADIOACTIVE MATERIAL WITHIN A PLANT AREA

1. Transfers of radioactive materials within a plant area which involve a change in the Department having monitoring responsibility shall be controlled by a Radioactive Shipment Record or Standard Radioactive Shipment Procedure; in other cases, no RSR or SRSP is required.

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2. When the dose rate to personnel from a piece of equipment or material is 2 mrem/hr, or less, transfer between Radiation Zones within a plant area may be made without specific reference to such a transfer on an SWP or Radiation Work Procedure. In all cases, adequate provisions must be taken (wrapping, boxing, etc.) to prevent the spread of contamination between Radiation Zones.
3. If the dose rate to personnel from a piece of equipment or material is greater than 2 mrem/hr, transfer between Radiation Zones in a Plant Limited Area shall be specifically covered by an SWP or Radiation Work Procedure. The requirements for contamination control outlined above must be observed.

D. MOVEMENT OF RADIOACTIVE MATERIALS BETWEEN PLANT AREAS

1. A Radioactive Shipment Record or a Standard Radioactive Shipment Procedure shall be required for the shipment of all radioactive material between plant areas.
2. Recurrent shipments of a specific type of material may be accomplished by use of a Standard Radioactive Shipment Procedure. If an SRSP for the specific material has not been established an RSR shall be used.
3. A copy of either an RSR or SRSP shall accompany the shipment. The Radioactive Shipment Record or the Standard Radioactive Shipment Procedure will serve as a material pass for movement of radioactive material throughout the plant area except out of the 303 Area.

Shipments of classified-radioactive or other non-inspective material must also meet security requirements as specified in CE&UO OFG 9.6.

4. Whenever possible, the Radiation Monitor at the destination shall be informed of the shipment prior to its departure from the originating area.

E. THE STANDARD RADIOACTIVE SHIPMENT PROCEDURE (SRSP)

1. An SRSP may be used for the repetitive shipment of the same type of radioactive material within HAPO.
2. All SRSPs issued in IPD shall be on a format approved by Radiological Engineering, Research and Engineering Section. The SRSP shall contain the following information:
 - a. Organization component performing the transfer
 - b. Type of material being moved
 - c. All locations involved in the movement

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- d. Radiological limits applying to the shipment
 - e. Protective clothing requirements
 - f. Radiation Monitoring requirements
 - g. Packaging requirements
 - h. Any instructions relative to radiation and contamination control that are appropriate to the shipment
3. The completed SRSP shall be approved by signature of the following parties:
- a. The reactor operation manager for each 100 Area involved in the shipment
 - b. The supervisor (s) of any organizational component (s) involved in shipping, carrying or receiving, when this component is not within the IPD Manufacturing Section
 - c. Appropriate Management of Security and Patrol
4. Requirements relating to certain routine shipments are presented in Radiation Control Standards 7.1.1, 7.1.2, etc.

F. THE RADIOACTIVE SHIPMENT RECORD (RSR)

1. An RSR is required for all inter-area shipments of radioactive material in all cases where an SRSP is not provided.
2. All RSRs issued in IPD shall be on a format approved by Radiological Engineering, Research and Engineering Section. All the information requested on the form shall be supplied, if possible.
3. RSRs shall be approved by supervision of the operating group making the shipment and by supervision responsible for radiation protection.
4. Material shall be shipped on an RSR only with the knowledge and concurrence of the recipient.

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SUBJECT

ON-SITE SHIPMENT OF RADIOACTIVE MATERIAL AND EQUIPMENT

The "SWP" form has been replaced by the "RWP" form; this change in wording should be made throughout both the Basis and the Standard sections of this Standard.

REFERENCE SECTION: Basic Rules Applying to All On-Site Movements of Radioactive Materials

Part 2

There is at present no allowance made for shipments made where closest approach must exceed 50 mrem/hr. These shipments have been made in the past but consideration must be given to both the person handling the shipment and the receiver. Add the following statement to this part:

"Where the dose rate at closest approach must exceed 50 mrem/hr, concurrence of both those handling the shipment in transit and the receiver are required before it is started. Other persons shall be prohibited from approaching within the 50 mrem/hr field."

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SUBJECT

R. R. WELL CAR SHIPMENTS

Basis

The use of railroad well cars for transporting process materials between plant areas presents problems in preventing the spread of contamination to members of the train crews, to the right of way on the plant, and to other rolling stock, such as coal cars, which are used only temporarily on the plant.

Experience has shown that if the well cars are kept within the limits stated below, the spread of contamination can be adequately controlled.

Standard

All well cars which have been loaded, unloaded, or used in any manner in IPD shall meet the following limits before they are moved between Reactor Areas or to the 200 Areas under the Standard Radioactive Shipment Procedure.

1. Direct reading:

All surfaces from the decks upward - less than 100 mrad/hr at surface

Sides of wells - less than 50 mr/hr at 2 inches

2. Smearable:

Couplers, cut levers, handrails, air hose connections, and hand brake wheel - less than 500 c/m smearable as determined by the Standard Smear Survey Technique (see RCP 4.6)

All surfaces from deck upward as determined by the Standard Smear Survey Technique, < 1000 c/m beta-gamma

Any well car not meeting the above limits shall be shipped on an RSR, and only with the prior knowledge and concurrence of the recipient.

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SUBJECT

R. R. WELL CAR SHIPMENTS

All reactors are equipped with full facilities to prepare well cars for shipment within the limits specified in this Standard. Studies have been made which show that if all casks are flushed after they are loaded before being placed in the well car, that routine well car decontamination and routine changing of the well water is eliminated. Other than urgency of production, there is no reason to ship a well car over limits. Additional control over a source which is inside the well of the car can be maintained by instructions to personnel to stay away from the high radiation field, but no additional controls are available for contamination on the outside of the car. To ship cars above limits does constitute a reportable Radiation Occurrence type 4a, as defined in Standard 10.7.

REFERENCE SECTION: Standard

The first sentence should be replaced with: "The limit of contamination on well cars and the limiting dose rates from well cars are as follows:"

The last sentence should be replaced with: "A well car shall not be moved when the smearable contamination exceeds limit. A well car should not be moved if the direct reading dose rate exceeds the limit, but if it is, it shall only be by (1) prior knowledge and concurrence of both the receiver and the Railroad Operation, (2) use of a Radioactive Shipment Record, and (3) follow-up with a Radiation Occurrence Report."

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RESEARCH AND ENGINEERING SECTION

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SHIPMENT OF PALLETS AND SLUGS TO THE 300 AREA

Basis

The contamination encountered in the 300 Area facilities of the Fuels Preparation Department consists almost entirely of uranium and uranium decay products. No fission products are involved. Cross contamination with fission products or corrosion products would severely complicate the contamination control problem within these facilities. For this reason, it is necessary that the Irradiation Processing Department insure, by suitable surveys, that 100 Area fission product and corrosion product activity is not transferred to the 300 Area on pallets or returned slugs, unless prior arrangements are made for each individual case so that proper control measures may be applied.

Standard

1. Pallets returned to the 300 Area shall meet the following limit:

Direct reading: < 5000 c/m beta-gamma per HGM probe area

2. Reject metal pieces returned to the 300 Area shall read less than 100 c/m beta-gamma, < 500 d/m alpha as determined by the Standard Smear Survey Technique (see RCP 4.6).
3. Metal pieces which have been charged through the reactor, whether irradiated or not, shall meet the following limits:

Direct reading: CP instrument, open window of chamber in contact with metal piece, meter deflection < 10 on X1 scale

Smearable: < 100 c/m beta-gamma, < 500 d/m alpha as determined by the Standard Smear Survey Technique

Prior arrangement may be made with the appropriate 300 Area group to receive materials in excess of any of the above limits. In such cases, the shipments shall be under control of a Radioactive Shipment Record.

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SUBJECT

VEHICLES AND MATERIALS TO TRANSPORTATION AND MAINTENANCE OPERATION FACILITIES

Basis

The primary Transportation and Maintenance Operation facilities are located in the 1100 Area. There strict limits on contamination levels must be imposed, because of the lack of personnel access control, decontamination facilities, and experience on the part of personnel with contamination work.

This standard describes the contamination limits and controls which have been established for the Transportation and Maintenance Operation, and which must be met before shipping any materials or vehicles to Transportation and Maintenance Operation facilities in the 1100 Area.

Standard

1. All vehicles, material and equipment shipped to Transportation and Maintenance Operation facilities outside perimeter fences from IPD facilities, shall be surveyed by a person qualified in radiation monitoring prior to shipment.
2. If the vehicles, material or equipment are free of significant contamination such that they may be released with no restrictions, the radiation release label (Form # 54-3000-022) shall be affixed in a prominent location to the shipment. In the case of vehicles, the label shall be located in the driver compartment.
3. If a vehicle, material or equipment is contaminated but meets the following requirements, the label (Form # 54-3000-022) shall not be used; a tag presenting the survey results, the date and the signature of the monitor shall be affixed instead.

Direct reading: General contamination level < 1000 c/m as measured with HAPO GM, except that: local contamination up to 5000 c/m is permissible if the contamination is covered and marked, and is physically remote from the location where work must be performed.

Smearable: < 100 c/m β - γ
 < 500 d/m α

4. Equipment and vehicles contaminated to values greater than those above will be returned to the assigned area for decontamination unless the prior approval of the 300 Area Radiation Monitoring Operation and Transportation supervision has been obtained.

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SUBJECT

SHIPMENTS TO CENTRAL STORES FACILITIES

Basis

Certain materials shipped to Central Stores may be reshipped off plant as nonradioactive without any further evaluation of their radiological status. It is essential, therefore, that the status of these materials be known before they are released to Stores, and that they meet current release limits.

StandardA. Surplus or Salvage Material for Public Sale

1. All material shipped to Central Stores facilities as surplus or salvage shall be surveyed by a person qualified in radiation monitoring.
2. If the material is free of contamination, the Property Disposal Request form should be marked "Cleared for Public Sale" and signed by supervision responsible for radiation protection.
3. If the material is releasable as tagged equipment (i.e., < 100 c/m & < 500 d/m smearable; < 600 c/m direct on a HAPC GM & < 2000 d/m no Pu, < 600 d/m Pu not known to be absent) it may be released for public sale provided the following requirements are met:
 - a. A durable plastic or metal tag embossed with the following inscription is firmly attached in a conspicuous place to each item or container:

FIXED SURFACE RADIOACTIVITY
DO NOT STORE WITHIN 5 FEET OF PHOTOGRAPHIC FILM
NOT A PERSONNEL HAZARD
 - b. The kind and level of contamination is plainly indicated on all pertinent documents.
4. If the material does not meet the requirements of 3 above, every effort should be made to reduce the level of contamination to the lowest practicable level with due consideration of the economic factors involved.
5. If the nature of the material is such that decontamination may result in absorption or occlusion of contamination within the material, release of the material shall be made only as in 3 above, provided, of course, that the stated limits are met.

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6. If absorption or occlusion within the material is not possible, release may be made as in 2 or 3 above, provided the applicable limit is met.
7. If, after thorough decontamination, the material still exceeds the limits in 3 above, it shall not be released for public sale, but shall be disposed of as contaminated equipment in the normal manner.

B. Other Materials

1. The following materials shall be surveyed by a person qualified in radiation monitoring prior to shipment to Central Stores:
 - a. Acid bottles, carboys, gas cylinders, pressure regulators, oil drums, and vacuum bottles for liquified gases if used within the 105 exclusion area or within a radiation zone.
 - b. Any equipment or material used in the 105 exclusion area or within a radiation zone which is to be returned to store stock or to a vendor.
2. All materials above must be free of contamination prior to shipment to Central Stores, and must be labeled with the radiological release label.
3. Stores personnel picking up the material are often willing to accept only labeled items from within the 105 exclusion area, and in addition may request assurance that similar unlabeled items located elsewhere have been used in such a manner that no survey is in fact required.

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SUBJECT

OFF-PLANT SHIPMENTS OF RADIOACTIVE MATERIALS

Basis

In addition to HAPO radiological protection requirements, federal regulations have been applied to the shipment of radioactive material by common carrier, including Railroad or Motor Freight, Ship, Air, Railway Express and Parcel Post. An abstract of these regulations is given in RCS #7.2.1. These regulations must be complied with unless the AEC obtains a special permit or provides special transportation and/or courier service.

Standard

Summary

The basic requirements for off-plant shipment are as follows:

1. Smear surveys of each container and of available floor surfaces after loading shall be less than 100 c/m beta-gamma/100 cm² area, and less than 500 d/m alpha/100 cm² area.
2. Gamma radiation shall not exceed 200 mr/hr at 2 inches through the side or end of the container.
3. Gamma radiation shall not exceed 10 mr/hr at one meter (39 inches) on any container.
4. Exposure rate in the vehicle shall not exceed 2 mrem/hr at the position of accompanying personnel.
5. Each container shall be labeled in conformance with federal regulations. In certain cases the AEC will authorize the shipment of material which does not meet the above requirements.

Special Instructions

1. All Radiation Zones where containers for off-plant shipment are handled, including the interior of the railroad car or vehicle, shall be considered as Controlled Injury Zones.
2. Any vehicle or railroad car which is used for off-plant shipment of radioactive materials shall be considered as being contaminated when it arrives at HAPO until all contamination surveys are completed and the contamination status is established.

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3. When loading the containers into the vehicle or railroad car, personnel shall be alert for any spills or drips of liquid from any containers. If spills occur, the shipment shall be held up and the Radiation Analyst or Supervisor, Radiation Monitoring shall be notified.
4. A typewritten Radioactive Shipment Record shall be processed in triplicate for each off-plant shipment. After shipment is loaded, a complete radiation and contamination survey shall be made of the vehicle or railroad car. All monitoring results shall be entered on the Radioactive Shipment Record form including the dose rate at 2 inches from the surface of the container, and at one meter (39 inches) from the container. For courier shipment in a railroad car, the monitoring results shall show the radiation level at the position of sleeping cots, in the aisle, on the top, sides, bottom, and ends of the car, and the maximum on any accessible surface of the loaded containers. Any special hazard from possible gas leaks, undrained water, cracks in the shielding, etc., shall be noted on the form under special instructions, for the benefit of the courier. All data shall be written in such a way that no security classification will be required.
5. Supervision originating the shipment shall complete the RSR in such a manner as to advise the recipient of the nature of the hazard in transfer and recommend the desired protection upon arrival at the destination.

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SUBJECT ABSTRACT OF FEDERAL REGULATIONS FOR SHIPMENT OF
RADIOACTIVE MATERIALS

I. Groups of Radioactive Materials

- A. Group I - Radioactive materials that emit gamma rays only or both gamma and electrically charged corpuscular rays.
- B. Group II - Radioactive materials that emit neutrons and either or both types of radiation characteristic of Group I materials.
- C. Group III - Radioactive materials that emit electrically charged corpuscular rays only, i.e., alpha or beta, etc., or any other that is so shielded that the gamma radiation at the surface of the package does not exceed 10 mr/24 hrs at any time during transportation.

II. Limits on Quantity in Package

- A. Not more than 2,000 millicuries of radium, polonium, or other members of the radium family of elements, and not more than 2,700 millicuries (disintegration rate of 100,000 million (10^{11}) atoms per second) of any other radioactive substance may be packed in one outside container for shipment by rail freight, rail express, or highway, except by special arrangements and under conditions approved by the Bureau of Explosives or except as specifically provided in sub paragraph (B) of this section.
- B. Not more than 300 curies of solid cesium 137, cobalt 60, or iridium 192 may be packed in one outside container for shipment by rail freight, rail express, or highway, except by special arrangements and under conditions approved by the Bureau of Explosives.

III. Exemptions from Prescribed Packaging, Marking, and Labeling Requirements

- A. Radioactive materials are exempt from prescribed packing, marking and labeling requirements provided they fulfill all of the following conditions.
 - 1. The package must be such that there can be no leakage of radioactive material under conditions normally incident to transportation.
 - 2. The package must contain not more than 0.1 millicuries of radium or polonium, or that amount of strontium 89, strontium 90 or barium 140 which disintegrates at a rate of 5 million atoms/second, or that amount of any other radioactive substance which disintegrates at a rate of more than 50 million atoms per second.

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3. The package must be such that no significant alpha, beta or neutron radiation is emitted from the exterior of the package and the gamma radiation at any surface is less than 10 mr per 24 hours.
- B. Manufactured articles other than liquids, such as instrument or clock dials or electronic tubes and apparatus, of which radioactive materials are a component part, and luminous compounds, when securely packed in strong outside containers are exempt from specifications packaging, marking, and labeling requirements provided the gamma radiation at any surface of the package is less than 10 milliroentgens in 24 hours.
- (1) Switchboard or similar apparatus containing electronic tubes, of which radioactive materials are a component part, are exempt from specification packaging, marking, and labeling requirements when shipped in carload or truckload lots or when transported by private motor carrier provided the gamma radiation at any readily accessible surface of the units when prepared for shipment does not exceed 50 milliroentgens in 24 hours.
- C. Radioactive materials such as ores, residues, etc., of low activity, packed in strong tight containers, are exempt from specified packing and labeling requirements for shipment in carload lots by rail freight only provided the gamma radiation or equivalent will not exceed 10 mr per hour at a distance of 12 feet from any surface of the car, and will not exceed 10 mr per hour at a distance of five feet from either end surface of the car. There must be no loose radioactive material in the car and the shipment must be braced so as to prevent leakage or shift of lading under conditions normally incident to transportation. Shipment must be loaded by consignor and unloaded by consignee. The shipper must furnish the carrier with such information and equipment as is necessary for the protection of the carrier's employees.
- D. Empty containers, if authorized for reuse (by the Bureau of Explosives, arranged at HAFO through the AEC) must have all openings including removal heads, filling and vent holes, tightly closed before being offered for transportation. Small quantities of the material with which the containers were loaded may remain in "empty" containers and when the vapors remaining therein are unstable, it is permissible to add sufficient inert gas to render the vapors stable.
- E. All containers and accessories which have been used for shipments of radioactive materials when shipped as empty must be sufficiently free of radioactive contamination so as to conform to Section III A above.
- F. Any box car or motor vehicle which, after use for the transportation of radioactive materials in carload or truckload lots, is contaminated with such materials to the extent that a survey of the interior surface shows that the beta gamma radiation is greater than 10 milliroentgens physical equivalent in 24 hours or that the average alpha contamination is greater than 500 disintegrations per minute per 100 square centimeters shall be thoroughly cleaned in such a manner that a re-survey of the interior surface shows the contamination to be below these levels. A certificate to that effect must be furnished to the local agent of the carrier

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or to the driver of the motor vehicle. Car and motor vehicles which are used solely for the transportation of radioactive materials are exempt from the provisions of this section.

IV. Packing and Shielding

- A. Radioactive materials that present special hazards due to their tendency to remain fixed in the human body for long periods of time (i.e., radium, plutonium and radioactive strontium, etc.) must, in addition to the packing hereinafter prescribed, be packed in inside metal containers, specification 2R, or other container approved by the Bureau of Explosives.
- B. All radioactive materials must be so packed and shielded that the degree of fogging of undeveloped film under conditions normally incident to transportation (24 hours at 15 feet from the package) will not exceed that produced by 11.5 mr of penetrating gamma rays of radium filtered by 1/2 inch of lead.
- C. The design and preparation of the package must be such that there will be no significant radioactive surface contamination of any part of the container.
- D. The smallest dimension of any outside shipping container for radioactive materials must be not less than 4 inches.
- E. All outside shipping containers must be of such design that the gamma radiation will not exceed 200 mr/hr or equivalent at any point of readily accessible surface. Containers must be equipped with handles and protective devices when necessary in order to satisfy this requirement.
- F. The outside shipping container for any radioactive material, unless specifically exempt by Section III above or unless approved by the Bureau of Explosives, shall be as follows:
 1. Spec. 15A or 15B (49CFR 78.168 or 78.169)*. Wooden boxes. Authorized for not more than 2,700 millicuries.
 2. Spec. 12B (49CFR 78.205)*. Fiberboard boxes. Authorized for not more than 2,700 millicuries.
 3. Spec. 21A or 21B (49CFR 78.222 or 78.223)*. Fiber drums. Authorized for not more than 2,700 millicuries.
 4. Spec. 6A, 6B, or 6C; 17C or 17H (single-trip). (49CFR 78.97, 78.98, 78.99, 78.115, or 78.118)*. Metal barrels or drums. Authorized for not more than 2,700 millicuries.
 5. Spec. 55 (49CFR 78.250)*. Metal encased, lead-shielded containers. Authorized for not more than 300 curies (49 CFR 73.391)*. Containers must be equipped with a seal.

*Title 49, Part 78.168, etc., Code of Federal Regulations. Copy in AEC Legal Library, 703 Building.

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- G. Radioactive materials Group I, liquid, solid or gaseous, must be packed in suitable inside containers completely surrounded by a shield of lead or other suitable material of such thickness that at any time during transportation the gamma radiation at one meter from the point on the radioactive source will not exceed 10 mr/hr*. The shield must be so designed that it will not open or break under conditions incident to transportation. The minimum shielding must be sufficient to prevent the escape of any primary corpuscular radiation to the exterior of the outside shipping container.
- H. Radioactive materials Group II, liquid, solid, or gaseous, must be packed in suitable inside containers completely shielded so that at any time during transportation the radiation measured at right angles to any point on the long axis of the shipping container* will not exceed the following limits:
1. Gamma radiation of 10 mr/hr at 1 meter.
 2. Electrically charged corpuscular radiation of 10 mrads/hr at 1 meter.
 3. Neutron radiation of 2 mrem/hr at 1 meter.
 4. If more than one of the types of radiation named above is present, the radiation of each type must be reduced by shielding so that the total does not exceed the equivalent of paragraphs 1, 2, or 3.

The shielding must be designed so as to maintain its efficiency under conditions normally incident to transportation, and must provide personnel protection against fast or slow neutrons and all other ionizing radiation originating in the radioactive materials or any part of the aggregate constituting the complete package.

- I. Liquid radioactive materials Group I, II and III must, in addition, be packaged in tight glass, earthenware or other suitable inside containers. The inside containers must be surrounded on all sides and within the shield by an absorbent material sufficient to absorb the entire liquid contents and of such nature that its efficiency will not be impaired by chemical reaction with the contents. If the container is packed in a metal container specification 2R or other container approved by the Bureau of Explosives, the absorbent cushioning is not required.
- J. Radioactive materials Group III, liquid or solids, must be packed in suitable inside containers completely wrapped and/or shielded with such material as will prevent the escape of primary corpuscular radiation to the exterior of the shipping container, and secondary radiation at the surface of the container must not exceed 10 mr/24 hrs at any time during transportation.
- K. Liquids (shipped by airplane) shall be packed only in containers which are securely closed, sufficient in strength to prevent leakage or distortion of the containers caused by change in temperature or altitude during transit, and so filled as to provide adequate outage.

*In IPD, this shall be interpreted to mean distances measured from the surface of the container.

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L. Specification 2R-Inside Containers - Metal Tubes:

1. Size - Outside diameter of the tube must not exceed 3 inches and length must not exceed 8 inches exclusive of flanges, or handling, or fastening devices.
2. Manufacture - Stainless steel, malleable iron, or brass having a wall thickness of not less than 3/32 inches for diameter up to two inches and not less than 1/8 inch for diameter up to three inches. The ends of the tube must be fitted with screw type closures except that one end of the tube may be permanently closed by a welded or brazed plate. Welded or brazed seams are authorized.
3. Welding and Brazing - Must be done in a workmanship-like manner and must be free from defects.
4. Closing devices - Must be of screw type. Number of threads per inch must be not less than U.S. Standard pipe threads. Caps or plugs are authorized.

V. Labeling

- A. Unless exempted according to Part III above, each outside container of Group I or II radioactive material being shipped must be labeled with the properly executed red label (49CFR 73.414(a)*, and of Group III with properly executed blue label (49CFR 73.414(b)*.
- B. Radioactive materials requiring a caution label under ICC regulations are prohibited in the mails, but those exempted (complying with Part III, and Part IV C and I) may be mailed provided that the package is marked "Radioactive Material Gamma Radiation at Surface of Parcel Less than 10 Milliroentgens for 24 hours - No Significant Alpha, Beta, or Neutron Radiation".
- C. Containers shipped as "empty" must have the old labels prescribed (by Federal regulations) removed, obliterated, destroyed, or completely covered by a square white label measuring not less than six inches on each side, and bearing thereon the word "EMPTY" in letters not less than one inch high. This does not apply to carload or truckload shipments to be unloaded by consignee.

VI. Loading

- A. When radioactive materials are loaded by the shipper (as well as the carrier) into railroad cars, motor vehicles, airplanes, or other carriers, the shipper shall observe the following requirements:
 1. A container of Group I or II radioactive material must not be placed in

*Title 49, Part 78.168, etc., Code of Federal Regulations. Copy in AEC Legal Library, 703 Building.

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vehicles, depots, or other public places closer than 3 feet to an area which may be continuously occupied by passengers, employees, or shipments of animals; closer than 3 feet to the dividing partition in a combination vehicle carrying passengers and/or express shipments; or closer than 15 feet to any package containing undeveloped film.

2. If more than one such container is present, the distance must be computed from the following table by adding the number of units shown on the labels on the containers (1 unit = 1 mr/hr at 1 meter, or the amount of radiation which has the same effect on film as 1 mr/hr at 1 meter of hard gamma rays of radium filtered by $\frac{1}{2}$ inch of lead).

Total Units	Feet to Undeveloped Film	Feet to Dividing Partition	Feet to Area Occupied:	
			Less than 8 Hrs.	More than 8 hrs.
0-2*			1*	
3-5*			2*	
6-10*			3*	
1-10	15	3	3	5
11-20	20	4	4	7
21-30	25	5	5	9
31-40	30	6	6	10

*Aircraft

3. Not more than 40 units of Group I or II radioactive material shall be transported in any vehicle or stored in any public location at one time. A package of Group I or II material remaining in the same building for more than 24 hours must be moved to a different location after each 24 hours. All containers of such material must be carried by the handles when handles are provided.
4. Radioactive materials, Groups I, II, or III, must not be loaded, transported, or stored with Class A explosives (detonating or otherwise of maximum hazard, as compared to Class B flammable or Class C minimum hazard explosives), or with samples of explosives.

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SUBJECT

SOLID RADIOACTIVE WASTE DISPOSAL

Basis

In the course of reactor operation certain materials are encountered that are no longer useful, but being contaminated or otherwise radioactive they cannot be disposed of by the same procedures prescribed for non-radioactive wastes. Their radioactivity becomes the controlling influence in determining the disposal method.

Where exclusively short-lived radioisotopes are involved, consideration should be given to disposal of the material as non-radioactive waste after its retention in a controlled area until the residual activity meets the limits for the method of disposal chosen. For long-lived radioisotopes permanent controlled storage in pits or trenches with suitable backfilling is preferred.

Safety of personnel is the primary objective of this standard. The secondary objective is to avoid unnecessary limitations on the use of ground areas made necessary by contamination spread during the burial process.

Standard

Burial

1. For the purposes of this standard, solid waste is defined as material that is essentially dry, or whose fluids are of small volume, adequately contained, and cannot be physically removed from the waste. Radioactive solid waste is defined as contaminated material which is spent or no longer useful and whose continued presence at a work location would cause a real or potential hazard.
2. As there is no upper limit on the radiation from or the contamination on material disposed of as solid waste, significant dose rates may exist at some distance from them which require special precautions for the protection of personnel during burial operations. Such precautions shall be arranged in advance and efforts directed toward avoiding exposure to unconcerned personnel. Upon completion of the disposal, the radiation level shall not exceed 1 mrem/hr at the burial ground fence.
3. Loose contamination may be a problem at the point of original collection of the waste, in transit to the burial ground, or after disposal to the trench. Good radiation control practices applicable to handling contaminated materials and equipment and their shipment or storage, apply equally as well to waste as to other items. Containment of the waste shall be adequate to prevent dispersion or spread of contamination during storage or transfer to the disposal area and following disposal.

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SOLID RADIOACTIVE WASTE DISPOSAL

Standard

4. Each container used for storage or transfer shall be conspicuously identified as containing contaminated waste. In order to prevent confusion as to the status of their contents, containers such as preprinted cardboard boxes marked for disposal of contaminated waste shall not be used for any other purposes. Ice cream cartons, plastic bags and other small parcels may be exempt from the marking requirement if they are adequately sealed within another container which has been properly labeled. The fire, explosive and toxic by-product hazards should be considered before placing waste in a common disposal location.
5. All unboxed waste shall be contained in a pit with a cover, or if buried in an open trench such waste shall be covered with six inches of dirt immediately following each burial operation.

Burning Contaminated Waste

Burning contaminated waste as a method of volume reduction or contamination dispersion is not normally practiced at HAPO. Whenever incineration of contaminated waste is planned, Radiological Engineering shall specify the necessary control measures consistent with the most recent information available at the time.

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SUBJECT

UNDERGROUND RADIOACTIVE WASTE DISPOSAL FACILITIES

Basis

This standard is designed to provide long term control of radioactive materials stored underground. It is necessary to maintain good marking and records to allow deliberate excavation for recovery of materials and to prevent accidental excavation. Control of the location, depth or size of a facility and the material placed in it is necessary to assure operation of cribs and burial grounds in a manner that will best accomplish their intended function which is to provide permanent storage of radioactive materials.

Standard

1. Solid waste pits and burial grounds shall be used exclusively for solid waste disposal and pits and cribs for liquid wastes shall be used exclusively for liquid wastes.
2. Records of the locations, dimensions and contents of all waste disposal sites in the 100 Areas shall be maintained by Radiological Engineering, Research and Engineering Operation.
3. Whenever a new waste disposal trench, pit or crib is planned the using operation shall notify Radiological Engineering, Research and Engineering Operation of the proposed exact location, dimensions and intended use. The concurrence of Radiological Engineering shall be required in all cases prior to actual use of the facility.
4. The ability of any material introduced into a crib to release the radioactive contamination contained in that crib shall be destroyed or neutralized before that material is discharged into the crib.
5. Upon termination of use, or when filled to capacity, burial trenches and pits shall be backfilled to normal grade, providing at least 2 feet of dirt cover and a radiation level of not more than 1 mrem/hr at normal grade. Erection of a mound to meet these requirements is not permitted.
6. Future use of ground areas utilized for burial purposes must be permanently controlled. For this reason and to facilitate possible future recovery of materials, it is necessary to define the actual trench area with permanent markers.

The minimum permanent identification of a filled burial trench shall be steel posts with signs attached indicating the presence of radioactive material underground. These posts shall be located so as to satisfy the following conditions:

1. A maximum of 50 feet between posts.
2. A post on each corner and on the centerline at the ends of the trench.

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6. (cont'd)

3. At least three signs must be visible from any direction of approach except when the burial area is small as in the case of pits.

No effort should be made to locate and mark trenches that are closed and are no longer definitely marked. Instead, the area including all such trenches shall be marked at the four corners and at approximately 50 foot intervals along the sides. In order to avoid cave-ins, vehicular traffic shall be prohibited over closed trenches.

7. When a waste disposal trench, pit or crib is closed, the using operation shall notify Radiological Engineering, Research and Engineering Operation of the date of closure and the nature of the waste buried.
8. Some weeds have tap roots long enough to reach contaminated material and in addition are able to concentrate certain radioisotopes stored there. In order to avoid this problem and to prevent concealing signs, a soil sterilization program shall be carried out.
9. An annual inspection of each waste disposal site shall be made to see that signs are in place, readable and unobstructed and to see that weed control and other radiological control measures are effective.

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SUBJECT

UNDERGROUND RADIOACTIVE WASTE DISPOSAL FACILITIES

REFERENCE SECTION: Basis

To define the purpose of permanent marker posts at closed burial sites and to clarify intent of the Standard on enclosure of an active burial ground, the following statement should be added to the Basis:

"The Standard permits use of fencing that is equal to or better than the specified chain barricade which is the minimum acceptable enclosure of a solid waste disposal facility. Permanent marker posts are required on boundaries of an officially closed burial site to aid in the control of future land use and to facilitate possible recovery of buried materials."

REFERENCE SECTION: Standard

Parts 6 and 7

The method of marking boundaries of Hanford burial grounds was standardized in 1960, making items 6 and 7 obsolete. Therefore, these parts are replaced by the following:

- "6. Each solid waste disposal facility shall be an identified "Radiation Zone." A chain barricade, described in Architectural Civil Standard AC-5-2, shall be the minimum acceptable enclosure for such a burial ground."
- "7. Permanent marker posts, described in Architectural Standard AC-5-40, shall be installed according to Instructions for Use of AC-5-40 to define the boundaries of plots containing underground radioactive material. These markers shall be installed at the time each waste disposal site is officially closed. No further disposal nor any storage of radioactive material will be permitted at the site after the posts are erected. Radiological Engineering shall be notified by the disposal facility custodian when marker posts are to be installed."

APPROVED

RESEARCH AND ENGINEERING SECTION

ACCEPTED

MANUFACTURING SECTION

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PRODUCTION FUELS SECTION

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SUBJECT

DESIGN OF NEW FACILITIES AND CHANGES AND MODIFICATIONS TO EXISTING FACILITIES

Basis

The design, construction, and proposed operation of new facilities or equipment, and the alteration or expansion of existing facilities or equipment within the Irradiation Processing Department may involve radiological safety problems. It is essential that all plans for the above be reviewed to insure adequate consideration of radiological safety.

Standard

All plans for the design, construction, or operation of new facilities or equipment, and the alteration or expansion of existing facilities or equipment within the Irradiation Processing Department shall be examined by the Project Engineer for possible radiological safety considerations.

If radiological safety is involved, the plans should be submitted in early stages of planning or design to the Radiological Engineering Operation for review or comment. The concurrence of the Radiological Engineering Operation should be obtained before the proposed construction, modification or operation is started.

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SUBJECT

REACTOR SHIELDING

Basis

The effectiveness of reactor biological shielding may be seriously reduced by radiation leakage through inadequately shielded holes. Doses to personnel from these sources are unnecessary and in most cases, may be easily avoided.

The shielding specified below has been found, through experience, to be adequate but not excessive.

Standard

The following minimum hole shielding shall be used in shielding dry holes. This standard is not intended to apply to engineered shields provided for special process installations nor for shields associated with production test installations, in which case shielding requirements shall be specified in the Production Test Proposal, and approved by Radiological Engineering.

Front Face

Gamma Shielding - 6 each 8" grooved steel pieces (or equivalent) in the process tube or bayonet.

Neutron Shielding - An external paraffin filled can lined with cadmium or a boroffin filled can, at least 4 " dia. x 8" long; or equivalent additional internal shielding.

If an engineered design bayonet containing grooved steel, paraffin, and cadmium is used, no external neutron shielding is necessary.

Rear Face

Gamma Shielding - One 8" grooved steel piece plus two regular steel upstream (or equivalent) in the process tube. In an empty channel a bayonet containing 3 grooved steel must be used.

Neutron Shielding - None required.

The shielding effectiveness of the discharge area rear wall shall be maintained.

Near Side

Gamma Shielding - 2' column of steel plugs, snug fit, preferably stepped.

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Standard

Near Side (continued)

Neutron Shielding - 12" thickness of boroffin (or paraffin covered with cadmium sheet) large enough to lap hole by 4" all around, backed with 2" of lead; or the equivalent in internal shielding.

If the hole is coaxial with a port in the sandwich wall, the equivalent of a 6" thickness of lead shall be used to cover the port in the sandwich wall.

Far Side

Gamma Shielding - 4' column of steel plugs, snug fit, preferably stepped; or equivalent.

Neutron Shielding - 12" thickness of boroffin (or paraffin covered with cadmium sheet) large enough to lap hole by 4" all around, enclosed in 4" of lead; or the equivalent in internal shielding.

Top of the Reactor

Inside the VSR enclosure

Gamma Shielding - VSR tip or equivalent.

Neutron Shielding - None required.

Outside the VSR enclosure

Gamma Shielding - 4' column of steel plugs, snug fit, preferably stepped; or equivalent.

Neutron Shielding - 12" thickness of boroffin (or paraffin covered with cadmium sheet), large enough to lap hole by 4" all around, enclosed in 4" of lead; or the equivalent in internal shielding.

Radiation Monitoring shall check the effectiveness of the shielding installed on a dry hole, each time the shielding is disturbed, before any personnel are allowed to perform work in the vicinity.

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SUBJECT

REACTOR SHIELDING

The shields required are very specific in design and if followed explicitly, eliminate all problems which might otherwise appear from not considering all possibilities of beams, gamma, neutrons, and void sections. Equivalent shielding is allowable if it has been considered and approved by Radiological Engineering, Research and Engineering.

Add the following statement to the first paragraph of the Standard: "Equivalent shielding whose design has been approved through Radiological Engineering, Research and Engineering, may be used in place of the following:"

Part: Front Face

The following front bayonet has been tested and approved, and may be added to this part: "Concrete bayonet - six-foot process tube holding one 8-inch grooved steel piece at the tip and the remainder filled with iron serpentine concrete as specified in HW-66117."

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RESEARCH AND ENGINEERING SECTION

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PRODUCTION FUELS SECTION

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SUBJECT

RADIOACTIVE SOURCES

Basis

Various types and sizes of prepared radioactive sources are used within the Irradiation Processing Department, primarily for calibrating and testing radiation detection instruments. These sources are routinely used outside established Radiation Zones. Therefore, it is essential that they be identified and controlled to prevent uncontrolled exposures to personnel.

Examples of prepared sources used in IPD are:

- a. Radium - Beryllium neutron sources ~10 mc
- b. Radium Integron sources ~ 2 mc
- c. Cobalt V-Block sources ~ 0.75 mc
- d. Radium V-Block sources ~ 0.1 and 0.2 mc
- e. Strontium-Yttrium beta sources ~235 μ c
- f. Alinor Dewpoint instrument sources
- g. Jordan chamber sources
- h. Mica window and alpha counter sources

Standard

The handling and use of radioactive sources by any personnel other than Radiation Monitoring, shall be controlled by a Radiation Work Procedure or Special Work Permit.

Source Holder

1. The source holder shall be constructed in such a manner that the source material cannot escape from the source holder under conditions of normal use and handling.
2. The source holder shall be constructed so as to allow handling and use of the source at dose rates of 25 mrem/hr or less.
3. Each source holder shall be marked with the approved radiation symbol.

Storage Containers

1. A storage container should be supplied for each radioactive source, or group of sources. The container should be large enough to reduce the reading to less than 5 mrem/hr at the surface of the storage container.
2. Provision should be made for locking high level source containers, to prevent the removal of the source by unauthorized persons.

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Standard

3. All storage containers shall be posted with the approved radiation symbol, and an appropriate message such as: "Gamma Source", "Beta Source", "Neutron Source", etc.

Storage

1. In the 105 exclusion area, sources in containers which meet all of the above requirements may be stored outside of an Established Radiation Zone; sources in containers not meeting all the above requirements, or sources for which no container is provided shall be stored inside an established Radiation Zone.

2. Outside the 105 exclusion area, sources shall be stored within an established Radiation Zone.

Shipments

The shipment of radioactive sources between plant areas shall be controlled by a Radioactive Shipment Record.

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SUBJECT

RADIOACTIVE SOURCES

REFERENCE SECTION: Source Holder

To amplify the criteria set forth in this section, the following addition or changes are to be made.

Part 1 (add)

"1a. Sources containing more than 1 μ c will be jacketed and sealed."

"1b. Sources containing more than 1 mc will be double encapsulated to maintain source integrity."

REFERENCE SECTION: Storage Containers

Part 2

High level sources are sources containing greater than one millicurie. The words "(greater than 1 mc)" should be added following ".... high level source"

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J. E. Gorman

SUBJECT

RECEIPT OF RADIOACTIVE MATERIAL FROM OFF-PLANT

Basis

The use of radioactive materials in industrial equipment is becoming increasingly more common. Even though the hazards of radiation are generally appreciated, some manufacturers still do not identify or label such equipment as radioactive. Instances have occurred here at HAPO, where items of specialized equipment containing radiation sources were received and put into service with no consideration being given to possible radiation control problems; the equipment was not marked in any way to indicate the presence of the radioactive source, and no warning was given the receiver by those responsible for the selection of the equipment.

This standard is established to insure that any radiation hazards associated with material or equipment which is received for use in IPD facilities are promptly recognized and controlled.

Standard

1. This standard shall apply to all radioactive material that is to be received from off-site, except for process materials for which special accounting and control procedures have been established.
2. Any individual ordering radioactive material, or equipment incorporating radioactive material, for use in IPD facilities shall inform the intended recipient (if other than himself) of the nature of the material and the expected date of arrival.
3. The intended recipient shall notify supervision of the appropriate Radiation Monitoring Operation, as far in advance of receipt of the shipment as possible, of the nature of the material and the expected date of arrival.
4. Upon receipt of the material, the recipient shall notify supervision of the appropriate Radiation Monitoring Operation prior to the opening of the package containing the material or equipment.
5. Radiation Monitoring shall be responsible for establishing suitable controls or procedures for use and handling of such material.
6. Any case where radioactive materials are received in packages which are not properly labeled to indicate the presence of radioactive material shall be reported without delay to Radiological Engineering, Research and Engineering Operation.

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SUBJECT

RADIATION ALARM

REFERENCE SECTION: RADIATION EMERGENCY ALARM

E. ReportingPart 1

As of the end of 1964, it will no longer be necessary to make reports to RPO, HL; delete the phrase "and the Exposure Evaluator, Radiation Protection Operation, HL," from the text.

To clarify the system within Manufacturing for reporting false alarms and radiation incidents, add the following

"Each emergency alarm actuation caused by a radiation incident shall be reported immediately in compliance with RCS 10.8, "Radiological Communications."

"Each emergency alarm actuation at a Manufacturing facility which occurs falsely shall be reported in the Reactor Operations Daily Report."

"Each Manufacturing radiation emergency alarm malfunction and the subsequent corrective action shall be reported to Radiation Practices Engineering."

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SUBJECT

RADIATION ALARM

STANDARD

The uniform methods of radiation dose rate alarming with fixed or semiportable equipment at IPD facilities are:

RADIATION EMERGENCY ALARM

A. Signal

The device shall create the audible sound specified for radiation alarms by HWS-8210-S, Hanford Engineering Standard for Emergency Audible Alarm Signals, and its Instructions for Use.

B. Trip Setting

1. The emergency alarm shall be set to trip whenever the gamma dose rate three feet from a point source within the zone exceeds 360 R/hr.
2. The trip setting device shall be locked. Unlocking and changing the trip setting shall be done only by direct authorization of the processing manager.
3. The alarm may be rendered inactive only when people are physically barricaded from the zone. (Also, see Alternates.)

C. Response

1. Upon hearing the alarm, each person shall immediately leave the zone without any hesitation.
2. Response to this alarm shall override the response required by other signals.
3. During a scheduled performance test, a person may, if necessary, remain in the zone while the alarm is sounding only so long as he knows the dose rate at which he is being exposed.

D. Record

There shall be a permanent record of:

1. Each alarm trip setting
2. The operating condition of the system at all times
3. Tests and functional checks
4. Actuation of the alarm signal

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SUBJECT

RADIATION ALARM

STANDARD

E. Reporting

1. When the emergency alarm signal is actuated unexpectedly, either by radiation or falsely, it shall be reported to the Manager, Manufacturing or Production Fuels, Supervisor, Radiological Engineering, R&E, and the Exposure Evaluator, Radiation Protection Operation, HL, or a representative of each of the above. (See Call List, RCS 10.8 Attachment.)
2. If the alarm is being tested or there is some other preplanned actuation and all who are within hearing have been warned in advance, further reporting is not required.

RADIATION CONTROL ALARM

A. Alarm Signal

The device shall create a visual signal of yellow light equivalent of the revolving Beacon-Ray light, yellow lens, manufactured by Federal Sign and Signal Corporation. The alarm signal(s) shall be placed so as to visually alert persons entering or working in the affected location.

B. Trip Setting

1. The alarm shall be set to alert people to a significant increase in their whole body gamma dose rate, to maintain exposure control. It should not allow more than a 50 per cent increase in the planned dose rate.
2. The alarm setting is part of the dose rate control system for which the radiation monitoring function is responsible.

C. Response

Upon observing the control alarm signal, leave the zone immediately unless:

1. The increased personal dose rates can be immediately measured and work at the new higher dose rates meets the approval of the responsible management.
2. Where immediate corrective action will prevent further loss of control and it warrants additional exposure, the time spent at the location shall not exceed 30 seconds without re-evaluation of each person's dose rate.

D. Record

1. Each setting of the alarm trip shall be recorded as a permanent record.
2. Operational and functional tests of the equipment shall be recorded as a permanent record.

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RADIATION ALARM

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STANDARDE. Reporting

Each alarm trip shall be reported to the reactor building supervisor and the radiation monitoring service.

ZONE ALARM REQUIREMENTSA. Dual Alarms

In zones where the working dose rates change over a considerable range and there is the possibility of an emergency level dose rate (above 360 R/hr) occurring, coverage shall be maintained by both emergency and control alarms.

B. Emergency Alarm

In zones where the possibility exists for an emergency level dose rate, such as might result from a criticality event, and the working dose rates are constant with no other probabilities of an intolerable change, coverage shall be maintained by emergency alarm but the control alarm is not required.

C. Control Alarm

In those zones where the possibility of an emergency level dose rate is not present but significant changes in working dose rates can occur, coverage should be maintained with a control alarm.

D. None

In zones where the sources of radiation can be adequately measured to establish a maximum potential dose rate and this is tolerable, then dose rate alarming is not required. This definition of sources includes hidden ones which can appear unexpectedly to create undesirable dose rates by losing their shielding or being injected into the zone.

E. Alternates

Where a radiation alarm system has been established, it shall be fully operational when people are present in the zone or else continuous radiation monitoring is to be provided by a qualified person. Where a zone is covered by a dual alarm system, both the emergency and a control alarm must be operating to qualify as fully operational. Any other methods or systems of coverage require the prior approval by Radiological Engineering.

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RADIATION ALARM

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BASIS

A radiation alarm system is to alert people to an unplanned or unexpected increase in their dose rate. A person alerted by an alarm has little choice as to his immediate course of action. When a radiation emergency alarm is actuated, the dose rate is so high it overrides judgment, leaving only one course of action: get out and away from the zone as quickly as possible. The radiation control alarm allows some judgment in that a short time period can be taken for corrective action. A dual radiation alarm system utilizes both alarms, and two trip levels, making the two conditions distinguishable one from the other.

The Irradiation Processing Department's basic policy is to control exposure of each individual to less than 3 rem in 13 consecutive weeks, as stated in Radiation Control Standard 1.1. To reduce the possibility of a person exceeding this dose once the control alarm is actuated, the time of delay before evacuating is limited to 30 seconds. Since the maximum whole body dose rate to which an individual can be exposed without the emergency alarm sounding is 360 R/hr, the maximum dose he would receive in 30 seconds is 3 R. A person who might take corrective action must understand the cause of the high dose rate because he has only 30 seconds to make corrections. This does not mean he has to be out of the zone in 30 seconds, but he must not hesitate when leaving from the location and must be started by this time.

The control alarm can also serve as a working tool for controlling personnel exposure to radiation. The trip setting of the control alarm should be adjustable to maintain very close surveillance of personnel dose rates. Thereby, by proper setting of the control alarm at a point of initial concern, personnel can be set up to work with little, if any, additional surveillance. Where personnel are left to work in a zone on an established dose rate, the attendant control alarm trip should be adjusted as close to the background as practical by the person responsible for determining the dose rate. Any increase in the radiation dose rate will then alert those in the zone so they can retreat until new dose rates are established.

A number of unwarranted alarm trips will soon discourage proper reaction to any alarm system. To prevent this condition from developing: (1) the emergency alarm trips were established as high as it was felt to be safe and practical, and (2) reporting and recording of alarm trips are required to maintain adequate surveillance of the systems and to encourage immediate corrective action when necessary.

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SUBJECT

RADIATION ALARM

BASIS (cont'd.)

The audible signal for the radiation emergency alarm was developed as a Hanford plant-wide standard. Where it is installed, it must be loud enough to overcome any background noise. The fact that such a noise level will probably make conversation impossible was considered, but since evacuation is the only correct response, interference with verbal communication is of secondary importance.

There are several purposes in having a visual signal for the radiation control alarm. Communication is frequently very important where judgment, decision, teamwork, and quick corrective action may be administered. In this application the silent signal offers no interference. The contrast between it and the audible alarm is to avoid confusion in the response action being initiated. The flashing light, high beam intensity, and yellow color created by the required signal are to gain quick attention by those faced toward or away from the light source even in a well-lighted area.

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SUBJECT

DOSE RATE MONITORING

Basis

The various radiation control standards are established on the basis of dose rate instrument interpretations made in a specific manner.

The standard below describes the dose rate monitoring techniques and methods on which the standards are based.

Strict adherence to these rules by all monitoring personnel will help insure consistent application of Radiation Control Standards within the department.

Standard

1. All instrument interpretations and dose rate determinations shall be made in accordance with instructions contained in current procedures in Vol. II of this manual.
2. Contamination control bagging shall not exceed 10 mg/cm² in thickness over the beta-window portion of dose rate monitoring instruments.
3. Under no circumstances shall GM instrument readings be used to determine personnel dose rates.
4. The shielding afforded by goggles and masks may be routinely considered in establishing eye dose rates, provided that the eye is effectively shielded from beta radiation from all angles. The shielding afforded by gloves and boots may be routinely considered in establishing hand and foot dose rates. The shielding effects of clothing for other parts of the body shall be considered in establishing dose rates only upon the specific authorization of Radiation Monitoring Supervision in each case.
5. All ranges of dose rate monitoring instruments shall be checked for proper response and for off scale reading with the beta source before going on the job, and at least every 4 hours while in use.
6. A new instrument shall be obtained immediately if erratic or other unusual response is noted, or if for any reason the user has reason to doubt the accuracy of the instrument. If significant dose rates are involved, the work zone shall be evacuated until the new instrument is obtained.
7. Because of the very large and unknown correction factors involved when determining the surface dose rate of very small sources, direct contact with them shall be avoided whenever possible by utilizing remote handling methods. If any substantial dose is received from such a source, the source size shall be verified by autoradiographing as described in current radiation control procedures.

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SUBJECT

DOSE RATE MONITORING

Standard

8. Earphones or speakers shall be used with GM instruments when making personnel surveys.
9. GM instruments with glass detecting tubes shall not be used for personnel surveys unless the tube is shielded to prevent flying glass in case of breakage.
10. Occasionally new or modified radiological instruments are received with a request for evaluation under field conditions. Such instruments shall not be used for establishing dose rates unless the results are continuously verified by the use of an approved instrument.
11. No instruments shall be used for personnel dose rate monitoring within the Irradiation Processing Department except those that have been approved for use by Radiological Engineering.

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SUBJECT

DOSE RATE MONITORING

REFERENCE SECTION: Basis

The relationship between personnel exposure measurement and recording and dose rate monitoring needs to be understood. To do this, the Basis should be expanded to include: "Dose rate monitoring of beta-gamma radiation is performed to augment the measurement made by and recorded from the film of the beta-gamma badge worn by personnel. The results may be used to predict the badge results by determining the radiation dose rates which will be incident on the badge or they may supplement the badge by determining the relationship between badge dose rates and those to other portions of the body."

In clarifying the intent of this standard, the third paragraph of the Basis should be replaced with: "Where job conditions, including dose rates, have been established, it is sometimes necessary to continue monitoring for increase of the dose rates. Where it is possible to do this with a device which can be preset to annunciate at a prescribed radiation level, it should not be implied from this standard that a person qualified in radiation monitoring must be present, too."

REFERENCE SECTION. Standard

Part 3

If properly interpreted, the GM instrument can be used to measure personnel dose rates; therefore, this part should be removed from the Standard.

Part 4

HW-66771, "Beta Contribution to Lens of the Eye Doses in IPD," shows that shielding beta radiation from the eye is not as significant as originally considered. The first sentence of this part should be removed.

Part 7

Since this Standard originated, a full set of correction factors have been developed for dose rate instruments. The first sentence of this part should be removed.

Parts 8 and 9

These two parts are to be removed from this Standard, since they do not pertain to dose rate monitoring.

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MANUFACTURING SECTION

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SUBJECT

STANDARD ROUTINE SURVEY SCHEDULE

Standard

Surveillance of the radiation dose rates and contamination levels, adequate to maintain control of personnel exposure, radioactive contamination and environmental conditions within Radiation Control Standards, is required of the radiation monitoring service for each facility. The surveys required by this Standard are to be recorded on form BM-5300-51, "Routine and Repetitive Survey Record."

The minimum survey frequency required for various locations in IPD is:

A. Shiftwise during reactor outage and during the first eight hours after reactor startup the 105 building shall receive a beta-gamma survey at the following locations:

1. Eating locations
2. Corridors and hallways in use
3. Freight elevator
4. Pickup chute area
5. Protective clothing change rooms
6. Step-off pads in use
7. Used protective clothing hampers and carts
8. Tool and equipment storage locations in use
9. Rear face entry zones
10. Work area and C work platform

B. Following a reactor startup:

1. Where there has been a disturbed channel front, top or side of the reactor, a radiation survey is required prior to personnel entry.
2. Dose rates in front of the front face tubes when the reactor reaches 90 per cent of equilibrium power level shall be verified.

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STANDARD ROUTINE SURVEY SCHEDULE

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C. The facilities within the 105 exclusion areas plus 189-F and 108-B where radioactive materials are routinely used shall receive a beta-gamma radiation-contamination survey a minimum of:

1. Weekly Intervals (at least three times each month)

- a. Eating locations (lunchrooms, 105 gate house, offices, shops, control rooms, etc.)
- b. Contamination-free areas through which personnel traffic passes adjacent to radiation zones where there is a crosstraffic of contaminated equipment (hallways and corridors including their floor drains, stairwells, storage areas, monitor room, freight elevators, etc.)
- c. Radiation zone step-off pads
- d. Trash luggers
- e. All inside radiation zones where personnel enter on a predetermined dose rate and are not accompanied by a radiation monitor

2. Monthly Intervals (at least ten times each year)

- a. Other offices, shops, and laboratories which are not eating locations or radiation zones
- b. Contamination-free areas remote from contaminated radiation zones and all zones and areas which are only infrequently trafficked (metal storage, roofs, air conditioning rooms, R.F. viewers, outside radiation zones)
- c. Clean protective clothing storage

3. As Necessary

Those radiation zones into which the personnel entries are monitored by a radiation monitor do not require a routine survey, but shall receive a radiation-contamination survey when entered.

4. Quarterly

All other locations within the 105 exclusion area not specified above.

D.¹ Neutron Allowance Surveys

1. Annually the neutron dose rates in the neutron allowance zones shall be measured and recorded. (Ref. RCS 1.7)

¹ Section D. changed.

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2. Monthly the neutron dose rate shall be confirmed and recorded at least once during each badge period. (Ref. RCS 1.7)
3. Where no personnel entry is made into a neutron zone during the month, this may be noted on the neutron check record and a survey bypassed.
- E. All areas and facilities within the plant limited area* except those in A. above, and all facilities outside the plant limited areas which are under the management control of IPD shall be surveyed for radiation and contamination with a scheduled frequency as follows:
 1. Monthly
 - a. 190 tunnels to 105
 - b. 1701 main gate house
 - c. All shops and garages
 - d. All buildings where radiation zones are located (i.e., 108-D, 189-D, etc.)
 - e. First Aid
 - f. All permanent radiation zones (burial ground, 107 zones, etc.)
 - g. Trash burning pits
 2. Quarterly
 - a. All process buildings not covered above (181, 182, 190, 151, etc.)
 - b. All buildings used primarily for offices
 - c. All other buildings and facilities
 - d. Railroad beds within 100 feet of stop points for trains (gates and switches); part of the locations to be surveyed each quarter but to include all locations within the plant limited area* each year
 - e. A 100 square foot section of open ground outside the 105 exclusion area within one quadrant of the plant limited area*. All four quadrants to be surveyed annually.

* Plant limited area refers to the original boundaries which existed up through 1959.

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STANDARD ROUTINE SURVEY SCHEDULE

Basis

Routine radiation and contamination surveys of all facilities and locations within the IPD plant areas are made by radiation monitoring to insure that contamination, or significant radiation fields do not exist outside radiation zones and that inside they remain within pre-established, reasonable levels. Surveys should be made often enough that the status of each location is known at all times with reasonable certainty.

Two goals of the radiation protection program are to prevent the spread of radioactive contamination and to allow only planned radiation exposure to personnel. Contamination can be spread from contaminated locations to clean locations in any of several ways; leakage during the transport of radioactive material, by the wind, by insufficient dispersal of wastes from the reactor stacks, or by an individual on his shoes or clothing. Increases in radiation dose rates, both inside and outside radiation zones, can be created by reduction or repositioning shielding and by relocation of sources, which without adequate forethought or follow-up measurements are not always predictable or recognized.

The neutron allowance surveys perform a dual function serving as a basis for both exposure control and measurement. The beta and gamma dose rate records serve only the exposure control function.

The frequency with which it is necessary to survey a particular location is dependent upon:

1. Probability of contamination spread to the location
2. Probability of personnel contamination resulting
3. Probability of internal deposition resulting
4. Probability of significant dose rates
5. Probability of uncontrolled personnel exposures resulting

To give uniformity to the Routine and Repetitive Survey Program throughout the reactor facilities, the minimum schedule and the record form are established by this Standard. Another goal of the monitoring program is to make it possible for each person trained in monitoring to be able to perform his duties with equal dispatch at each of the reactors. To this end the procedure for handling the routine survey program should be as nearly alike at all reactors as possible.

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SUBJECT

RADIATION MONITORING RECORDS

A. RECORD FORMS

1. Radiation monitoring records shall be accumulated on forms approved by Radiological Engineering.
2. The approved forms will be issued through the Forms Control Unit acting for the Department.
3. A current list of approved forms will be maintained as a supplement to this Standard.

B. REQUIRED RECORDS

1. Surveys of gamma, beta, and neutron dose rates and activities describing sources of radiation and radioactive contamination exposing people and describing the radiological status of the environs of the plant grounds, buildings, and equipment.
2. Shipments of radioactive material and radioactively contaminated equipment.
3. Air sample evaluations of airborne radioactive contaminants.
4. Neutron doses accumulated by employees.
5. Fixed radiation monitoring chamber measurements.
 - a. Radiation emergency alarms
 - b. Effluent water and air monitors
 - c. Air sample monitors
6. Operational and performance tests of fixed radiation dose rate monitoring and detection equipment.
7. Radiation Occurrences and Incidents.

C. RECORD RETENTION

1. Permanent Records shall be sent to Records Center in accordance with an approved Records Flow Schedule. These records may be maintained as an office record for 6 to 12 months.
2. Current Use Records should be discarded after a reasonable period as established by procedure.

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New

RECORD FORMS - PERMANENT RETENTIONTitleForm Number

Beta-Gamma Air Sample Log	A-5300-035 (8-59)
Building Survey	BM-5900-036 (8-64)
(Back Side)	BM-5900-037 (4-64)
Chart Records (Standard for the recorder model used and divided appropriately to scale of measuring instrument)	
Hand-Shoe Counter	BD-5300-046 (3-59)
Lab Counter Performance	BD-5300-115 (4-64)
Neutron Exposure Register	BD-5300-111 (2-64)
Neutron Exposure Report	BD-7800-150 (2-64)
Pencil Dosimeter Performance	BD-5300-118 (7-64)
Pulse Reader Performance	BD-5300-119 (7-64)
Radiation Occurrence Report	BM-5300-026 (5-64)
Radiation Survey Report	BD-5500-004 (10-58)
Radiation Work Procedure	BM-5900-010 (1-63)
Radioactive Shipment Record	54-3000-219
Report of Contaminated Personal Effects	54-3000-343 (5-60)
Routine and Repetitive Survey Record	BM-5300-051 (4-64)
(Back Side)	BM-5300-052 (4-64)
Routine Neutron Survey	BD-5300-112 (4-64)
Routine Startup Survey	BD-5300-114 (6-64)
Skin Decontamination Record	BD-5900-047 (11-59)
Standard Radioactive Shipment Procedure	BM-5600-011 (10-59)
Supplemental Routine Survey	BD-5300-116 (6-64)

For Fuels Production Section, the authorized forms are those in current use by Radiation Monitoring, RPO, HL.

RECORD FORMS - CURRENT USETitleForm Number

Detail Survey of Rear Face	BD-5800-065 (2-62)
Gamma Pencil Register	54-5300-082 (11-62)
Hand Counter Failure Notice	54-5800-060 (9-60)
Pocket Radiation Exposure Estimate	54-3000-333 (12-62)
Portable Instrument Check and Inventory	BD-5300-117 (4-64)
Radiation Exposure Estimate	54-5300-073 (12-62)
Radiation Occurrence	A-5300-053 (5-64)
Radiation Release	54-3000-022 (5-57)
Report of Contaminated Personal Effects	54-3000-343 (5-60)
Shift Routine Guide (Daily - Weekly)	BM-5900-038 (4-64)
Shift Routine Guide (Monthly - Quarterly)	BD-5300-113 (4-64)

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SUBJECT

RADIATION OCCURRENCE REPORTS

Basis

An important part of any radiation protection program is maintaining good records of radiation work experience. It is important that rather complete records of the exposure of personnel to radiation and contamination be kept, especially those occurrences which might be of future interest or which might be the basis of future legal action. Such records can point out conditions needing improvement, and from these records a measure of the radiation performance of the Irradiation Processing Department can be obtained. Radiation Occurrence Reports are a part of the permanent record of Irradiation Processing Department radiation experience.

Standard

One copy of each Radiation Occurrence Report (Form BD-5900-001) shall be forwarded to the Supervisor, Radiological Engineering, who shall maintain a central file of these reports. These Radiation Occurrence Reports shall become a part of the permanent radiation records. Each Radiation Monitor, Radiation Analyst, Reactor Specialist, or supervisor responsible for radiation monitoring shall initiate a Radiation Occurrence Report on any occurrence which may come to his attention. The supervisor responsible for radiation monitoring should review and investigate the occurrence, as appropriate, before forwarding it to Radiological Engineering. The following are types of occurrences which shall be reported:

External Exposure

1. Uncontrolled personnel exposure from external sources.
2. Uncontrolled personnel exposure from contamination on protective clothing.
3. Uncontrolled dose rates existing inside or outside of a Radiation Zone.
4. Exposure of personnel to dose rates greater than 3 rem/hr whole body penetrating, or equivalent exposure to the eyes, whole body skin, or the extremities (see RCS #1.1).

Personnel Contamination Control

5. Skin contamination.
6. Any contaminated injury.
7. Any significant personnel exposure to contaminated air without adequate protection. Any case of positive nasal surveys.
8. Personal clothing contamination.

Surface Contamination Control

9. Any contamination transported outside of plant perimeter.
10. Spread of contamination outside Radiation Zones.
11. Spread of contamination in the immediate work area beyond that which was planned for or might normally be expected.

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RADIATION OCCURRENCE REPORTS

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12. Any fire or explosion occurring in a Radiation Zone.

Administrative Control

13. Employee working in a Radiation Zone without adequate timekeeping.
14. Employee working in a Radiation Zone without required or adequate monitoring.
15. Employee working in a Radiation Zone without wearing required or adequate protective clothing and equipment.
16. Employee working in a Radiation Zone in violation of RWP or SWP.
17. Employee working in a Radiation Zone without personnel meters.
18. Any case of lost personnel meters or loss of personnel meter readings.

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DATE ISSUED

10-1-63

RCCA ISSUE DATE

9-17-64

RCCA EXPIRES

12-31-64

SUBJECT

RADIATION OCCURRENCES AND INCIDENTS

REFERENCE SECTION: III. Radiation Occurrence Reports

Part A

This form number has been changed and should read "BM-5300-026."

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RESEARCH AND ENGINEERING SECTION

ACCEPTED

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MANUFACTURING SECTION

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PRODUCTION FUELS SECTION

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SUBJECT

RADIOLOGICAL COMMUNICATIONS

Basis

In many types of radiation occurrences, action may be required by groups other than the plant operation involved, to assess the effects of the occurrence upon personnel and upon the environment, and to inform management, the AEC and the public of the significance of the occurrence. In cases involving possible deposition of radioactive material, possible overexposure to external radiation, or medical treatment, the Exposure Evaluator, Radiation Protection Operation, HLO, must be notified in order that any necessary bioassay samples, dosimeter evaluations, or assistance to Industrial Medical may be promptly provided. In cases where facilities or land areas outside the plant area involved may be affected, it is essential that regional monitoring, and other plant operations be notified promptly. In cases where fires, explosions or spills are involved, or where a group of people are involved, higher management, the AEC, plant employees, and the public may need to be informed. The preparation and dissemination of such information is the responsibility of the Radiation Protection Operation, HLO; therefore, prompt and accurate communication with the RPO is required.

Information as to employees' radiation exposure history is considered to be strictly private, and is controlled in a similar manner to medical information. That is, concerned company personnel and the individual are entitled to the information, but the record is made available to other persons only with the written authorization of the individual involved. The discussion with an individual of his radiation exposure is the joint responsibility of management and the Industrial Medical Operation. Normally this discussion is undertaken by the immediate supervisor; an industrial physician will also be present.

Since Radiological Engineering, Research and Engineering Operation is responsible for representing IPD in radiological liaison with the Hanford Laboratories Operation, all communications regarding radiological matters should normally be made through Radiological Engineering. However, requests for non-routine processing of personnel meters or for non-routine bioassay samples, may be made directly of the Exposure Evaluator by supervision responsible for radiation protection.

This standard describes the flow of radiological information from individuals and IPD Supervision to other groups outside IPD who are concerned with radiation matters, and the method of transmittal of information regarding an individual's radiation status from the Radiation Protection Operation to the individual involved.

Standard

- A. Each employee is responsible for promptly notifying supervision responsible for radiation protection, of any situation involving a potential or existing loss of

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control over personnel exposures or radioactive contamination, which may come to his attention. Situations to be reported include those where:

1. Personnel receive a radiation dose in excess of that planned.
2. Personnel receive a radiation dose, the magnitude of which is unknown.
3. Skin or personal clothing contamination occurs.
4. Personnel may have ingested or inhaled radioactive material.
5. An injury occurs in a radiation zone.
6. Contamination is spread outside a radiation zone.
7. An emergency such as a fire, explosion, accident or spill occurs, which involves radiation or radioactive materials.
8. A group of people are involved in a radiation occurrence, whoever they may be, and whether they receive a significant exposure or not.
9. An individual not an employee of HAPO-GE or HOO-AEC is involved in a radiation occurrence.

B. Supervision responsible for radiation protection shall report the following types of occurrences immediately, (within one hour) by phone, to a representative of Radiological Engineering, using the call list attached to this standard:

1. Any evidence of contamination which may extend beyond the plant limited area.
2. Any case where exposure believed to be in excess of 1 rem ("whole-body" - penetrating) is received.
3. Any case of ingestion, inhalation or penetration to the blood stream of radioactive materials which could contribute in excess of 10% of the MFJ for the isotopes involved.
4. Any radiation occurrence which involves personnel other than HAPO General Electric Company employees, HOO-AEC or HAPO-GE Contractor personnel, or HOO-AEC employees.

C. Supervision responsible for radiation protection shall report the following types of occurrences to Radiological Engineering (2-5343, 2-5488) promptly if occurring on day shift (weekends and holidays excluded), or at the start of the next working day otherwise.

1. Any case of skin contamination other than noble gases such that the product:

$$\left[\begin{array}{l} \text{true surface dose rate to} \\ \text{the skin in rads/hr} \end{array} \right] \times \left[\begin{array}{l} \text{area of the contamination in cm}^2 \\ \text{(minimum area to be used = 1 cm}^2 \text{)} \end{array} \right] \text{ is greater than } 10$$

For example:

> 10 rad/hr skin dose rate	1 cm ² area
> 5 rad/hr skin dose rate	2 cm ² area
> 1 rad/hr skin dose rate	10 cm ² area, etc.

These cases are of interest because of the possibility of radioactive materials being absorbed through the skin. The amount of material absorbed is a function of the isotope involved and its chemical form, the medium in which it is carried,

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the level of contamination, the area involved, and the time during which the contamination is in contact with the skin. A complete evaluation of the possibility of absorption of contamination through the skin is quite complex, and is made when necessary, by the Exposure Evaluator, RPO, HLO. This equation will insure, however, that all cases where absorption of significant amounts of contamination is possible, will be reported.

Since noble gases are of relatively minor biological significance, contamination known to be noble gases is not a significant absorption hazard. Such cases are not included in this requirement (See Radiation Control Standard #2.4 "Respiratory Protection - Gas Activity").

2. Any case of a contaminated injury.
3. Any case where evidence of ingestion or inhalation of radioactive material (except noble gases) is found (positive nasal or sputum smears, contaminated nostrils, etc.).
4. Any case where personnel are exposed to airborne particulate materials in concentrations greater than permissible for the respiratory protection worn, such that the product

$$\left[\begin{array}{l} \text{factor by which concentration} \\ \text{exceeds the MPC} \end{array} \right] \times \left[\begin{array}{l} \text{hours exposed} \end{array} \right] \text{ is greater than } 10$$
5. Any case where medical treatment or examination is required because of radiation or contamination.
6. Any case of contamination spread beyond normal limits but within a plant area, resulting in significant external dose rates or significant levels of airborne contamination (except noble gases).
7. Emergencies such as fires, explosions, accidents in shipment, etc., which involve radiation or radioactive materials.
8. Unusual radiological situations or occurrences which involve 5 or more people.
9. Any case where exposure believed to be in excess of the normal working limits is received.

D. When reporting the occurrences listed in B and C above to Radiological Engineering, the following information should be supplied if it is available:

1. Name of reporter, time and date of the occurrence.
2. Location of the occurrence.
3. Type of occurrence (fire, blowback, injury, inhalation).
4. Names, payroll numbers, and verified home addresses of personnel involved, if pertinent.
5. Description of the occurrence

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D. (continued)

6. Estimate of external exposure
7. Estimate of internal exposure potential. (Isotopes involved, medium in which carried, and solubility if known).
8. Results of special studies (smears, surveys, films, air samples).
9. Initial action taken.

E. Radiological Communications with the employee.

1. Each supervisor is responsible for advising personnel under his supervision of the potential for exposure to radiation during the performance of work within the plant areas. In addition, prior to the employee's assignment to radiation work, the supervisor shall inform him concerning current radiological procedures and practices, in sufficient detail to allow him to perform his work safely.
2. An employee shall be promptly advised of his exposure status in the event of a probable exposure which would affect continued occupational exposure to radiation.
3. An employee shall be advised of his exposure status when he has received or may have received a significant exposure which requires that he be temporarily removed from radiation work.
4. Whenever an employee is exposed in a known radiation incident, he will normally be asked to help in investigating the circumstances of both the incident and his possible exposure. After this investigation, the employee shall be informed of his exposure evaluation.
5. The exposure of employees to radiation is systematically measured and evaluated by the Radiation Protection Operation, HLO. The results of these measurements and evaluations, the primary radiological records, shall be available to concerned company personnel and to the employee involved, but shall be made available to other parties only with the written authorization of the employee involved.
6. An employee shall be advised of his exposure status in all cases upon his request. Such requests shall be directed to Radiological Engineering, Research and Engineering Operation, by the supervisor.

- F. The Radiation Protection Operation, HLO, is responsible for the formal evaluation of exposures of personnel to ionizing radiation of HAPO origin. For this reason, information as to the significance, severity, or extent of radiological occurrences shall be released to HAPO Management, the AEC, or the public only by the Radiation Protection Operation, HLO.

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CALL LIST - RADIOLOGICAL COMMUNICATIONS

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Manufacturing, Radiation MonitoringSupervisors

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
L. M. Mitchell (B-C)	2-4348 or 2-4381	944-8288
R. A. Winship (D-DR)	2-5308	547-7667
W. G. Westover (F-H)	2-5764 or 2-5877	264-2891 (Benton City)
R. E. Slater (KE-KW)	2-4342	946-6226

Radiation Control Engineers

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
L. R. Wallis	2-5360	945-7783
J. H. Soehnlein	2-5130	943-1744
R. H. Smith	2-5130	264-2471 (Benton City)

Radiological Engineering, Research and Engineering

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
P. C. Jerman	2-5488	944-8977
F. E. Owen	2-5525	946-6305
M. L. Smith	2-5871	582-8434
W. N. Koop	2-5743	943-1327

Exposure Evaluation, Radiation Protection Operation, HL

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
K. R. Heid	3625 (Emer. 3589)	967-2186
J. M. Selby	3365	582-2459
C. E. Newton	3341	945-3013
I. C. Nelson	3664	943-3747

When notification of Industrial Medical is required, call in the following order:

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
1. First Aid - 100-B	2-4403	
100-D	2-5503	
100-F	2-5603	
100-H	2-5403	
100-K	2-4503	
2. 200-W First Aid	2-7703	
3. P. A. Fuqua	6-4414	944-5180

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NOTE: When technical assistance in radiological matters is required, the desired order of contact, to reach someone who can be helpful, is as follows:

1. The Radiation Monitoring Supervisor for the reactor
2. A Radiation Control Engineer, Manufacturing Section
3. A Radiological Engineer, Research and Engineering Section

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CONTROL OF PERSONNEL EXPOSURE TO RADIATION

GENERAL

Radiation Control Standard 1.1 presents two sets of external exposure limits. The first set, the "Basic HAPO Exposure Standards" are the limits which reflect the current recommendations of the NCRP and other groups of responsible experts in radiation protection for personnel occupationally exposed to radiation. These limits are not intended to represent the dose above which detectable injury would result; rather, they are the recommended method for distributing personnel exposure such that the average dose per year remains within 5 rem. Nevertheless, these recommendations are accepted as operating standards at HAPO, and we are determined to stay within them in each individual case.

To assure that no person inadvertently exceeds the Basic Exposure Standards limits, a second set of limits, the "Operational Controls" are presented. They are intended to be applied in just that way: as control devices. Even though it is true that exceeding an operational control does not in itself constitute a violation of the basic standards which is the ultimate test of our ability to control personnel external exposure, sincere effort should be made by each individual, his supervision and management of the operating groups to assure that these controls are not inadvertently exceeded.

In some special cases, it may be reasonable to exceed these control limits. This is tolerable provided alternate controls of some kind are imposed so that we still have assurance that the Basic Exposure Standards will be met. Radiation Control Standard 1.1 therefore requires that any plans for exposure of personnel in excess of the operational control limits must be cleared through Radiological Engineering. The standard further requires the documentation of any cases where operational controls are exceeded, whether planned or inadvertent, for record purposes.

Operational Controls are of two types: long term or calendar year controls, and short term or four week badge period controls.

CALENDAR YEAR EXPOSURE CONTROL

The calendar year control of personnel external exposure can be achieved through watching the accumulation of dose as measured by the badge. The calendar year operational controls are as follows:

1. The whole body penetrating dose should not be permitted to exceed 1 rem in any regular four week badge period, or 5 rem including 3 r in any calendar year.
2. The whole body skin dose should not be permitted to exceed 2 rem in any regular four week badge period, or 10 rem in any calendar year.
3. The extremity dose should not be permitted to exceed 8 rem in any regular four week badge period, or 40 rem in any calendar year.

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With only very rare exceptions in IPD, whole body gamma exposure (3 r in a calendar year) is the limiting consideration. Therefore, satisfactory control over all calendar year exposures can be achieved with active control of whole body gamma, and passive control over the other limits. Active control over another type of exposure would only be required if exposure totals indicated that another limit would be exceeded first by a specific individual.

After each badge pull, a "Detail Suffix Exposure Report" is issued by RPO, HLO. Radiological Engineering and the Radiation Analysts receive copies, usually on the second Monday following a badge pull. This report lists all personnel who receive significant exposure during their work, together with accumulated exposure totals. On the basis of this information, Radiological Engineering prepares an "IPD Radiation Exposure Status" report which contains the above information. The report is duplicated, and issued in time to be received by all interested components by the following Friday (which is two weeks after the badge pull). This report is widely distributed throughout IPD, and is the basis for our calendar year controls. It provides supervision with a basis for judging what action is necessary to keep their personnel within annual limits. In addition, a summary report is issued which relates the average accumulated dose of the critical work groups, the average dose of the work groups extrapolated to the end of the year, and other information useful in exposure control.

In calendar year exposure control:

Radiological Engineering is responsible for providing accumulated gamma dose measurement information to responsible supervision on a timely basis.

Supervision is responsible for assuring that each individual's accumulated gamma dose as measured by the badges does not exceed 3 r in a calendar year.

SHORT TERM (FOUR WEEK) EXPOSURE CONTROL

The Radiation Exposure Estimate based on radiation monitoring's dose rate determinations and on timekeepers data, is the most immediate indicator of the radiation status of an individual, and is of prime importance in maintaining control over exposures on a short term basis. The beta-gamma film badge results constitute the official record of exposure actually received by the wearer, but since it is an after-the-fact measurement device is of no value for short term control. Each radiation worker together with his supervision must be held responsible for keeping his radiation exposure within these limits.

The short term control limits are as follows:

Whole body penetrating	(δ/n)	1 rem/4 week badge period
Whole body skin	($\delta/\beta+n$)	2 rem/4 week badge period
Extremity	($\delta/\beta+n$)	8 rem/4 week badge period

Each of these limits must be met in each badge period. A separate account of each individual's status relative to each of these limits would be prohibitively confusing

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and unwieldy in practice. To avoid this confusion, radiation monitors interpret the dose rate considering the relative amounts of penetrating and non-penetrating radiations, the parts of the body receiving these dosages, and the various limits, and arrive at a dose rate figure which is used for control purposes which may or may not reflect the maximum dose rate to which a part of the body is exposed. This figure does indicate that if work is continued (under the same radiological conditions, using the same dose rate figure) until the man has received 1000 units, the most limiting of the three limits will have been reached. If this figure is kept within 1000 units, there is reasonable assurance that a control limit will not be inadvertently exceeded.

In short term exposure control:

Supervision is responsible for regulating the radiation exposures received by their people to keep them less than 1000 units in each four week period by,

1. Establishing for their people the allowable dose for each job, prior to the start of the job.
2. Approving any radiation exposure to be received by their men while they are "on loan" and working under other supervision.
3. Giving due consideration to the exposure status of individuals within a work group in assigning work involving radiation exposure.

Each individual performing radiation work is responsible for:

1. Maintaining his exposure estimate card up to date and complete. This includes name, payroll number and suffix at the head of the card, and entry of date, RWP or SWP number, building number, work site, total estimated exposure, and estimated neutron exposure for each radiation zone job performed.
2. Limiting his exposure total to less than 1000 units in each four week period.
3. Informing timekeepers of the dose he has been authorized by his supervision to receive at the start of the job.
4. Keeping his supervision informed as to his exposure status.

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CONDUCT IN RADIATION ZONES

Entering the Radiation Zone

The correct sequence to be followed by personnel entering a Radiation Zone is as follows:

1. Determine the maximum dose which you will be allowed on this job. Do not take a dose greater than 50 mrem without the knowledge and concurrence of your supervision.
2. Determine whether a RWP is valid for the work you are to perform, or for the zone you want to enter.
3. Check the RWP to see that your group is authorized to use the RWP; if not, the RWP is not valid for you, and an SWP will be required.

RWP Valid

SWP Valid

4. Read the RWP to determine whether the work to be performed is authorized by the procedure. In case of doubt, contact Processing supervision.5. Read the RWP to determine the protective equipment and monitoring requirements. Note any special instructions.6. Obtain the dose rate from the RWP. If none is given, contact a radiation monitor.7. Determine the need for a timekeeper. If the dose rate is expected to be greater than 50 mrem/hr, a timekeeper may be assigned; if 50 mrem/hr or less, you will probably keep your own time.8. Change to the prescribed protective clothing, removing items of personal equipment and jewelry which are not allowed in contaminated areas. Be sure that all items of protective clothing are in good condition, that proper fit is attained and that proper closures are made. The coveralls should not be so long as to touch the floor, nor so short as to leave a gap between the coveralls and the rubber.9. Check to be sure that you have and are wearing the prescribed dosimeters. A beta-gamma film badge is always required. In addition, pencils or other dosimeters may be required.	4. Notify the operating group who will prepare an SWP for the specific job to be done.5. After the SWP has been completed and necessary approvals obtained, read it to determine the protective equipment and monitoring requirements. Note any special instructions.6. Obtain the dose rate from the SWP. If none is given, monitoring assistance will be provided.

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10. Notify the timekeeper of your planned dose, note the time of entry, and enter the zone.

While in the Zone

Each individual who performs radiation work is responsible to see that he receives the full benefit of the protective system by complying with the provisions of the SWP or RWP.

If, during the course of the work, you feel that work progress or conditions are about to deviate or have deviated from that outlined by the RWP or SWP, and may lead to abnormal radiation conditions, leave the area immediately, and notify your supervisor, and supervision of the operating group.

Always utilize the method of accomplishing the work which will result in the least radiation exposure to you, and a minimum of contamination spread.

Avoid local "hot spots" and beams. If the job is temporarily delayed, wait in a low dose rate portion of the zone.

During the course of radiation work which involves withdrawing, uncovering, opening, valving, disassembling or changing things, be sure that Process supervision has been informed of your intentions before the fact so that a radiation monitor may be present to evaluate the radiological consequences.

In zones where high levels of contamination are present, the monitor should make frequent clothing surveys to insure that contamination on the clothing is kept low enough that it does not significantly affect your dose rate. You should always conduct yourself so as to minimize the possibility of smearing contamination on the protective clothing. Do not sit down in a contaminated area unless the surface has been surveyed; assume that all surfaces and objects are contaminated. Do not remove protective clothing while in the zone unless instructed to do so by a radiation monitor. If a mask is required in the zone, do not handle the mask with contaminated gloves, and do not remove it while in the zone.

Leaving the Radiation Zone

Leave the Radiation Zone as quickly as possible, consistent with safety, for any of the following reasons:

1. You are instructed or signalled to do so by a radiation monitor.
2. When your dose received is equal to your planned dose.
3. Failure of any part of your protective equipment.
4. Conditions exist within the zone which are not covered by the SWP or RWP; work to be performed is outside the intent of the SWP or RWP.

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5. Your exposure status becomes uncertain for any reason.
6. Evacuation - practice or actual.
7. Injury.
8. Completion of work.

The normal procedure for leaving the zone is as follows:

1. Contact a radiation monitor if a personnel check is required.
2. Remove the protective clothing at the Radiation Zone change station, taking care not to contaminate the skin or personal clothing in the process. A satisfactory method for accomplishing this is presented in Procedure #1.4 - Radiological Protective Clothing.
3. Remain at the step-off pad if a personal survey is required.
4. Check hands and shoes before eating or leaving the area.
5. Enter the exposure received on the Exposure Estimate Card.

In case of injury, surveys, step-off pad procedures and efforts to prevent contamination spread should be performed only to the extent that medical treatment is not delayed.

In case of an evacuation other than a practice evacuation, leave the Radiation Zone as rapidly as possible observing the normal clothing removal procedures. Personnel in zones of high level contamination should remove all protective clothing except the last pair of coveralls. Hand and shoe checks and required personal surveys should be omitted. At the first opportunity after the "all clear," the contamination checks and exposure record entries should be made.

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DETERMINATION OF PERSONNEL DOSE RATES

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Personnel dosimeters are the primary method of personnel exposure measurement at HAPO. These dosimeter results also provide the basis for long term (calendar year) exposure control. They do not, however, provide short term exposure control, that is, control within the four week badge period. Therefore, personnel exposure estimates obtained by means of dose rate monitoring and timekeeping are used to assure that personnel exposure are kept within the short term limits.

These short term limits are presented in Radiation Control Standard 1.1, and are as follows:

Whole body penetrating	1 rem/4 week badge period
Whole body skin	2 rem/4 week badge period
Extremity	8 rem/4 week badge period

In order to estimate personnel dose rates, the dose rate from neutrons, gamma and beta must all be known. Neutrons will be involved only in areas adjacent to or above the reactor, and then only during reactor operation.

Dose rates to personnel are established by the following formulas. In any situation, the formula producing the highest dose rate is controlling.

1. Whole body penetrating dose rate: $(\gamma_{WB} \text{ dose rate} / n_{WB} \text{ dose rate})$
2. Effective whole body skin $(\gamma_{WB} \text{ dose rate} / n_{WB} \text{ dose rate} / \beta_{WB} \text{ dose rate})$
(or derma) dose rate: $\frac{2}{2}$
3. Effective extremity dose rate: $(\gamma_E \text{ dose rate} / n_E \text{ dose rate} / \beta_E \text{ dose rate})$
 $\frac{8}{8}$

In order for the effective extremity dose rate to be limiting, the total dose rate to the extremities must be over 8 times the total whole body penetrating dose rate. The shielding effectiveness of gloves should be considered in determining dose rates to the hands and arms. "Fly Swatters," fitted with samples of various glove materials are useful for this purpose. In making the determination, the appropriate shielding material is held between the chamber window and the source.

In order for the derma dose rate to be limiting, the (β) dose rate must be greater than the (γ / n) dose rate.

For most work in IPD, the whole body penetrating dose rate will limit and will normally provide a satisfactory basis for short term exposure control. Should the derma dose rate be found to be the limiting factor, consideration should be given to decontamination or shielding the beta. Should the extremity dose rate be found to be limiting, consideration should be given to the use of tongs or other remote handling methods, decontamination, or shielding.

On given jobs, assuming no actual change in conditions, it is highly desirable that dose rates determined by different monitors be consistent as well as accurate. Differences in dose rate estimates set by different monitors under these conditions indicate inaccurate monitoring methods or equipment, and in some cases inconsistent application of established methods. Such instances give rise to dissatisfaction on the part of personnel monitored concerning the quality of protection furnished them.

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DOSE RATE

Neutron dose rates are measured with the BF_3 and double moderator. There are two HAPO-approved BF_3 instruments, the BFP and the BFQ.

- A. 1. The neutron dose rate is measured with the BF_3 tube inside the assembled double moderator (dosimeter) from the fast scale.
 - 2. Fast neutrons only may be measured the same way if the double moderator is covered with cadmium.
- B. 1. The slow neutron dose rate is measured with the bare BF_3 tube exposed from the slow scale.
 - 2. Fast neutrons may be determined by the difference between the neutron dose rate and the slow neutron dose rate.
- C. 1. The ratio of double/single moderator rates determines the combined neutron spectrum average energy.
 - 2. The single moderator rate is measured with the BF_3 tube inside the inner moderator (fluxmeter) from the fast scale.
- D. Gamma dose rates, which are taken as an index of neutron dose rates, are to be measured with the CP or other HAPO-approved gamma dose rate instruments only.

SURVEY

- A. A complete evaluation survey requires determination of four primary rates:
 - 1. Neutron dose rate
 - 2. Slow neutron dose rate
 - 3. Single moderator rate
 - 4. Gamma dose rate

Each of these rates has to be determined at the same point in space.

- B. A neutron check requires determination of only one primary rate, the neutron dose rate.
- C. 1. A complete zone survey includes a check of the neutrons throughout the occupiable space with a complete evaluation at the point of maximum total neutron dose rate and at a representative reference point.
 - 2. A representative reference point is established in the best judgment of the person performing the survey. As a guide it should be:

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- a. at or above the average neutron dose rate for the zone.
- b. easily identified so that repeat measurements can be made in the future.
- c. centrally located in front of the neutron source area.

D. A monthly neutron check survey includes a scan of the occupiable area with an assembled moderator and BF₃, plus neutron check at the reference point or points designated by the Radiation Monitoring Supervisor.

NEUTRON ALLOWANCE ZONE

- A. Any zone where the neutron dose rate exceeds 1 mrem/hr occupied by people is a neutron allowance zone.
- B. The average neutron dose rate for a neutron allowance zone should represent as closely as possible the average work condition dose rate, but it should be above the average of the maximum and minimum rates for the zone.
- C. The spread for an average neutron dose rate for a neutron allowance zone is not to exceed 15 mrem/hr from minimum to maximum at rates less than 75 mrem/hr. Above 75 mrem/hr the spread should not exceed 25 mrem/hr.
- D. To depict the boundaries of each neutron allowance zone, maximum and minimum dose rate "contours" of the location are to be mapped. The zone within a location should be readily identifiable by all personnel concerned from the map.
- E. Surveillance of each neutron allowance zone requires:
 1. A complete zone survey annually with the reactor power level above 90 per cent of maximum. (Normally the best time to accomplish this is when the river temperature is at a minimum, about the end of January or the beginning of February.)
 2. A neutron check survey monthly within each HAPO badge period. This should include a scan of the zone neutron dose rates and the specific neutron dose rate at the reference point.
 3. Whenever the neutron shielding of the reactor is disturbed, the location and its neutron allowance zones are to be checked with a neutron check survey. This should be done prior to personnel entry to the location.
 4. Whenever a neutron dose rate at the reference check point deviates more than 20 per cent from the original zone survey, the zone rates are to be re-established by a new complete zone survey.
- F. Most neutron allowance zones lend themselves to routine surveys. For those that are infrequently occupied, a survey is only necessary at the time of a personnel entry. Where the exposure time is short, a neutron check survey of the zone is adequate. A complete zone survey is appropriate when an appreciable amount of neutron exposure will be incurred by a number of people.

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DOSE RATE RECORDS

All surveys made to establish neutron dose rates need to be recorded and the records retained permanently.

- A. These surveys are normally recorded in the Routine and Repetitive Survey Record. The recorded contour maps of zones are also prepared on the same R&R Survey Record form.
- B. Where a location is so infrequently occupied that no routine surveys are made, the neutron survey made at the time of entry can be recorded on a Radiation Survey Report.
- C. The gamma dose rate should be recorded with each neutron dose rate to assist in determining gamma ratios.
- D. Where a complete evaluation has been made, all four primary rates need to be recorded as primary data.

PERSONNEL DOSE EVALUATION

- A. The neutron dose is calculated for each neutron allowance zone by multiplying the time in the zone by the average neutron dose rate for the zone.
- B. When there is some doubt of the average dose rate because of work back and forth across two or more zones, a conservative estimate should be based on the higher zone rate.
- C.
 1. Each person is to calculate his own dose. He can obtain the necessary assistance in making the calculation from radiation monitoring.
 2.
 - a. Each person is accountable for his own time of exposure. He may utilize the assistance of a timekeeper in determining it.
 - b. Exposure timing should be to the nearest tenth of an hour (six minutes).
 3. Each person is accountable for knowing his own dose rate as provided from the radiation monitoring survey record.

PERSONNEL DOSE RECORD

- A. Each person with the aid of radiation monitoring is to record his neutron dose each day he wears a neutron badge.
 1. The total dose is recorded when the neutron badge is returned to the storage rack for the day.
 2. Record the dose in whole numbers. A dose of less than one is to be recorded as zero.

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ATTACH

NEUTRON MEASUREMENTS AND RECORDS

3. Radiation monitoring reviews the accuracy of each recorded exposure.
- B. The reactor's Neutron Exposure Register contains:
1. Reactor identification number
 2. Day, month, year of the badge period
 3. Date of each day for the period
 4. Neutron badge number
 5. Name
 6. Payroll number
 7. Neutron dose by date
- C. Dose Record
1. At the end of each badge period, total the dose for each individual and transcribe it with his name, badge, and payroll number to the Neutron Exposure Report.
 2. The Neutron Exposure Report is reviewed for accuracy and signed by the facility's Radiation Monitoring Supervisor.
 3. The Neutron Exposure Report is sent with the neutron badges for the period to External Dosimetry, RPO, HL, 3705 Bldg., within one week.
- D. The reactor's Neutron Exposure Register is retained as a permanent record, which should include 6-12 months retention in the reactor office files.

NEUTRON BADGES

- A.
1. A neutron badge is to be issued to an individual entering a neutron allowance zone when the dose is to exceed 1 mrem.
 2. The individual will be reissued the same badge throughout the remainder of the badge period.
 3. The badge is returned to the storage rack when it is not out in use and always by the end of the work shift.
- B. Neutron badges are delivered from External Dosimetry before the beginning of each HAPO badge period to each reactor via reactor gatehouse (1702 Bldg.).
- C.
1. Deliver the boxed badges and the Neutron Exposure Report to the reactor gatehouse (1702 Bldg.) within one week after the last day of the badge period.
 2. External Dosimetry will pick up the boxes and return them to 3705 Bldg.

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PERSONNEL METER AND BIOASSAY PROCEDURES

The Exposure Evaluation and Records Operation, Radiation Protection Operation, HLO, is responsible for obtaining, evaluating and recording radiation exposure information on each employee who is exposed to radiation here at HAPO. A part of this information is obtained by the use of radiation dosimeters or "personnel meters".

In addition to the personnel meters required for obtaining record information, other personnel meters may be required to provide immediate notification of any unusual or unplanned exposures which may have been received during the course of radiation work.

In case a personnel meter result is lost or questionable for any reason, an estimate is made of the radiation exposure received during the period that the lost dosimeter was used. The "Investigation of Personnel Radiation Monitor Result" form is used in obtaining and recording this information.

Whenever an individual may have taken radioactive material into his body, bioassay samples are used to evaluate the dose, if any, from the material.

The routine procedures for obtaining personnel exposure information are briefly outlined below, together with the non-routine procedures used when an individual has been involved in an unusual situation requiring an immediate evaluation of his radiation status.

I. Personnel Meter Procedures

A. Beta-Gamma Film Badges

Film badges are worn routinely by all personnel working in IPD plant areas. The film portion consists of a small dental film packet containing a sensitive and an insensitive sheet of x-ray film wrapped in paper. This film packet is sandwiched between three pairs of shields and a pair of open windows. The windows allow the passage of low energy gamma and beta radiation; by properly interpreting the film darkening under the various shields and under the open window, the received dose can be evaluated. The normal range of the film is from 5 mr to about 30 roentgens. By the use of special silver irradiation and counting techniques, doses up to about 100 roentgens can be interpreted.

The film badges are routinely changed every fourth week on Friday.

The used badges are taken to the 300 Area and disassembled. The film in the packets are developed together with a blank film, and a set of films which have been exposed to various known doses of radiation. The density, or amount of darkening on each calibration and blank film is measured using a photocell light measuring device called a densitometer. This calibration data is punched on an IBM card. The various densities on each individual's film are then measured on the densitometer, and this data punched on an IBM card. The IBM machine compares each individual film card with the batch calibration card, and determines the dose received by that film.

Responsible supervision may request that an individual's badge be pulled

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whenever the individual's exposure status is of interest because of an unusual occurrence. Such requests should be directed to the Exposure Evaluator, Radiation Protection Operation, HLO.

B. Neutron Film Badges

All persons who enter radiation zones where significant neutron radiation is present are required to wear neutron film badges. The badge is similar in construction to the beta-gamma film badge except that it is thicker, light grey in color, and has no personnel identification or picture. Two shields, tin and cadmium, are built into the badge. A 522 slow neutron film packet is located behind these shields which are of such thickness as to provide equal gamma shielding. The film behind the cadmium will be darkened more than that behind the tin when the badge is exposed to neutrons. This is the result of various neutron-gamma and neutron-beta reactions which occur in the cadmium shield but not in the tin shield. The difference in film darkening behind the two shields is therefore a measure of the slow neutron dose received.

Behind the 522 slow neutron film packet is a second film packet containing the same NTA fast neutron film which was used in the old fast neutron film badge. The NTA fast neutron film has a thick emulsion which is rich in hydrogen. When fast neutrons strike the hydrogen atoms, the hydrogen nuclei recoil, leaving tracks in the emulsion. After developing, this film is examined under a microscope, and the tracks counted. The number of tracks is proportional to the fast neutron dose received.

Once a neutron badge has been issued to an individual, that individual and only that individual will use that badge for the remainder of the badge pull period. It is important that neutron badges be stored in the regular box when they are not in use. On the day the badges are to be pulled, the "Routine A Film Processing" forms should be completed, and taken to the gatehouse together with all the neutron badges for exchange.

Neutron film badges are not pulled non-routinely except in rare instances. Should other dosimeters indicate an exposure in excess of that planned, the neutron film badge may be pulled for exposure evaluation.

C. Finger Rings

Finger rings containing small pieces of film may be issued to personnel whose hand exposure may be expected to be considerably higher than the exposure to the whole body.

Finger rings are not routinely used in the Irradiation Processing Department. If such rings are desired they may be obtained upon request of the Radiation Analyst, from the Supervisor, Exposure Records. They are issued to the user by radiation monitoring personnel and are normally worn for not longer than one week. Care must be taken to properly identify each ring with the name of the wearer and of the period worn. Finger rings should be worn on the hand which

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is likely to receive the highest radiation dose. If two rings are issued, one should be worn on each hand. They should be worn so that the film portion is not shielded from the source of hand exposure. If the exposure to be evaluated involves grasping or handling of irradiation or contaminated material, the rings should be worn with the film portion turned toward the palm of the hand.

Finger ring results are not routinely investigated by the Exposure Evaluator. Each Reactor Operation must originate its own investigation of any finger ring results. However, if it appears that working limits may have been exceeded, the Exposure Evaluator, RPO, HLO, should be notified so that other dosimeter results may be investigated if necessary.

D. Gamma Pencils

In locations where high and/or variable dose rates are encountered, pocket dosimeters, commonly called gamma pencils, may be useful in controlling personnel exposures. SWPs and RWPs will specify those locations or jobs where pencils are to be worn. Some jobs or locations where pencils may be used are:

1. All reactor rear face work
2. Front face work associated with stuck rupture removal or tube removal
3. Burial work
4. Wash pad
5. X level
6. Top of unit

Pencils are signed out by the user and returned to the sign out location after use. Pencils will be read, on a daily basis, by an employee who has been properly instructed and qualified, with the results recorded on the sign out sheet. Pencils should be worn for no more than one day, and should not be taken home.

Gamma pencils are small bakelite-walled ionization chambers. The walls of the pencils are coated with graphite, and form one electrode of the chamber. A carefully insulated wire is located in the center of the chamber. Before being issued, an electric charge is placed across these two electrodes. These pencils are sensitive to x- or gamma radiation only. Such radiation ionizes the air in the chamber, and causes the pencils to lose their charge, the loss being proportional to the amount of radiation received. Used pencils are read on a device known as a minometer which indicates the amount of radiation received and recharges the pencils for the next user. The range of these pocket dosimeters is from 0 to 280 mr.

E. Self-Reading Dosimeters

A limited number of continuously readable pencils are available at each radiation monitoring office. They are useful in providing a quick and continuous check on the gamma dose received by personnel working in high dose rate zones. These pencils are similar to the regular gamma pencils except that the dose is

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indicated by the movement of a charged fiber across a calibrated scale in the pencil. Each pencil can be read at any time prior to complete discharge by holding it up to the light and looking into the lens at the top. The range is from 0 to 200 mr. These pencils are charged using a minometer specifically designed for this type of pencil.

Self-reading pencils should be kept charged whether they are in use or not. If allowed to lie idle in a discharged state and then recharged for use, they will lose a significant portion of the charge in reaching a dielectric equilibrium. If required by the SWP or RWP, these dosimeters may be obtained from the radiation monitoring office and should be returned to the radiation monitoring office at the end of the shift, or at the end of the job for which they were issued.

F. Contamination of Dosimeters

If personnel meters become contaminated, erroneous readings may be obtained. Every reasonable effort should be made to avoid personnel meter contamination. In contaminated zones where two layers of clothing are required, the personnel meters should be worn on the inner layer to prevent their becoming contaminated; if they are worn on the outer layer, they should be enclosed in the approved plastic bag which is available at clothing storage rooms. Whenever you know or suspect that your personnel meters have become contaminated, deliver them promptly to radiation monitoring for survey. Radiation monitoring personnel will survey the dosimeters and if contaminated, take whatever action is possible and necessary to preserve the exposure information.

II. The "Investigation of Personnel Radiation Monitor Result" Form

Personnel meter results are a part of the permanent record of radiation exposure to the employee. When a personnel meter result is lost because of unusual treatment or improper processing, or when the results are doubtful because of fogged film, poor packaging, etc., the lost result must be replaced in the plant records by the best estimate which can be made of the radiation received during the period covered by the dosimeter. This information is recorded on the form "Investigation of Personnel Radiation Monitor Results", which is originated by the Exposure Evaluator, RPO, HLO. The form will also be routinely completed whenever a film badge reading is greater than some standard value established by the exposure evaluations group.

On receipt of this form, the Radiation Analyst will forward the form to the supervisor of the employee involved.

The supervisor should complete items 1, 2, 3, and 4 on the basis of his records and discussion with the employee involved, sign his name in the lower right corner of the item 5 block, and return the form to the Radiation Analyst from whom he received it.

The Radiation Analyst will then complete item 5 and return the form to the Exposure Evaluator.

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III. Bioassay Samples

Whenever an employee is involved in an occurrence wherein the possible deposition of radioactive material is involved, bioassay samples should be obtained promptly from the employee involved. In any such case, the Radiation Analyst should notify the Exposure Evaluator who will make arrangements for the necessary samples.

In the case of the intake of plutonium and most fission products, the first urine sample requested will normally be of the "48-hour" type (sample will consist of urine passed during specified periods during two consecutive days) and will be requested during the first or second day following the occurrence. In cases where the exposure potential appears to be great, immediate "spot" samples may be obtained to serve as a basis for judging whether or not special treatment to reduce deposition is warranted. In some cases, another follow-up sample "24-hour" type (sample to consist of all the urine passed during the 24-hour period) will be requested of the employee on his first normal day off. Subsequent samples may be arranged for, usually on days convenient to the employee.

In the case of intake of uranium activity, immediate urine samples should be obtained--in fact, it is highly desirable that all the urine passed during the first few days be collected in separate containers and the time of delivery noted on each such container. The collection during the next few days need not be necessarily in separate containers for each delivery but the specimens obtained on different days should not be combined. Samples may also be requested periodically during the first few weeks following the occurrence.

In the case of intake of insoluble compounds of plutonium, fission products, or uranium, special samples may be requested in addition to urine samples.

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IPD PENCIL PROGRAM

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FUNCTION

The function of the IPD pencil program is to supplement the measurement by HAPO film badge of whole body gamma radiation received by an individual.

The measurement made by the IPD pencil for a work shift provides dose information for use in making work assignments on subsequent shifts and to flag a high exposure.

PROCEDURES

I. Use

- A. An IPD pencil is worn by each person entering any radiation zone.
- B. The pencil is worn in the manner specified in RCS 1.5.
- C. The pencil is procured and registered at the 105 Building pencil station and returned to the same station within the shift. It is to be worn for no longer than one shift.
- D. Pencil registration consists of:
 - Name
 - Payroll Number
 - Pencil Number

II. Processing of Pencils

The processing of IPD pencils is the responsibility of the radiation monitoring function.

A. Reading

- 1. Pencils may be read and recharged only by personnel authorized by the supervisor of the radiation monitoring function.
- 2. Process the pencils as soon as practical after their return (if possible before shift end) and no later than the first hour of the following shift.
- 3. Do not process an employee's pencil until the anticipated radiation zone work for the shift is complete unless authorized by the supervisor of the radiation monitoring function.
- 4. Recharge pencils daily.

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5. Stepwise pencil process:

- Test the pulse pencil reader, by Procedure 8.7.7, prior to use.
- Read and recharge pencil.
- Record reading on register.
- Return pencil to ready rack.

6. Any case of a missing pencil, an off-scale pencil result or a result greater than 100 mr should be immediately reported to the supervisor of the monitor function for follow-up as outlined in Section III.

B. Routine Report

Within the first hour of each shift, report last shift's pencil results.

- Dial 2-5463. (Electronic recorder).
- Give area code, shift code and date at beginning of report.
- For each entry give payroll number and pencil reading. (Include all zero readings).
- Report pencil results for HAPD employees only.
- When the pencil reading is missing or off-scale, report the reading as "under investigation" along with the corresponding payroll number.

C. Correction Reports

- A correction sheet, listing the missing pencils and the payroll numbers not listed for IPD, is sent to the reporting operation.
- As soon as the correction sheet is received, the supervisor of the radiation monitoring function will have corrections made.
- Report corrected results as above in Section B, starting with, "This is a correction report," and give the original date with each correction.
- When any pencil result is totally lost or proved to be erroneous, an estimated exposure provided by the employee's supervisor* and approved by the supervisor of the radiation monitoring function will be reported as a correction.

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D. Filing

1. Remove and replace the pencil registration sheet each shift.
2. Enter area code, shift code and date on each sheet.
3. File completed register sheets for 90 days before discarding.
4. File each correction report for a week.

III. Investigation Pencil Results

The employee's supervisor* is responsible for the investigation of a high result or a missing pencil. The supervisor of the radiation monitoring function is to notify the employee's supervisor of a missing pencil, an off-scale pencil result or a result greater than 100 mr and is to provide the necessary assistance to investigate and evaluate the result. The purpose of each investigation is to determine and assign an estimate of the exposure which was received by an individual for the shift in question.

A. Investigation

1. Missing pencil - Either the pencil is to be located, returned and read, or, in lieu of a missing result, an estimated value is to be assigned.
2. High pencil result (where the pencil result is higher than the estimated exposure, the extreme case being an off-scale pencil).
 - a. Did the dose rate change significantly where the employee was working?
 - b. Did the activities of the employee take him to a location where the dose rates were higher than those established?
 - c. Could any high dose rate condition have been created which would have later rectified itself?
 - d. When was the job site under monitoring surveillance?
 - e. Was the employee alone or with someone to whom his exposure can be compared?
 - f. In the case of the off-scale result, is it true, doubtful, or false?
 - g. In the case of a high result, but not off-scale, what has caused the higher-than-expected exposure?

*The "employee's supervisor" as used herein is the individual giving work direction at the time.

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B. Action as a result of the investigation:

1. Missing pencil

- a. Where the pencil has been found and read, record the reading in the proper place in the pencil register.
- b. Where an estimated value is necessary, the employee's supervisor authorizes it by initialling the entry on the pencil register.
- c. In both cases the resulting entry is reported in as described above in Section II.

2. High pencil result

- a. Where an off-scale is verified to be true, the area R.M. Analyst is to be promptly notified and the employee's other personnel dosimeters processed.
- b. Where the result is doubtful, the area R.M. Analyst is to be advised and the HLO pencil processed as authorized by External Dosimetry.
- c. Where the result is shown to be false, then the estimated value is entered in the register and called in.
- d. Other high pencil results coming to the attention of the employee's supervisor should also be investigated and the result brought to the attention of the area R.M. Analyst for review.
- e. The employee's supervisor authorizes the corrected value by initialling the entry on the pencil register.
- f. In all cases the resulting entry is reported in as described above in Section II.
- g. Any off-standard conditions discovered during an investigation are to be corrected.

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THE CREATION AND DISPOSITION OF RADIOLOGICAL RECORDS

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- I. Radiological records are grouped into three types; the primary record, secondary records, and supporting records.

Primary records are those which describe exposures received by personnel, such as dosimeter results and processing data, bioassay and special sample results, etc. All primary Radiological records at HAPO are originated by the Radiation Protection Operation, HLO, accumulated in individual exposure record folders in the 3705 building and retained permanently. Forms and procedures relating to the primary records are wholly under the control of the Radiation Protection Operation, HLO.

Secondary records are those which describe radiological environments to which personnel may be or are exposed.

Supporting records are those which do not relate to personnel exposures, but which may be useful in supplementing the information contained in the primary and secondary records.

- II. The Irradiation Processing Department radiological record is maintained by the Processing Operations together with Radiological Engineering. For record storage purposes, each type of information is accumulated into one of several "record files" each of which has been assigned a number. Similar files have the same number throughout the department except that a suffix is added to identify the Processing Operation involved, i.e:

HA-326-DR means "Radiological Records" from DR Area,

HA-326-139 means "Radiation Survey Results"

"DR" means that the file pertains to DR Processing Operation

The radiological records of each Processing Operation are organized into record files as follows:

Secondary Records

Radiation Survey Results
Radiation Zone Work Authorizations
Instrumentation Records
Waste Disposal Records
Health Monitor Charts
Personnel Exposure Estimates and
Contamination Cases
Special Radiological Studies

File No. (Insert Bldg. Suffix)

HA-326-139

HA-326-140

HA-326-141

HA-326-93

(filed with primary records)

HA-326-142

Supporting Records

Radioactive Shipment Records
Radiological Administration Records

HA-326-86

HA-326-143

Office Files

Dosimeter, film, and sample analysis results (office file only)

Each of these files is discussed in detail below:

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A. Radiation Survey Results - Records File Number HA-326-139

1. Radiological Surveys are of three general types: Personal dose rate monitoring surveys, area and equipment surveys, and airborne contamination surveys. The record should include all measurements made, all results obtained, and all personnel dose rates set, for any radiation survey which is made by personnel qualified in radiation monitoring.

Negative results are to be reported whenever they are obtained.

2. All information in this record file should be recorded on one of the following forms. No others should be used.

- a. All airborne activity concentration determinations should be recorded on "Air and Gas Sample Log" form (54-3000-274).
- b. Daily building surveys should be recorded on "Building Survey" form (BM-5900-036).
- c. Personnel dose rate, routine surveys, and area or equipment radiation or surface contamination surveys, which are of a routine or highly repetitive nature may be written up on the "Routine and Repetitive Survey" form, (BM-5300-051 & 052). Proper use of this form should result in collecting related information onto one sheet, reducing the bulk of the survey record, and minimizing duplication of information on a non-record check list and the survey report sheets.
- d. All other personnel dose rate monitoring surveys, and each area or equipment radiation or surface contamination survey which is made, except for those of a routine or highly repetitive nature, should be written up on the "Radiation Survey Report" form (BE-5500-004).

3. All the above records for one month should be bound together (4 sections) and kept in the radiation monitoring office. At six months intervals, records old enough that they are not useful, (over 4 months old) should be shipped to the records center as described in Procedure #3.2.

B. Radiation Zone Work Authorizations - Records File No. HA-326-140

1. This record consists of the Special Work Permits and the Radiation Work Procedures. The use of these authorizations is described in Radiation Control Standard 4.2.
2. The Radiological Engineering copy of the Radiation Work Procedures will be considered to be the record copy; all building copies are office files, which may be destroyed when no longer useful.
3. Special Work Permit (54-3000-202) is the only form which should be included in this Processing Operation file.

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Radiation Zone Work Authorizations - Records File No. HA-326-140 (cont'd)

4. The SWPs should be accumulated by radiation monitoring, arranged in chronological order, bound by the month, and kept in the radiation monitoring office. At six month intervals, records old enough that they are no longer useful (over 4 months old) should be prepared for shipment to the records center as described in Procedure #3.2.

C. Instrumentation Records - Records File No. HA-326-141

1. This record should describe all inventories, performance tests, and calibrations of portable and fixed monitoring instrumentation.
2. The following forms should be included in this file:
 - a. 5 Fold Test
 - b. Counter Tests
 - c. Portable Instrument Check and Inventory
 - d. (HM Chamber Checks)
(Monitor Alarm Checks)
 - e. Source and Background Counts
3. This file should be accumulated by radiation monitoring, bound in chronological order and kept in the radiation monitoring office. At six months intervals, records old enough that they are no longer useful (over 4 months old) should be prepared for shipment to the records center as described in Procedure #3.2.

D. Waste Disposal Records

E. Health Monitor Charts - Records File No. HA-326-93

1. All charts from recording instruments which are present primarily for the purpose of obtaining personnel protection information should be included in this file.
2. Various chart rolls are used, obtainable from Stores.
3. The chart rolls should be accumulated in the radiation monitoring office. Periodically, they should be shipped to the records center as described in Procedure #3.2. A listing of the locations and time periods covered should be kept for each shipment.

F. Personnel Exposure and Contamination Records - (File with Primary Records)

1. All secondary records which describe individual personnel exposure estimates, handcounts or other personal contamination surveys, and skin contamination cases, are filed together with the primary personnel exposure records at the 3705 building.

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Personnel Exposure and Contamination Records (cont'd)

2. Forms used:

a. Radiation Exposure Estimate Card (54-3000-203)

Any individual entering a radiation zone shall record the entry on this form, unless (as in the case of contractor personnel) other approved methods are employed for accumulating this information. The responsibility for completion of this record is shared by the individual and his supervisor. The card should be forwarded to a radiation monitoring office monthly.

The pocket Exposure Estimate Card (54-3000-333) may be useful in accumulating information for this record, but shall not be used as the record form.

b. Hand and Shoe Score Sheet (A-6940-001)

This form is provided at all hand and foot counter locations for the use of visitors and persons not required to complete the radiation exposure estimate card. Persons completing a radiation exposure estimate card should record their handcounts on the back of that form, rather than using the hand and shoe score sheet.

c. Skin Contamination - tourniquet record card (A-6940-004)

This card must be completed by radiation monitoring in every case of skin contamination, or contaminated injury.

3. At the end of each month, radiation monitoring should accumulate all the above forms completed during the month, and all older ones found, and forward them to the radiation analyst in the building involved. The radiation analyst should forward them to the 3705 building, 300 area.

G. Special Radiological Studies - Records File No. HA-326-142

1. Data obtained in any special radiological studies may be academically useful in the future, and therefore should be preserved.
2. Data may be collected on analytical request form (54-3000-287), non-routine processing forms (H-498-D&D.2) or on papers, notebooks, unclassified published reports, etc.
3. All data from each study should be accumulated, placed in an envelope or other container, labeled, stored at the originating facility as long as useful, and then forwarded to the records center as described in Procedure # 3.2.

H. Radioactive Shipment Records - Records File No. HA-326-86

1. Any radioactive material which is shipped from a plant area to any other location, or from an IPD facility to another department facility whether

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Radioactive Shipment Records (cont'd)

inside the same plant area or not must be controlled by written shipment authorization.

2. Forms Used:

a. Standard Radioactive Shipment Procedure (EM-5600-011)

Routine or repetitive shipments of material of a specific nature may be adequately controlled by use of the Standard Radioactive Shipment Procedure, provided the shipment is within HAPC. One copy of each SRSP should be forwarded to Radiological Engineering by the issuing facility for the permanent record, which will be maintained by Radiological Engineering.

b. Radioactive Shipment Record (54-3000-219)

All off-plant shipments, and other shipments of a non-routine nature must be controlled by a Radioactive Shipment Record form.

3. One copy of each RSR issued by a facility should be collected, arranged in chronological order, bound in binders by the month, and stored in the radiation monitoring office. At 6 month intervals, records old enough that they are no longer useful should be shipped to the records center as described in Procedure #3.2.

I. Radiological Administration Records - Records File No. HA-326-143

1. All shift reports, checklists and other communications relating to the administration of the radiation protection program should be included in this file.

2. Forms Used:

a. Shift Report (A-5800-009)

b. Shift Routine Checklist (EM-5900-038)

Other related material not on a form.

3. The above records should be bound together (2 or more sections) in chronological order and kept in the radiation monitoring office for from 6 months to a year. Periodically, records old enough that they are no longer useful should be shipped to the records center as described in Procedure #3.2.

J. Dosimeter, Film Results, and Special Sample Results - Office File

1. One copy of all analytical requests (form 54-3000-287) is retained by the Analytical Laboratory for the permanent record, however the requestor's copy provides valuable reference data in the buildings. In the same manner, copies of all non-routine film processing requests, A film processing sheets, and neutron pencil sheets are retained by the Personnel Meters Operation for the permanent record, however they also provide reference data in the buildings.

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Dosimeter, Film Results, and Special Sample Results (cont'd)

2. Forms Used:

- a. NB&P results
- b. Routine A Film Proc.
- c. Analy. request
- d. Non-routine Proc. (white or yellow)

3. Disposition:

- a. NB&P results:
 - Keep as long as useful, then discard.
- b. Routine A Film Proc.
 - Keep as long as useful, then discard.
- c. Analytical requests:
 - 1. Waste disposal analyses - to waste disposal record.
 - 2. Analyses relating to special studies - to special study file (see "special radiological studies" above)
 - 3. All others, keep as long as useful, then discard.
- d. Non-routine Processing (white or yellow)
 - 1. All forms relating to special studies - to special study file. (see "special radiological studies" above)
 - 2. All others - keep as long as useful, then discard.

III. Radiological Engineering, Research and Engineering Operation, accumulates the following record files:

- a. Radiation Occurrence Reports (54-5900-001)
- b. Report of Lapse of Radiation Control (BM-5300-026)
- c. Radiation Work Procedures (BM-5900-010)
- d. Standard Radioactive Shipment Procedure (BM-5600-011)

One copy of each of the above (except b) is forwarded to Radiological Engineering, Research and Engineering Operation for inclusion in the record file. All other copies are office files, which may be destroyed when no longer useful.

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SUBJECT

DECONTAMINATION OF PERSONNEL AND PERSONAL EFFECTS

I GENERAL

Incidents which result in suspected or known excessive inhalation, ingestion, or absorption of radioactive material; contamination of wounds, skin or clothing; or escape of radioactive material to surroundings require prompt action to prevent or limit radiation damage. Responsible supervision must be notified so that further exposures can be controlled, necessary medical treatment can be initiated, and property damage can be limited.

Whenever personnel work with radioactive materials, there is always some possibility of their becoming contaminated. In case of such an occurrence, immediate action will be necessary to minimize the over-all potential effect to the employee from the radioactivity and the physical results of the occurrence. Although it is impossible to discuss here all possible circumstances involving personnel contamination, certain general considerations should control the handling of all cases.

- (1) Exposure rates to the individual from the contamination.
- (2) Seriousness of the physical damage to the individual from the incident-- shock, severe bleeding, burns, etc.
- (3) Type of contaminant and the carrier -- beta, alpha; acid, caustic.
- (4) Extent of contaminated skin area and its bodily location.
- (5) Condition of the skin of the contaminated area and of adjacent areas.

In considering these points, it should be realized that medical attention to serious injuries may well take priority over removal of contamination. However, if the individual is covered with gross amounts of contamination, it would be more important to remove as much of this contamination as soon as possible, rather than exercise extreme caution to prevent contamination spread. Similarly, if the contamination is carried by either a strong base or strong acid, with a resulting skin absorption hazard, immediate steps should be taken to flush the chemical off with tap water without regard to the spread of contamination. When the physical burn hazard has been eliminated, skin decontamination should be started and steps taken to control the spread of contamination.

When high dose rates or skin absorption are not a problem, more care should be exercised to localize and remove skin contamination. Most IPD cases of skin contamination are low level and can be readily removed through a simple soap and water wash.

In summary, any decision involving a choice between drastic cleaning methods to reduce dose rates or the use of more careful methods should be based on whether or not the intended action will minimize the over-all body damage. Each case will require the most conscientious efforts of radiation monitoring personnel to insure that the best possible action is taken.

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SUBJECT

DECONTAMINATION OF PERSONNEL AND PERSONAL EFFECTS

II PERSONNEL DECONTAMINATION**A. Decontamination Supplies**

Each building 105 Radiation Monitoring laboratory will have on hand the following listed equipment. This list incorporates the minimum requirements. From time to time, special approved reagents may be added.

Item	Quantity
Surgical gloves	1 pair
Applicators, cotton tipped	1 pkg
Cotton balls	1 pkg
Tongue blades	12
Reagent #1, potassium permanganate	25 pkgs (#00 capsules)
Reagent #2, sodium bisulfite	25 pkgs (#00 capsules)
pHisoHex soap	1 bottle
Na ₄ EDTA	1 lb dry powder
Wool wax cream	1 jar
Soft brush	1
1 oz. waxed paper cups	12
2 oz. plain paper cups	12
Detergent (Tide or equivalent)	1 box

1. The stock solution of Na₄EDTA should be prepared by dissolving 16 grams of 70% active Na₄EDTA chemical salt in 100 ml of distilled water. This gives a solution of 10% active ingredient (EDTA). A small amount of detergent should be added to the solution to provide a sudsing action which will help to remove the contamination.
2. A saturated solution of KMnO₄ is made by dissolving 1 capsule of KMnO₄ crystals in a 1 ounce waxed paper cup of water. This solution is usable as long as solid crystals remain undissolved in the bottom of the cup.
3. A 4% solution of NaHSO₃ is made by dissolving 1 capsule of NaHSO₃ crystals in a 1 ounce waxed paper cup of water. This solution should be freshly made just prior to use. For this reason it is pre-packaged for immediate mixing.

B. Localized Skin Decontamination

1. Closely observe the condition of the skin adjacent to the contaminated area and if any breaks or abrasions are observed, notify the operating supervisor and the supervisor responsible for radiation monitoring and immediately initiate the "Radiation Zone Injury Procedure," RCP #5.1. If no breaks or abrasions are detected, proceed with step 2.
2. The person doing the decontamination should wear rubber surgical gloves and a laboratory coat or SWP coveralls at all times, and respiratory protection if necessary.

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HANFORD ATOMIC PRODUCTS OPERATION
RADIATION CONTROL PROCEDURE
IRRADIATION PROCESSING DEPARTMENT

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3. Skin contamination known or suspected to have originated from radioactive material in solution should receive an immediate application of water by means of a damp cotton ball, to dilute any reagent which might react with the skin. Extreme care should be taken to prevent contamination spread to any skin or body openings.
4. If beta-gamma emitting contamination is possible, make appropriate surveys of the contaminated person to determine the dose rate. If the level is high enough to present an exposure problem, take immediate steps to reduce the level. Contaminated clothing should be removed immediately, and the man should be given a complete body survey for skin contamination.
5. Make an alpha survey of the person if any alpha contamination is suspected. If contamination is found, determine the size and shape of the skin areas which are contaminated and the approximate quantity of alpha-emitting material involved.
6. When reagents on the skin cause smarting, the case should be given special handling of an emergency nature. Consult Industrial Medicine in such cases through the supervisor responsible for radiation monitoring.
7. On occasion, the Hanford Laboratories Operation and Industrial Medicine will approve the use of special reagents. A specific procedure will be issued at the time of approval of each new reagent.

C. General Body Contamination

In all cases where shower or sink installations are utilized for personnel skin contamination, a qualified radiation monitor will make the appropriate surveys, after such use. A release by a qualified radiation monitor is required in all cases before such equipment is used by others.

III DECONTAMINATION PROCEDURE

Localized Skin
Decontamination

Step I

- 1) Isolate contaminated spot.
- 2) Wash contaminated area with mild soap and tepid water, not less than 2 minutes or more than 3 minutes.
- 3) Rinse and repeat as monitoring indicates, but not to exceed 4 washings.

Equipment Needed

pHisoHex soap
Tepid water
Wool wax

Precautions

If any breaks or abrasions are adjacent to contaminated area notify the operating supervisor and the supervisor responsible for radiation monitoring and initiate procedure for "radiation zone injuries". Ref: RPS 6.2

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Localized SkinDecontamination (continued)

4) Apply wool wax to prevent chapping.
 (Only if contamination is completely removed)

Equipment NeededPrecautions

Do not spread soap solution to non-contaminated areas.

Step II

1) If soap and water washing is not sufficient to remove contamination, scrub with soft brush using heavy lather and tepid water.
 2) Rinse and repeat as above not more than 3 times.
 3) Apply wool wax to prevent chapping. (Only if contamination is completely removed)

pHisoHex soap
 Tepid water
 Soft brush
 Wool wax

Apply only light pressure to the brush to prevent scratching or eroding the skin.

Step III

1) If soft brush and soap are not sufficient, apply a cotton tipped applicator soaked in soap solution to contaminated area.
 2) Rub skin with swab to produce good soaping action.
 3) Remove soap with a clean applicator.
 4) Dry with paper tissue.
 5) Repeat until all detectable contamination is removed, or until there is no decrease in the level of contamination.
 6) Apply wool wax to prevent chapping. (Only if contamination is completely removed)

pHisoHex soap
 Tepid water
 Cotton tipped applicators
 One ounce cup; waxed
 Wool wax
 Paper tissue

Destroy applicator after using once on contaminated skin. Used applicator should never be dipped into decontamination solution.
 Do not spread soap solution to non-contaminated areas.

Step IV

1) If step I, II, III are not effective, apply a solution of 10% EDTA plus detergent to the contaminated area with a cotton tipped applicator or cotton ball.

10% EDTA solution
 cotton tipped applicators
 Cotton balls

Destroy cotton balls and applicators after using once on contaminated skin.

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DECONTAMINATION PROCEDURE (continued)Localized SkinDecontamination (continued)Equipment NeededPrecautions

- 2) Rinse with clean water and repeat as above not more than 3 times.
- 3) Apply wool wax to prevent chapping. (Only if contamination is completely removed)

Wool wax

Step V

- 1) If the steps above are not effective, paint contaminated area with a 4% solution potassium permanganate (4% KMnO_4) using a cotton tipped applicator.
- 2) Allow solution to dry on skin.
- 3) Repeat with KMnO_4 three times, allowing each application to dry thoroughly. Use a new swab for each application. When dry, the skin should be almost black.
- 4) Using a cotton tip applicator, rub the darkened area with a 4% Sodium Bisulfite solution.
- 5) Repeat this application until the brown coloration is removed. Discard each applicator after use.
- 6) Remove any of the NaHSO_3 remaining on the skin by rubbing with an applicator soaked in water.
- 7) Dry well using 4 x 4 gauze.
- 8) Resurvey the treated skin area for contamination. If still present, repeat Step V.
- 9) If contamination is still present, consult the supervisor responsible for radiation monitoring.

Cotton tip applicators
 One ounce cups; waxed
 Preparation of 4%
 Potassium Permanganate
 solution. (One KMnO_4
 capsule in one ounce
 of water)
 Preparation of 4%
 Sodium Bisulfite solu-
 tion. (Dissolve 1
 NaHSO_3 capsule in one
 ounce water)

When reagents cause smart-
 ing, the case should be
 given special handling of
 an emergency nature.
 Notify Industrial Medicine
 through the supervisor
 responsible for radiation
 monitoring.

General Body ContaminationEquipment NeededPrecautions

Step I

- 1) In those cases where surveys indicate general body contami-

pHisoHex soap

Precaution when showering
 to prevent contamination

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DECONTAMINATION PROCEDURE (continued)General Body Contamination (cont'd)

nation, personnel should be instructed to shower, using a mild soap and tepid water. Should survey results, after shower, indicate localized contamination the procedure for localized decontamination should be initiated.

Equipment NeededPrecautions

from entering through any body opening.

Hair Contamination

Step I

1) When contamination of the hair or scalp is < 25,000 c/m, the procedure as outlined under "General Body Contamination" should be applied.

2) A body as well as head survey should be made to detect any contamination which may be transferred to other parts of the body.

Step II

1) If contamination level exceeds 25,000 c/m, have the patient remove all outer clothing and put on a pair of surgeon's gloves.

2) Wrap a towel tightly around his neck.

3) Bend his head well forward over a wash bowl containing an equal mixture of liquid soap and tepid water.

4) Massage mixture into hair to produce heavy lather.

5) Rinse lather from hair by carefully directing a spray of water over the scalp.

6) Survey of hair following decontamination should be made only when hair is dry. A survey of the face and neck should be included.

Equipment Needed

pHisoHex soap
Surgeon's gloves
Towel
Tepid water

Precautions

Prevent water from running under towel and contamination from entering the eyes and ears.

Change towel when it becomes damp.

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DECONTAMINATION PROCEDURE (continued)Hair Contamination (cont'd)

7) If contamination cannot be removed by 3 successive applications of the above procedures, notify the supervisor responsible for radiation monitoring.

Equipment NeededPrecautionsMouth Decontamination

Step I

1) If mouth is generally contaminated, begin flushing immediately with tap water. Keep head bent down to prevent water from reaching the throat and being swallowed. Contact Industrial Medicine through the supervisor responsible for radiation monitoring, or the radiation analyst.

Tap water

In no case shall EDTA solution, or solutions of KMnO_4 or NaHSO_3 be used in the mouth as they will damage and destroy mucous membranes. The use of an agent other than water shall be tolerated only by direction of a physician.

Eye Decontamination

Step I (Same as mouth decontamination)

1) Contact an Industrial Medicine physician at once through the supervisor responsible for radiation monitoring, or the radiation analyst.

Tap water

Nose Decontamination

Step I

1) Contact Industrial Medicine through the supervisor responsible for radiation monitoring, or the radiation analyst. (Nasal irrigation per IMS-OPG-33)

Under no circumstances allow a person with nasal contamination to eat, chew gum, or use tobacco until decontamination has been effected.

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IV PERSONAL EFFECTS DECONTAMINATION

A. Shoes

1. If it is suspected that the contaminant is dust or specks, masking tape may be used to remove the contamination. Press the gummy side of the tape to the area of the shoe that is contaminated. Remove and repeat until no substantial reduction in level is observed or until the shoe is free of contamination.
2. If the contamination cannot be removed with tape, leather soles should be scraped with a wire brush or emery paper until clean. During this operation, attempt to keep dust and filings from flying into the air. Use a scraping motion away from the body and catch all material on paper or in a box. Wear respiratory protection if indicated. Liquids should not be used on leather.
3. If contamination cannot be removed with tape, rubber soles may be scrubbed with lanokleen suds. A wire or stiff bristle brush should be used. Wipe off, rinse, dry with paper towels and resurvey. Repeat the scrubbing until no substantial reduction in level is observed or until contamination is removed.
4. If the level of contamination indicates no reduction after several washings, the soles should then be scraped with emery cloth or a file.
5. If the contamination cannot be removed using the above methods, final disposition of the shoes will be the decision of the owner, his supervision, the radiation analyst and supervision of the operating group.

B. Other

If contamination is detected on personal clothing, it should be removed with care to prevent the spread of contamination. A body survey for skin contamination should follow. Personal clothing which is contaminated to 25,000 c/m may be laundered in the sinks used for personnel decontamination. A qualified radiation monitor shall survey all clothing for release when thoroughly dry. A survey of the sink used shall follow all cases.

Clothing contaminated with noble gases from ruptured fuel elements should not be washed, since this contamination can be removed most quickly by merely airing out the fabric.

If personal clothing contamination in excess of 25,000 c/m is observed, the item (s) shall be wrapped in paper and thoroughly identified until disposition is agreed upon by the owner, his supervisor, the radiation analyst, and supervision of the operating group.

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IPD-MFG RADIATION WORK PROCEDURES

GENERAL INSTRUCTIONS

- 1 Entry into a radiation zone may be made only under the provisions of a valid radiation work procedure.
- 2 Effective radiation control is dependent upon the judgment, training and experience of individual employees. Radiation zone entries should not be made by those unfamiliar with radiation zone procedures except under the direct guidance of qualified persons.
- 3 Contact R. M. Service before starting work in a radiation zone. Protective requirements may be revised by the R. M. Service as conditions warrant.
- 4 Planned radiation exposure will be controlled by supervision within established limits.
- 5 A Film Badge and a Gamma Pencil are to be worn in all radiation zones.
- 6 Inspect protective clothing while dressing and do not wear damaged or ill-fitting clothing. Protect skin and personal clothing from contamination by adequate fastening.
- 7 Personal contamination control requires knowledge and careful application of clothing removal procedures. Assistance of a second person in removal of clothing known to be highly contaminated is advisable.
- 8 No smoking or eating within a contaminated radiation zone is permitted.
- 9 A personal contamination survey is required after leaving a radiation zone. The hand-shoe count is the minimum requirement. A complete personal survey may be required for specific work.
- 10 Skin decontamination is to be performed under the guidance of a qualified person. The release survey of personal clothing or skin surfaces from a contaminated status must be performed by a qualified person.
- 11 Tools and equipment must be surveyed prior to removal from a radiation zone.
- 12 If the radiation control alarm (flashing yellow beacon) is observed, leave the zone unless you are being monitored and other action is authorized by Supervision.
- 13 If the radiation emergency alarm (Howler) sounds proceed immediately to the control room and report, as soon as possible, to the Processing Building Supervisor for further instructions.

ISSUED BY

Lester R. Walker
SUPERVISOR, RADIATION PRACTICES ENGINEERING

APPROVED JUNE 1, 1965

O. Schraeder
MANAGER MANUFACTURING

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PROTECTIVE CLOTHING

SINGLE SINGLE-NPOC
(OVER PERSONAL CLOTHING) (NO PERSONAL OUTER CLOTHING)

DOUBLE
(NO PERSONAL OUTER CLOTHING)

APRON
(NO PERSONAL OUTER CLOTHING)

SUIT
(NO PERSONAL OUTER CLOTHING)

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RADIATION WORK PROCEDURE

NUMBER 1	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION 115 Building - Gas Instrument Room - Gas Tunnels - Exhaust Fan Cells - 117 Building - 119 Building		TITLE - DESCRIPTION GAS & EXHAUST VENTILATION SYSTEMS Perform maintenance and operating functions on and within controlled areas of these functions.
RADIOLOGICAL CONDITIONS 1. Radiation from gas lines, gel tower, and other equipment. 2. Radioactive gas escaping from leaks in system. 3. Low energy beta emitters in drier rooms. 4. Possible air-borne and surface contamination.		MONITORING Monitoring required when gas system is opened to atmosphere.
INSTRUCTIONS General: 1. Approval must be obtained from processing supervision before opening process lines. 2. Consult processing supervision for lock and tag procedure requirements. 3. All internal surfaces and concentrating mechanisms to be handled as contaminated. 115 Building: 1. Do not enter a drier room for 1/2 hour following regeneration or jetting cycles. Gas or Exhaust Tunnels: 1. Do not enter the exhaust tunnel during ruptured slug removal.		PROTECTIVE CLOTHING 1. 115 Buildings: SINGLE - No personal outer clothing. Respiratory protection as specified by RM. 2. Gas Instrument Room: Clothing requirements dependent on work to be done. Consult RM. 3. Gas Tunnel: SINGLE - No personal outer clothing. 4. Exhaust Fan Cells: As specified by RM. 5. 117 Building: No protective clothing required in the operating gallery or on the deck. Clothing requirements in the cells to be specified by RM. 6. 119 Building: No protective clothing required.
ISSUED BY: <i>L. K. Walker</i> SUPERVISOR, RADIATION PRACTICES ENGINEERING		APPROVED BY: <i>O. Schreder</i> MANAGER, MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 2	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Downcomer rooms, downcomers (except K), sample rooms, heat exchangers, sewage lift stations (1608) and effluent system outside 105 (lines, 107 basin outfall structure, and crib ditches, etc.).		TITLE - DESCRIPTION EFFLUENT WATER SYSTEM: Operate and maintain the equipment and facilities within the radiation zones of this system.
RADIOLOGICAL CONDITIONS 1. Radiation and contamination from the effluent system lines, valve boxes, basins, downcomers, and vents. 2. Air-borne contamination from dry interior surfaces (downcomers, lines, basin, etc.) and at vapor leaks and vents.		MONITORING 1. Consult RM before removing materials or equipment from the effluent system. 2. Monitoring required during the sampling for a suspected rupture.
INSTRUCTIONS 1. Consult process supervision before entering the effluent system (downcomers, lines, basins, etc.).		PROTECTIVE CLOTHING 1. Zones surrounding the system: Entry - SINGLE Handling on wet equipment - add waterproof gloves Work on contaminated equipment - SINGLE, waterproof gloves - No personal outer clothes. 2. Downcomer Room: Entry - SINGLE, no personal outer clothing Change goggle valve - SUIT 3. Downcomer, basins lines: Entry - DOUBLE Consult RM if it is necessary to work in water. 4. Respiratory protection to be specified by RM.
ISSUED BY <i>L.H. Walker</i> SUPERVISOR RADIATION PRACTICES ENGINEERING		APPROVED BY <i>O. Schneider</i> MANAGER MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 2	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Downcomer rooms, downcomers (except K), sample rooms, heat exchangers, sewage lift stations (1608) and effluent system outside 105 (lines, 107 basin outfall structure, and crib ditches, etc.).		TITLE - DESCRIPTION EFFLUENT WATER SYSTEM: Operate and maintain the equipment and facilities within the radiation zones of this system.
RADIOLOGICAL CONDITIONS 1. Radiation and contamination from the effluent system lines, valve boxes, basins, downcomers, and vents. 2. Air-borne contamination from dry interior surfaces (downcomers, lines, basin, etc.) and at vapor leaks and vents.		MONITORING 1. Consult RM before removing materials or equipment from the effluent system. 2. Monitoring required during the sampling for a suspected rupture.
INSTRUCTIONS 1. Consult process supervision before entering the effluent system (downcomers, lines, basins, etc.).		PROTECTIVE CLOTHING 1. Zones surrounding the system: Entry - SINGLE Handling on wet equipment - add waterproof gloves Work on contaminated equipment - SINGLE, waterproof gloves - No personal outer clothes. 2. Downcomer Room: Entry - SINGLE, no personal outer clothing Change goggle valve - SUIT 3. Downcomer, basins lines: Entry - DOUBLE Consult RM if it is necessary to work in water. 4. Respiratory protection to be specified by RM.
ISSUED BY <i>L.H. Walker</i> SUPERVISOR ADDITION PRACTICES ENGINEERING		APPROVED BY <i>O. Schneider</i> MANAGER MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 3	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Wash pad, storage area, transfer area, pickup chutes, tube exam pit, cask pad, dummy storage, metal storage, burial ground, soiled clothes sorting room, contaminated tool storage zones, temporary radiation zones and boundaries of all other radiation zones.		TITLE - DESCRIPTION REACTOR SERVICE AREAS Maintenance and processing of materials in and between the reactor service areas as designated.
RADIOLOGICAL CONDITIONS 1. Radioactive gas released from encapsulated fuels. 2. Beta-gamma activity from irradiated materials.		MONITORING RM is required for assessing radiation dose rates for work in any zone until conditions have stabilized and whenever deviation from existing procedure is required. Material and equipment removed from the storage basin shall be monitored.
INSTRUCTIONS 1. Material and equipment handling to be done in accord with Operating Procedures and within posted limits. 2. RM to be consulted prior to the movement of contaminated material between radiation zones. 3. Vehicles and equipment used for transporting contaminated material shall be surveyed after use. 4. The removal of cask lids to be monitored.		PROTECTIVE CLOTHING 1. Movement of material between R.Z. boundaries; If totally contained, NONE. Otherwise - COVERALLS AND GLOVES 2. Burial of waste from storage basin: DOUBLE 3. Decontamination on wash pad or decontamination room: APRON 4. Removal of equipment from storage basin for maintenance: APRON 5. Burial of boxes waste: SINGLE 6. Clothing sorting: SINGLE, No personal outer clothing 7. Hot tool storage: DOUBLE 8. Transfer area: SINGLE, No personal outer clothing
ISSUED BY: <i>L.P. Walker</i> <small>SUPERVISOR, RADIATION PRACTICES ENGINEERING</small>		APPROVED BY: <i>O. Schneider</i> <small>MANAGER, MANUFACTURING</small>

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RADIATION WORK PROCEDURE

NUMBER 4	DATE ISSUED June 1, 1965	AREA ALL IPD 100
LOCATION Both sides of the reactor and the top of reactor (including; winch and basket levels, C & D Mach, Ball 3X, Vacuum Producer, Inner and Outer Rod Rooms and Outer Rod Racks. All near and far levels).		TITLE - DESCRIPTION <u>CONTROL & SAFETY SYSTEM and EXPERIMENTAL AREAS</u> For required maintenance, processing functions, inspection and work associated with test holes, control and safety systems.
RADIOLOGICAL CONDITIONS 1. Radiation and contamination from equipment and material. 2. Neutron radiation from the operating reactor. 3. Radioactive gas and air-borne contamination from gas leaks, effluent vapor, improper air balance and/or work in progress.		MONITORING REQUIRED: 1. When removing material, equipment and test samples from the reactor. 2. When breaking lines or gas seals. 3. During startup. 4. All work affected by the transfer of 3X balls.
INSTRUCTIONS 1. Consult process supervision before entry into the subject zones. 2. Isolate the reactor from the gas circulatory system and vent the reactor before breaking a gas seal. In the K's and C reactors, open one or more ball valve and operate the vacuum system during extended work over open channels on or near the top of the reactors. 3. Consult RM before making changes in the original job plan. 4. Leave the top of the reactor area when the reactor screens unless monitored. 5. Use shielding to control radiation beams and plugs to control air-borne contamination at openings to the pile. 6. Neutron badges required during reactor operation.		PROTECTIVE CLOTHING 1. C & D Mach Room & Outer Rod Room: Entry to contaminated zones - SINGLE During rod removal - DOUBLE 2. Top or Reactor Near & Far Levels: Inspection of contaminated zone - SINGLE Removal of material, test samples, or equipment - DOUBLE 3. Ball 3X, vacuum Producer & Inner Rod Room: For all entries - DOUBLE 4. Rod Rack Outside Building: Inspection - SINGLE Rod removal or replacement - DOUBLE
ISSUED BY <i>L. R. Wallis</i> <small>SUPERVISOR, RADIATION PROTECTIVE ENGINEERING</small>		APPROVED BY <i>O. E. Schneider</i> <small>MANAGER, MANUFACTURING</small>

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RADIATION WORK PROCEDURE

NUMBER 5	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Charge face and pit, riser pits and tunnels, and work area.		TITLE - DESCRIPTION CHARGE FACE AND ASSOCIATED ZONES Operate, maintain, and inspect the equipment and facilities within these radiation zones.
RADIOLOGICAL CONDITIONS 1. Radiation and contamination from equipment and material. 2. Neutron radiation from the operating reactor. 3. Air-borne radiation contamination and gas leaks, effluent vapor, improper air balance, and/or work in progress.		MONITORING Materials, removed from the process tubes or channels, except port poles during routine port seating, require monitoring.
INSTRUCTIONS 1. Consult processing supervision before entering the subject zones. 2. Isolate the reactor from the gas circulatory system and vent the reactor before breaking a gas seal. 3. Wear neutron badge for the charge face and the work area during reactor operation (except 'K' work area). 4. Use shielding to control radiation beams and plugs to control air-borne contamination at openings in the reactor.		PROTECTIVE CLOTHING 1. General Work: SINGLE 2. Spline Work: APRON 3. Tube removal: DOUBLE 4. Tunnel: SINGLE 5. Rupture Removal: SUIT
ISSUED BY <i>L. H. Walker</i> SUPERVISOR, RADIATION PRACTICES ENGINEERING		APPROVED BY <i>O. Schneider</i> MANAGER, MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 6	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Discharge area. 'K' area tool dolly rooms.		TITLE - DESCRIPTION DISCHARGE AREA Operate, maintain and inspect the equipment and facilities within these radiation zones.
RADIOLOGICAL CONDITIONS 1. Radiation and contamination from equipment and material. 2. Air-borne radiation contamination from fission products, water products, or from reactor gas.		MONITORING Materials removed from the process tubes or channels require monitoring. Consult RM prior to all entries into the discharge area.
INSTRUCTIONS 1. Consult process supervision before entering the discharge area or the tool dolly room. 2. Isolate the reactor from the gas circulatory system and vent the reactor before breaking a gas seal. 3. Use shielding to control radiation beams at the openings in the reactor. 4. Personnel survey required after exit from the discharge area.		PROTECTIVE CLOTHING 1. General work - Tube Removal: DOUBLE 2. Cap Removal and Buttonup: APRON 3. Rupture Removals: SUIT
ISSUED BY: <i>L.R. Walker</i> SUPERVISOR RADIATION PRACTICES ENGINEERING		PROVED BY: <i>O. Schneider</i> MANAGER MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 7	DATE ISSUED June 1, 1965	AREA All IPD 100
LOCATION Internal portions of the Water Supply System: Filters, Pumps, Basins, and Lines. The Valve Pit. Filter section of Air Supply System.		TITLE - DESCRIPTION WATER SUPPLY SYSTEM and AIR SUPPLY FILTERS To enter "controlled" sections of these systems as necessary to operate and maintain the equipment and facilities.
RADIOLOGICAL CONDITIONS 1. Low-level beta-gamma contamination which has concentrated on the inside of the equipment and filter media. 2. Floor contamination in the Valve Pits.		MONITORING Equipment or material is to be surveyed by RM as it is removed from the system.
INSTRUCTIONS 1. Entry and exit may be made to filter beds after back-washing without monitoring assistance. Foot protection may be left on between filters if no visible material is clinging to them. 2. Establish a zone with step-off pad around any "controlled" section where people, material, or equipment will come out. 3. Thoroughly hose off 181 pumps when raised. Any other equipment upstream of the filters should be flushed before removal and be checked by RM. 4. Remove protective clothing when leaving the "controlled" area. 5. Take a hand-shoe count after working in a "controlled" zone.		PROTECTIVE CLOTHING SINGLE - add waterproof gloves for handling wet equipment.
ISSUED BY: <i>L. R. Wallis</i> <small>SUPERVISOR, RADIATION PRACTICES ENGINEERING</small>		APPROVED BY: <i>O. Schroeder</i> <small>MANAGER, MANUFACTURING</small>

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RADIATION WORK PROCEDURE

NUMBER 1706-1	DATE ISSUED July 1, 1965	AREA 1706-KER
LOCATION Cells, North corridor, dump valve area, hot shop, decontamination facility, soiled clothing storage room, temporary radiation zones and all other radiation zones, including TF-9.		TITLE - DESCRIPTION Operate and maintain the KER in-reactor recirculating systems, sampling system, hot shop and decontamination facility.
RADIOLOGICAL CONDITIONS <ol style="list-style-type: none">1. Radiation and contamination from system lines, tanks and associated equipment and from water leaks in the system.2. Air-borne contamination from dry interior surfaces and from steam leaks at any break in the system.3. Uranium alpha contamination may be present inside TF-9.		MONITORING Monitoring is needed when any process line is broken and for assessing radiation dose rates for work in any zone until conditions have been established and whenever deviation from existing procedure is required. Personal survey is required upon exit from a grossly contaminated area and TF-9. Monitoring required for all entries into TF-9.
INSTRUCTIONS <ol style="list-style-type: none">1. Comply with the IPD Radiation Work Procedure General Instructions.2. Consult with the monitoring service prior to starting work to verify radiological conditions and protective clothing.3. Report skin contact with process water to the monitoring service.4. Respiratory protection is required when specified by monitoring service.5. Gamma pencils are required.		PROTECTIVE CLOTHING <ol style="list-style-type: none">1. Operate sampling equipment and make visual inspection of all pump and valves: <u>LAB COATS RUBBERS CANNER GLOVES</u>2. Work on contaminated equipment: Consult RM.3. Break process lines and work in water: Add waterproof clothing as necessary. Consult monitoring service. Entry over double step-off pad: Add canvas boots to <u>SINGLE</u>.4. TF-9 - <u>SINGLE</u>
ISSUED BY: <i>L. R. Wallis</i> SUPERVISOR, RADIATION PRACTICES ENGINEERING		<i>W. J. Schaefer</i> MANAGER, MANUFACTURING

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RADIATION WORK PROCEDURE

NUMBER 1706-2	DATE ISSUED July 1, 1965	AREA 1706-KER
LOCATION Burial ground, soiled clothes sorting room, contaminated tool storage zones, temporary radiation zones. Loop room and 0' level at 1706-KE (except TF-9).		TITLE - DESCRIPTION <u>Reactor Service Areas</u> Maintenance and processing of materials in and between the 1706 service areas as designated. Operate and maintain all TF loops.
RADIOLOGICAL CONDITIONS 1. Beta-gamma contamination on materials and alpha activity on ruptured fuel elements. 2. Air-borne contamination as generated by the work in progress.		MONITORING Monitoring is required for assessing radiation dose rates for work in any zone until conditions have stabilized and whenever deviation from existing procedure is required.
INSTRUCTIONS 1. Comply with the IPD Radiation Work Procedure General Instructions. 2. Material and equipment handling to be done in accordance with Operating Procedures. 3. All contaminated material must be adequately contained before movement. 4. Vehicles and equipment used for transporting contaminated material shall be surveyed prior to return to normal service. 5. A gamma pencil is required. 6. Respiratory protection is required when specified by monitoring service.		PROTECTIVE CLOTHING 1. Movement of material between R.Z. boundaries: If totally contained: <u>NONE</u> Otherwise: <u>COVERALLS AND GLOVES</u> 2. Burial of waste boxes: <u>SINGLE</u> 3. Clothing sorting: <u>SINGLE N.P.O.C.*</u> 4. Hot tool storage: <u>SINGLE</u> 5. Operate and maintain TF loops. With no rupture: <u>NONE</u> With rupture: <u>SINGLE</u> *N.P.O.C.: No Personal Outer Clothing
ISSUED BY: <i>L.H. Hall</i> <small>SUPERVISOR RADIATION PRACTICES ENGINEERING</small>		APPROVED BY: <i>[Signature]</i> <small>MANAGER MANUFACTURING</small>

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RADIATION WORK PROCEDURE

NUMBER 8	DATE ISSUED November 1, 1965	AREA All 105 Deactivated Areas
LOCATION Area 1: Open radiation zones Area 2: Barricaded zones Area 3: Tagged and sealed locations		TITLE - DESCRIPTION Area 1: 105 building radiation zones, including storage area Area 2: Rear-face and inner rod room Area 3: Reactor block, gas circulation system, process tubes
RADIOLOGICAL CONDITIONS Area 1: Low-level contamination Area 2: Low-level contamination and radiation Area 3: Possible high-level radiation and contamination levels with air-borne contamination problems		MONITORING Consult D-area RM before each radiation zone entry unless a procedure, as described under instruction No. 1, removes this obligation.
INSTRUCTIONS 1. Work within Area 3 locations must be approved by the D-area Reactor Operation manager and must be done on a written procedure covering radiation contamination control. 2. Contact D-area RM to verify radiological conditions before entering a radiation zone. 3. All fixed monitoring systems have been deactivated. 4. Monitoring is required for entry into the storage area if low water is indicated by the water level indicator.		PROTECTIVE CLOTHING Consult D-area RM for clothing requirements before entering a radiation zone.
ISSUED BY SUPERVISOR, RADIATION PRACTICES ENGINEERING		APPROVED BY MANAGER, MANUFACTURING

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6/1/65

EMERGENCY RADIATION WORK PROCEDURE NO. AEC-E-1		PROTECTIVE EQUIPMENT REQUIREMENTS	
VALID FROM: April 1, 1965 TO: Jan. 1, 1966 SUPERSEDES:			
DESCRIPTION OF WORK LOCATION: All Radiation Zones in RLOO Contractor Facilities 1981 Firefighting or Emergency Rescue in Radiation Zones.		HEAD ☐ CAP ☐ HOOD See (3) ☐ WATERPROOF HOOD	
RADIATION CONDITIONS 1. Possibility for high-level dose rates. 2. Possibility for gross alpha and/or beta-gamma contamination. 3. Possibility for airborne contamination. 4. Radiation Zones established prior to emergency are posted.		BODY ☐ NO PERSONAL OUTER CLOTHING ☐ LAB COAT See (3) ☐ ONE PAIR COVERALLS ☐ TWO PAIR COVERALLS ☐ WATERPROOF OUTER LAYER	
RADIATION MONITORING REQUIREMENTS 1. Notify resident, the Radiation Monitoring group (at site if possible); otherwise, get word to RM as soon as possible after the alarm. 2. Ranking supervisor of the Fire Department on the scene is to assume radiation monitoring responsibility for the group until RM arrives, at which time RM will take this responsibility.		FEET ☐ SHOE COVERS ☐ CANVAS BOOTS ☐ RUBBERS ☐ BRITISH LEGGINGS ☐ HIP BOOTS	
SPECIAL INSTRUCTIONS 1. Radiation Monitoring will supply necessary monitoring as soon as possible after notification (within one hour). 2. Firemen will carry a high-range HFC meter (100 R/min.) and high range self-reading dosimeters on each fire call. They will maintain training at level sufficient to use the devices for self-monitoring. B-NW's Radiation Protection Department will share the responsibility for this training. 3. Firemen will wear Chemox or Scott Air-Pac mask. The normal protective apparel worn by Firemen while fighting fires offers sufficient protection. Ranking building supervision shall indicate if equipment or facility is considered vital. In his absence, the ranking supervisor of service group is to make this decision. 4. When Radiation Monitoring is not promptly available, Firemen will self-monitor the entry. No entry shall be made where dose rates are too high to be measured. Maximum radiation exposure permitted for emergency purposes is to be based on considerations in AEC Manual Chapter, Appendix 0524 Part III, "Guidance for Emergency Exposure During Rescue and Recovery Activities." Maximum planned exposure shall not exceed 5 rem for the year unless authorized by the person-in-charge who shall be knowledgeable relative to the philosophy of AEC Manual Chapter 0524. 5. Contamination control shall be established at the exit point from the probable contaminated zone. Following an emergency entry, all exposed personnel and equipment shall be held at the control point for RM checkout. 6. Local building safety procedures and instructions regarding Radiation Zone control practices, such as fire fighting instructions for plutonium fires, shall be followed. 7. The Fire Department will consult with RLOO Health and Safety Division representatives in the event any Fireman is undergoing therapeutic treatment involving radiation to determine if this person should receive an emergency dose to effect human rescue.		HANDS ☐ CANVAS GLOVES ☐ LEATHER GLOVES ☐ SURGEON'S GLOVES ☐ RUBBER GAUNTLET ☐ PLASTICIZED CANVAS	
		RESPIRATORY ☐ RESPIRATORS ☐ ASSAULT MASKS ☐ HALF - MASKS ☒ CHEMOK MASKS ☐ OR ☐ FRESH AIR MASKS See (3)	
		METERS ☐ FILM BADGE ☐ GAMMA PENCILS ☐ NEUTRON FILM ☐ NEUTRON PENCILS ☐ X-RAY FILM ☒ SELF-READING PENCILS (600 R) ☐ FINGER RINGS	
		APPROVALS FIRE PROTECTION CONTRACTOR <i>[Signature]</i> GE FACILITY CONTRACTOR <i>[Signature]</i> B-NW FACILITY CONTRACTOR <i>[Signature]</i> MANAGER, RLOO <i>[Signature]</i>	

HW-7000-100 (11-61) AEC-04 HIGHLAND, WASH.

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EMERGENCY RADIATION WORK PROCEDURE NO. AEC-E-2		PROTECTIVE EQUIPMENT REQUIREMENTS	
VALID FROM: April 1, 1965 to: Jan. 1, 1966 SUPERSEDES:			
<u>DESCRIPTION OF WORK</u> <u>LOCATION:</u> RLOO Contractor Facilities or Kadlec Methodist Hospital <u>JOB:</u> RL Medical Contractor to perform emergency work in radiation zones.		HEAD ☐ CAP See (5) ☐ HOOD ☐ WATERPROOF HOOD BODY ☐ NO PERSONAL OUTER CLOTHING ☐ LAB COAT See (5) ☐ ONE PAIR COVERALLS ☐ TWO PAIR COVERALLS ☐ WATERPROOF OUTER LAYER FEET ☐ SHOE COVERS ☐ CANVAS BOOTS ☐ RUBBERS See (5) ☐ BRITISH LEGGINGS ☐ HIP BOOTS HANDS ☐ CANVAS GLOVES ☐ LEATHER GLOVES ☐ SURGEON'S GLOVES See (5) ☐ RUBBER GAUNTLET ☐ PLASTICIZED CANVAS RESPIRATORY ☐ RESPIRATORS ☐ ASSAULT MASKS ☐ HALF - MASKS See (5) ☐ CHEMOK MASKS ☐ FRESH AIR MASKS METERS ☐ FILM BADGE ☐ GAMMA PENCILS ☐ NEUTRON FILM ☐ NEUTRON PENCILS ☐ X-RAY FILM ☒ SELF-READING PENCILS, Hi Range ☐ FINGER RINGS	
<u>RADIATION CONDITIONS</u> 1. Possibility for high-level dose rates. 2. Possibility for gross contamination inside the affected area or on personnel removed from the affected area. 3. Possibility for airborne contamination.			
<u>RADIATION MONITORING REQUIREMENTS</u> No radiation entry without specific advice from associated Operating or Monitoring group relative to radiation and other safety hazards to be encountered.			
<u>SPECIAL INSTRUCTIONS:</u> - Upon notification of medical emergency involving radiation: 1. Record information given. 2. Have caller notify responsible Operations and Monitoring and report to scene of action. 3. Take action indicated. 4. Entry is not permitted into an area where the dose rate and extent of other serious hazards are unknown. 5. Wear recommended safety protective clothing and equipment. 6. Final checkout survey must be performed by Radiation Monitoring. 7. Assure that all pertinent data are recorded regarding personnel involved. 8. Personnel or equipment which, of necessity, must leave the immediate area without a release survey being made should be isolated as much as possible and held for a later survey by Radiation Monitoring.		<u>APPROVALS</u> MEDICAL CONTRACTOR <i>W. E. Johnson</i> GE FACILITY CONTRACTOR <i>W. E. Johnson</i> B-NW FACILITY CONTRACTOR <i>J. J. Lawrence</i> MANAGER, RLOC <i>D. J. Williams</i>	

BM-7800-109 (12-61) AEC-GE RICHLAND, WASH.

BM-5300-023 (11-56) AEC-GE RICHLAND, WASH.

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EMERGENCY RADIATION WORK PROCEDURE NO. AEC-E-3

VALID

FROM: April 1, 1965 TO: Jan. 1, 1966 SUPERSEDES:

DESCRIPTION OF WORK

LOCATION:

All Radiation Zones in RLOO Contractor Facilities

JOB:

Security Patrol responsibilities in relation to radiation incidents and occurrences.

RADIATION CONDITIONS

Unspecified. Radiation Zones are posted. However, in the event an emergency or disaster condition occurs, it must be assumed that Zone boundaries are no longer valid, until checked by Radiation Monitoring personnel.

RADIATION MONITORING REQUIREMENTS

Patrol to request Radiation Monitoring assistance as soon as possible after receipt of emergency call.

Radiation Monitoring will specify requirements and establish conditions upon arrival.

SPECIAL INSTRUCTIONS:

- Patrol shall facilitate the entry of Fire Protection, Radiation Monitoring, and other authorized personnel through barricades so that a minimum delay is required to utilize qualified manpower.
- Personnel involved in an emergency situation are to be kept in the vicinity up-wind of the building or area involved pending survey and final disposition by Radiation Monitoring.
- All personnel are to be barred from casual entry into any area or zone classified as an emergency zone by Radiation Monitoring or the Emergency Director.
- Patrol personnel should not enter any emergency zone until radiation and other safety conditions have been established.
- Fire Protection Operation should be notified immediately in the event emergency rescue work is required.
- Additional protective clothing and safety equipment to be specified by Radiation Monitoring and operation personnel as conditions may require.
- Final survey checkout must be performed by Radiation Monitoring.

PROTECTIVE EQUIPMENT REQUIREMENTS

HEAD	☐ CAP See (6)
	☐ HOOD
	☐ WATERPROOF HOOD
BODY	☐ NO PERSONAL OUTER CLOTHING
	☐ LAB COAT See (6)
	☐ ONE PAIR COVERALLS
	☐ TWO PAIR COVERALLS
FEET	☐ WATERPROOF OUTER LAYER
	☐ SHOE COVERS
	☐ CANVAS BOOTS
	☐ RUBBERS See (6)
HANDS	☐ BRITISH LEATHERS
	☐ RUB BOOTS
	☐ CANVAS GLOVES See (6)
	☐ LEATHER GLOVES
RESPIRATORY	☐ SURGEON'S GLOVES
	☐ RUBBER GAUNTLET
	☐ PLASTICIZED CANVAS
	☐ RESPIRATORS
EYES	☐ ASSAULT MASKS See (6)
	☐ HALF - MASKS
	☐ FULL FACE MASKS
	☐ FRESH AIR MASKS
	☐ FILM BADGE
	☐ GAMMA PENCILS
	☐ NEUTRON FILM
	☐ NEUTRON PENCILS
	☐ X-RAY FILM
	☐ SELF-READING PENCILS See (6)
☐ FINGER RINGS	

APPROVALS

SECURITY PATROL CONTRACTOR
W.E. Johnson

GE FACILITY CONTRACTOR
W.E. Johnson

B-1W FACILITY CONTRACTOR
W.E. Johnson

MANAGER, RLOO
W.E. Johnson

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DATE ISSUED

3/15/66

RADIATION WORK PROCEDURE

NUMBER 105-KE-1	DATE ISSUED March 15, 1966	AREA 100-K
LOCATION X-2 Level, Neutron Spectrometer Facilities	TITLE - DESCRIPTION For operation and maintenance of the neutron spectrometers	
RADIOLOGICAL CONDITIONS <ol style="list-style-type: none">1. Radiation and contamination from stored equipment and material2. Radiation from the neutron spectrometers3. Radioactive gas and airborne contamination from gas leaks, effluent vapor, improper air balance and/or work in progress		MONITORING <ol style="list-style-type: none">1. Dose rates will be established by DUN Radiation Monitoring for all entries.2. Monitoring is required when the spectrometers are operated or the shielding is modified in a manner which may change the background radiation levels from those shown on the survey map in the Radiation Monitor's office.
INSTRUCTIONS <ol style="list-style-type: none">1. PNL personnel will immediately notify the KE Processing Supervisor of their arrival and intent to enter the level.2. After obtaining the facility key, contact Radiation Monitoring to obtain dose rates and clothing requirements.3. Contact Radiation Monitoring at any time work plans or methods are changed which will affect established dose rates or radiation levels.4. Record results of most recent survey on map in Radiation Monitor's office.5. All radiation zones in excess of 10 mRem will be identified by appropriate signs and/or barricades.6. Upon terminating work, or if the facility is not being attended, PNL personnel are to lock the facility door and report the facility status to Radiation Monitoring and the Processing Supervisor.7. Planned maintenance on in-reactor components or major maintenance on out-of-reactor components requires advance notification.8. Neutron badges required during reactor operation.		PROTECTIVE CLOTHING As specified by Radiation Monitoring
ISSUED BY: <i>Lynn R. Wallis</i> SUPERVISOR, RADIATION MONITORING		APPROVED BY: <i>[Signature]</i> MANAGER, MANUFACTURING

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DETERMINATION OF PERSONNEL DOSE FROM SKIN OR CLOTHING CONTAMINATION

SUPERSEDES ISSUE DATED
New

Whenever skin or clothing contamination is discovered which has a dose rate high enough to contribute significantly to the dose received by the individual, our first concern is to remove the contamination to stop the exposure of the individual. A thorough and accurate evaluation of local exposures from contamination requires many bits of information which are often not recorded even though they were obtainable at the time. In cases of high level skin contamination, detailed measurements may have to be sacrificed in the interests of dose reduction, however we should attempt to obtain as much information as possible under the circumstances.

The following procedure outlines methods for obtaining survey instrument measurements and other data, and for using these in making estimates of dose rates.

I. Obtaining Data

A. Contamination on the Skin

1. If contamination levels are high enough to contribute significant dose, as quickly as possible, obtain survey instrument (preferably CP) readings, both ow and cw with the end of the chamber centered on the source, and as close to the source as possible. Note the time. Estimate the source size.
2. Immediately attempt to remove the source intact, with masking tape. If the source is successfully removed, wrap and identify it properly, and save it for further study. If attempts to remove the source intact are unsuccessful, decontaminate the skin area using approved methods and techniques.
3. Notify supervision responsible for radiation protection.
4. Record as many of the following facts as can be determined under the circumstances:
 - a. Type of instrument used.
 - b. Source size (see II below).
 - c. ow deflection (inst. as close as possible).
 - d. cw deflection (inst. as close as possible).
 - e. The time the readings were taken.
 - f. The time the contamination was discovered.
 - g. The time the dose rate was reduced, and to what level.
 - h. The location of the skin area affected.
 - i. Estimate of the time when the contamination was received.
5. Label and preserve the source if possible, for future study.

B. Contamination on Clothing

1. When contamination levels permit, the radiation monitor should evaluate the radiation exposure due to the contamination while the clothing is being worn. If dose rates are high, remove the clothing (or contaminated portion) as quickly as possible to stop exposure of the individual. Care should be exercised during removal to prevent the transfer of contamination to the skin.

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or other clothing, and to preserve the source intact for further investigation as necessary to establish the dose received. The proper identification and segregation of the protective clothing involved is the responsibility of the radiation monitor at the site. Identify the outer side, locate the source, and mark it. Note the time the clothing was removed, and what clothing if any was between the contaminated clothing and the skin.

2. Working on a papered area and exercising care to avoid spreading contamination or altering the source, take the following instrument readings (preferably CP):
 - a. Inside garment with distance and shielding duplicated as closely as possible, screen centered on the source, ow and cw.
 - b. Outside garment, screen in contact with and centered on the source as nearly as possible, ow and cw.
 - c. Outside the garment, screen at 6" from the source, ow and cw.
3. Record the following information:
 - a. Type of instrument (preferably CP).
 - b. Estimate of the source size (see II below).
 - c. Six instrument readings (2 above).
 - d. Time the readings were taken.
 - e. Time contamination was discovered on the man.
 - f. Time the clothing was removed.
 - g. Estimate of time when contamination occurred.
 - h. The location of the skin area affected.
 - i. Probable source - skin distance.
 - j. Description of shielding materials between source and skin.
4. Label and preserve the source in case further studies are required.

II. Estimating the Source Size

The source size can be determined quite accurately as follows:

1. Put an aluminum sheet about 100 mg/cm^2 in thickness, with a hole having an area of 1 cm^2 over the source. Center the instrument chamber over the hole and note the deflection. Remove the aluminum sheet without moving the instrument. If the reading remains the same, the source is less than 1 cm^2 in area. Report area as $< 1 \text{ cm}^2$. If the reading increases on removing the aluminum shield, the source is $> 1 \text{ cm}^2$ in area -- go to step (2).
2. Center the instrument chamber over the source and slowly insert the edge of the aluminum shield under the chamber, until the reading starts to drop off. Mark the location of the edge of the aluminum sheet. Repeat the above from other directions until the edges of the source are defined. Report the area of the source in cm^2 .

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III. Estimating the Dose Rate to the Skin

The dose rate to the skin can be estimated from the open window instrument deflection by the use of the correction factors below. The correction factor is a function of the source size.

Use these factors together with the open window deflection as obtained in IA4c above for skin contamination, and IB2a above for clothing contamination.

Source Diameter	OW-CP correction factor (Dose rate at screen) (Instrument deflection)
0.5" or less	100
0.75"	50
1.00"	30
1.5"	20
2"	10
3" or greater	5

Whenever the initial estimates indicate that a significant localized exposure may have been received, and the source has been preserved, submit the source to External Dosimetry, HLO, for autoradiographing.

IV. Submitting Samples for Autoradiographing

- A. The Radiation Protection Operation, HLO, is responsible for performing all autoradiography work necessary for dosimetry determinations.

When autoradiographs are necessary to determine personnel exposures to contamination, contact one representative of the Radiation Protection Operation, HLO, using the call list below:

	Phone
1. External Dosimetry Operation	3645, 3664, 3625
2. R. H. Wilson (home)	JU 2-7754
3. B. V. Andersen (home)	WH 6-6445
4. H. V. Larson (home)	WH 5-5362
5. A. J. Stevens (home)	WH 3-3783

Indicate to the person contacted, how soon the result is needed; if results are not actually needed on a rush basis, don't ask for rush handling, because overtime will be used when necessary.

Either the requesting operation or the Radiation Protection Operation, HLO will provide transportation for the source, depending upon the urgency and availability of personnel; this should be clarified during the phone contact.

1 CP correction factors revised 5/10/61.

2 Call list revised 5/10/61.

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- B. Attach the following information to the source if possible; this will materially speed up the filming.
1. Name of instrument used (preferably CP)
 2. WO and WC readings, source-screen distance as short as possible
 3. WO and WC readings, source to screen distance 6"
 4. The time the above readings were taken
- C. Wrap the source in heavy paper, sealing all openings, and affix a radioactive label to the package. Prepare an RSR to cover the shipment.
- D. The sample is to be delivered to the Radiation Monitoring office, 3707-C Building, 300 Area.
- E. Results can normally be expected in 24 hours from the time the sample is delivered to the 3707-C Building; however, in cases where decay is important, or in cases of relatively cold sources where the film exposure time may be long, more than 24 hours would be required. The results will be reported to the requesting operation by phone as soon as they are obtained, and will be verified in writing.

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RADIOLOGICAL PROTECTIVE CLOTHING

G. Removal of Clothing (Cont'd)

1. Remove outer gloves and place in the hamper.
2. Unbutton hood, remove, and place in hamper.
3. Remove the mask by grasping the exhaust valve and lifting upward. Place the mask in the box provided.
4. Untape boots. Tape to waste, not to clothing hamper.
5. Standing sideways to the red pad, using the bootjack if necessary, remove the boot from the foot nearest the pad, and step on the pad with that foot. Do not allow the boot to dangle over the pad, place it in the hamper.
6. Remove the other boot and place that foot on the pad and the boot in the hamper. Do not allow the boot to be over the pad, as contamination may drop off on the pad.
7. Unbutton outer coveralls. Remove your arms from the coveralls, and slide the coveralls down to your knees, letting them turn inside out. Pick up the coveralls and place them in the hamper. Handle the inside of the coveralls only.
8. Proceed to the green step-off pad.
9. Remove all remaining tape at wrists, ankles, and/or down the front of the coveralls and place it in the wastebbox, not in the clothing hampers.
10. Remove the inner gloves, touching only the inside surfaces barehanded, place them in the hamper.
11. Remove personnel meters, and place them in clean location.
12. Standing sideways to the pad, remove the canvas boot from the foot nearest the pad, and step on the pad with that foot. Do not hold the boot over the pad.
13. Remove the canvas boot from the other foot and step on the pad with that foot.
14. Unbutton inner coveralls and remove your arms from them and push the coveralls down, inside out, to the ankles.
15. Pick up the coveralls and place them in the hamper. Handle only the inside of the coveralls.

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RADIOLOGICAL PROTECTIVE CLOTHING

G. Removal of Clothing (Cont'd)

16. Get a contamination survey if required. Following work in areas of high level contamination, surveys of the outer apparel before it is removed may be required to be certain that high level deposition has not gone undetected.

17. Take a handcount.

18. Put on personal clothing.

Normally, all protective clothing should be removed when leaving the zone and placed in the containers provided. In those cases where the job involves transporting material out of the zone, the inner coveralls and gloves may be left on. Turn up the cuffs if necessary to prevent spreading contamination to the shoes or floor. Remember that the coveralls and gloves may be contaminated; do not touch clean items. On completion of the job, return the coveralls and gloves to a used laundry hamper.

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SUBJECT

RESPIRATORY REQUIREMENTS FOR TUBE REPLACEMENT

General

The question of respiratory requirements during process tube replacement can be a significant problem because of wide variations in work methods between operations and between those responsible for radiation protection practices. This procedure is intended to standardize, throughout IPD, the work practices associated with tube replacement which may affect the quantity of airborne contamination and thereby standardize respiratory protective requirements as well.

Procedure

1. Respiratory protection will be worn:
 - (a) If activity concentrations, as indicated by air sampling techniques, exceed the limits specified in RCS #2.3
 - (b) On the rear face of the reactor during the broaching operation
2. Respiratory protection is not required if the following conditions are met (providing 1(a) is satisfied):
 - (a) Plugging of open channels - Open tubes and channels plugged front and rear after removal of nozzles. (All open channels to be plugged except those being worked on.)
 - (b) Push poles, cables, and other equipment removed from the reactor block flushed or wiped clean. (Compression bar flushing device should be installed and used according to procedures of Special Outage Services Operation.)
 - (c) Broaches cleaned and placed in closed container upon removal from reactor. Splitters stored under water until decontaminated or packaged for shipment.
 - (d) Work platform sprays in operation throughout the tube replacement job or reactor front and rear faces washed down on a frequency which will prevent contamination from becoming airborne.

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SUBJECT

RECOVERY FROM A CONTAMINATION SPREAD

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GENERAL

Many of our radiological standards and procedures have been developed for the sole purpose of keeping radioactive materials within established zones. However, in spite of our best efforts to prevent it, contamination is occasionally spread as a result of personnel or equipment failures, or other circumstances beyond our control. Contamination spreads may range in severity from the near trivial (such as very low level contamination confined to a small area) to problems of major importance involving large areas and large numbers of people.

Obviously the specific action to be taken following a contamination spread is dependent upon the location, extent, and levels of contamination in that specific case. However, some generalizations can be made which would apply in principle to any case of uncontrolled contamination spread, since the same objectives must be met regardless of the severity. These objectives are:

1. To minimize radiological effects on humans.
2. To prevent further spread which would further complicate recovery.
3. To return affected areas to normal status insofar as possible.

The following procedure outlines the proper course of action to be applied following a contamination spread. This procedure would of course be simplified to the extent necessary to meet the needs of the specific situation.

1. Avoid Overexposure of Personnel

- a. Take immediate action in support of personnel already exposed, to minimize effects of such exposure. This will include prompt evaluation of their probable condition and treatment where indicated. If inhalation or ingestion hazards exist, or if injuries are involved, follow up the possibility of internal deposition in the normal manner.
- b. Check the affected area to determine whether high dose rates are present. If high dose rates are present, remove personnel as quickly as possible to avoid overexposures. If high dose rates exist in essential facilities which must be manned, replace the original personnel with as few people as possible, who are adequately dressed, masked, and monitored. These people may receive exposure to the extent described in Radiation Control Standard 1.2, "Personnel Exposures Under Emergency or Unusual Conditions".

2. Stop Uncontrolled Movement of Personnel Until the Extent and Severity of the Spread can be Evaluated

- a. Strict control of movement out of the affected area is necessary to restrict further spread of contamination. In the event of an extreme situation, however, personnel should be evacuated to a location known to be safe from further risk, but restrained to the area thus intentionally contaminated pending restoration of contamination controls.
- b. Movement into the affected area should be stopped except for those persons directly involved in regaining control.

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3. Determine the Source if Possible, and Impose any Controls Necessary to Stop Further Emission and Spread of Radioactive Material

4. Roughly Define the Extent of the Spread

Determine whether:

- a. Within building
- b. Within the exclusion area
- c. Within the plant limited area
- d. Outside the plant limited area

If the contamination may have originated outside the plant limited area, or if the source is known to be within the plant limited area but the spread might reasonably be expected to extend beyond the plant limited area fence, other monitoring groups must be informed immediately, through the channels described in Radiation Control Standard 10.8, "Radiological Communications". In such cases, the Radiation Protection Operation, HLO, will be in charge of the overall radiation protection aspects of the situation. In cases where the spread originates within and is confined to a plant limited area, the supervisor responsible for radiation protection in the plant involved will be in charge of directing recovery.

5. Establish a Control Perimeter

Establish a control perimeter around the known contaminated area. Existing fences and natural barriers should be utilized. This perimeter should include barricades at all routes of access to the affected area. Locate this perimeter as close to the affected area as practical, but at the same time minimize the number of traffic barricades required. Request assistance from Patrol in establishing the barricades.

a. Stop all traffic into the affected area except for that necessary for survey and recovery, and insure that all personnel and vehicles leaving the affected area have been surveyed and released.

b. Radiation monitoring personnel should establish a survey station at each traffic barricade on the control perimeter.

6. Make a Detailed Survey from the Control Perimeter, Back Toward the Contaminated Area

a. As personnel and vehicles are encountered, release them or hold them for decontamination.

b. Released vehicles, material and equipment should be tagged with release labels so they may be later identified.

7. Adjust the Control Perimeter as the Detailed Survey Progresses.

a. Interested supervision including members of Security and Patrol should be kept informed of the progress of the survey.

b. Facilities and equipment should be freed for use as quickly as possible.

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8. Establish a Temporary Radiation Zone Barricade at the Edge of the Contaminated Area when it is Established
 - a. Isolated specks or spots of low level contamination may be encountered which are not related to the incident. Do not make the controlled area larger than necessary by including these isolated spots; look for the edge of the generally contaminated area.
 - b. All areas which are generally contaminated to 500 c/m or greater, and all areas where dose rates exceed 5 mrem/hr must be included within the temporary Radiation Zone. (See Radiation Control Standard 4.1, "Radiation Zones").
9. Establish Normal Radiation Zone Controls Over the Affected Area when it has Been Defined
 - a. Remove all remaining unessential personnel.
 - b. Properly equip remaining essential personnel, or replace them with men who are properly equipped. Be sure to provide necessary monitoring.
10. Recover the Area
 - a. Decontaminate and release as much of the area as is economically feasible. (See Radiation Control Standard 4.1, "Radiation Zones", and Radiation Control Standard 5.1, "Release From Radiation Zone Status").
 - b. Establish the remainder as permanently controlled areas.
11. Document the incident as justified by its severity. In minor cases, the radiation occurrence report is sufficient; in severe cases, a formal documentation would be warranted. (See Radiation Control Standard 10.7, "Radiation Occurrence Reports", and Radiation Control Procedure 6.1, "Formal Investigation of Radiation Occurrences").

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CONTAMINATION MONITORING

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I. General

Contamination monitoring consists of identifying the type and measuring the quantity of both fixed and removable radioactive materials which exist in locations where they may be harmful to personnel or where they may interfere with production or laboratory operations. It is often necessary to determine if radioactive contamination is fixed or removable, especially if release limits are involved. Fixed contamination may create a radiation problem, depending on the level of the contamination. Removable contamination, besides creating a possible radiation problem, is a potential source of internal contamination to personnel.

II. Direct Surveys(A) Beta-Gamma

- (1) The survey instrument used is dictated by the contamination levels and type of radiation present. (Descriptions and capabilities of available instruments are to be found in Section 8 of this manual.) The following instruments may be used for direct beta-gamma contamination surveys:
 - (a) G-M meter with conventional detector
 - (b) G-M meter with mica window detector
 - (c) Ionization chamber instruments - Samson, CP, Juno
 - (d) Scintran with G-M or scintillation detector
- (2) To locate contamination, keep the beta shield open, hold the detector or chamber as close as practical to the surface being monitored, and scan the entire surface.
- (3) Pass the probe over every object and surface that is to be monitored, but avoid actually touching objects with the probe.
- (4) For low level contamination monitoring, proceed slowly and carefully. Accuracy is much more important than speed. Whenever a reading is taken, stop and hold the instrument still long enough to let the meter reach its maximum deflection (about 3 to 10 seconds, depending upon the particular instrument being used). Also, when switching from one scale to another, allow sufficient time for the instrument to come to equilibrium (3 to 10 seconds).
- (5) If the source of radiation is not readily apparent, try to locate it by moving the instrument slowly in a systematic search for the highest radiation level. (Side shielding of the probe is often helpful.)
- (6) Upon locating the source, take a reading at near-contact (< 1 inch). Be sure that the open window of the probe or chamber is directed toward the radiation source.

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- (7) Record the results, noting the distance of the instrument relative to the object or surface being monitored. Also indicate the type of monitoring instrument being used. (Example: 10 mrad/hr, beta shield open, at 1 inch, Juno.)
- (8) If a field of radiation is located that causes the meter to go off scale on the highest range, determine at what distance an on scale reading is possible and record. Obtain a higher range instrument for further measurements.
- (9) Post radiation warning signs, if appropriate, indicating the presence and the magnitude of the radiation. Tag and mark contaminated equipment.

(B) Alpha Surveys

- (1) Detection of alpha contamination requires tedious, meticulous survey techniques. An alpha calibration source should always be used to establish relative audible signals during the survey.
- (2) Alpha activity should be reported in disintegrations per minute per area of the detection element. (Example: 2000 d/m/75 cm² when using the Hanford portable poppy.)
- (3) Since alpha particles have very short ranges in air, the detector should be held as close as possible (about 1/4 inch) to the surface being checked. The detector should be moved slowly across the surface for maximum sensitivity. If the surface is irregular, a smear survey may be the only way that the item can be monitored, which is not an indication of fixed contamination.

III. Smear Surveys

- (A) In the event that a high radiation background exists where a low level contamination survey is desirable, or a surface is inaccessible to survey instruments, a smear survey may be taken. It is possible to detect removable contamination by wiping a clean material such as absorbent paper or filter paper over the surface in question.

If the smear procedure is carefully controlled, the wipe sample is nominally taken to represent 10 per cent of the removable contamination. The amount of contamination picked up by a sample of this kind depends upon the monitor's technique, the type of material used, the chemical and physical composition of the contamination, and the surface condition of the contaminated object. For a general contamination survey, the type of material used for the smear and the surface being wiped will determine the degree of pressure used; in any case, the sample paper should not tear. The standard smear procedure is

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to lightly wipe a 12 square inch surface area. (Example: 1" x 12" or 3" x 4".)

(B) Smears may be evaluated by one of the following methods:⁽¹⁾

- (1) Count on the first (top) shelf of the laboratory beta-gamma counter. (This method is used for very low level contamination.)
- (2) Read the smear with a mica window G-M probe as close as possible without touching it.
- (3) If soft beta contamination (beta energy < 0.17 Mev max.) is not to be expected, the smear may be read with a standard G-M probe.
- (4) If tritium is suspected to be present as the main contaminant, smears must be counted in an open walled ionization chamber, such as the Pete. It is extremely important that the smear medium be free from lint and other foreign material to insure against spurious count.
- (5) It may be necessary to count smears for alpha contamination when off-plant shipments or excess material are involved. (Within the Irradiation Processing Department, alpha contamination is not commonly encountered; therefore, less emphasis is placed on this type of survey.) Alpha smears can be counted in an alpha proportional counter or by utilizing a portable poppy and comparing the count rate with a calibrated alpha source.

(C) For sake of standardization, it is recommended that Whatman 41 filter paper be used for smear material. In the event that several surveys are to be made, each smear should be placed in a separate envelope and data relating to time, date and location of the sample should be recorded on the envelope.

(D) Alternate smear techniques such as the use of clean shoe covers or gloves are recognized as excellent methods to determine the presence of contamination on large floor areas or surfaces such as long lengths of wire or cable. However, these techniques are not readily standardized and therefore will not always yield reproducible quantitative results under field conditions.

(1) Contamination levels are normally reported in counts per minute. If it is appropriate to report approximate levels in disintegrations per minute or units of microcuries, the following counting efficiencies may be used:

- (a) Laboratory counters; use posted geometry factor and correct for source size and back scatter if appropriate.
- (b) Mica window G-M tube (wall thickness 2-3 1/2 mg/cm²); assume counting efficiency of 0.25. (Example: $\frac{2000 \text{ c/m}}{0.25} = 8000 \text{ d/m}$)
- (c) Standard G-M tube (wall thickness ~30 mg/cm²); assume a counting efficiency of 0.05. (Example: $\frac{2000 \text{ c/m}}{0.05} = 40,000 \text{ d/m}$)

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SUBJECT

RADIATION ZONE INJURY PROCEDURE

A. General

In cases of relatively minor injuries involving no risk of life or permanent injury, consideration should be given to controlling the spread of contamination to normally clean areas, and any necessary action should be taken to prevent the deposition of radioactive material in the body.

In case of severe injury involving broken bones, severe bleeding, unconsciousness, shock, intense pain or other symptoms that indicate severe injury, immediate medical treatment takes precedence over contamination control.

B. Minor Injuries

1. The injured should conduct himself in accordance with the following procedure when a minor injury occurs in a Radiation Zone:
 - a. Notify the building radiation monitor and operating supervision immediately. Describe the nature and body location of the injury, identify the zone in which the injury occurred, and state where the injured will be available for a contamination survey. (Cut hand on wire rope at burial ground - meet at first aid).
 - b. Leave the Radiation Zone immediately. Get assistance from others in removing protective clothing if necessary, to be sure that potentially contaminated clothing surfaces do not come into contact with the injury. Damage the clothing if necessary, but keep contamination out of the wound. Follow normal contamination control procedures as closely as possible when leaving the zone.
 - c. Whenever possible, get the object causing the injury out of the zone, and available for survey by a radiation monitor. Handle the object in such a manner as not to change its contamination status. A contamination check of the object causing the injury aids in finding out whether or not the injury has contamination in it.
 - d. Keep any protective clothing which was pierced by the object in causing injury, separate from other protective clothing. The building radiation monitor will want to survey this item of clothing.
 - e. If the injury occurred in a zone inside the 105 exclusion area, wait at the step-off pad for a survey of the injury by a radiation monitor.

If the zone is outside the 105 exclusion area, go directly to first aid, and wait outside the building for a radiation monitor. (Be sure to be where you said in (a) above that you would be available for survey).
 - f. If you arrive at first aid with a skin break injury, and the nurse has not previously been informed, she will ask if the injury occurred in a Radiation Zone, and whether a radiation monitor has surveyed the injury. If the injury was received in a Radiation Zone, the nurse will contact a radiation monitor

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B. Minor Injuries (cont'd)

for a survey if you have not already contacted one. Every skin break injury occurring in a Radiation Zone must be surveyed by a radiation monitor.

- g. If surveys indicate that the wound is not contaminated, the radiation monitor will so notify the first aid nurse, and release the injured to first aid for medical treatment.
- h. If surveys indicate that the wound is probably contaminated, or if evidence of contamination is found, go to the nearest source of cold running sanitary water, and flush the wound while massaging gently toward the injury to promote bleeding. (Severe bleeding is of course serious injury and the procedure for serious injuries would be followed). The wound should be flushed a full five minutes. This procedure is very effective in removing contamination from a wound. After flushing the wound, go with the building radiation monitor to first aid where any further treatment will be directed by an Industrial medical physician.

2. Radiation monitoring procedure in case of a minor injury in a Radiation Zone is as follows:

- a. When notified of an injury in a Radiation Zone obtain the following information:
 - 1. Nature of the injury (cut, puncture, abrasion, etc.).
 - 2. Body location of the injury.
 - 3. Zone where the injury occurred.
 - 4. Relative severity of the injury.
 - 5. Where the injured will be available for survey.
- b. Obtain the required survey instruments. If the injury occurred in a zone where the contamination is predominantly soft-beta emitting, a Samson type survey meter, or a mica-window GM probe will be required. If contamination in the zone involved is predominantly hard beta-gamma emitting, a standard thinwall GM instrument may be used.
- c. Proceed promptly to the survey site designated, which may be the Radiation Zone change station, or the first aid station.
- d. Survey the injury, the object causing the injury, and any clothing pierced by the object in inflicting the injury.
- e. If contamination is found in the wound, or from the status of the object causing the injury it is probable that contamination is present at depth in the injury, direct the injured to flush the injury with cold running sanitary water, massaging gently toward the wound to promote bleeding.

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B. Minor Injuries (cont'd)

- f. Notify Industrial Medicine immediately, stating the area in which the injury occurred (i.e., 100-F Area).
- g. While the injured is flushing the wound, make a thorough personal contamination check of the injured. It is important to avoid carrying contamination to medical facilities.
- h. After flushing is complete, accompany the injured to the first aid station and render assistance as required. The Industrial Medicine physician or nurse will of course direct any further decontamination effort.
- i. If the injury is free of contamination, so inform the nurse and release the injured to first aid.

In cases where the wound itself is believed contamination free, but contamination is discovered on other skin surfaces, the action to be taken will depend on the need for first aid, probable duration of first aid treatment, degree of contamination, and probable duration of decontamination efforts. The first aid nurse or industrial physician should be consulted in such cases.

C. Severe Injuries

In cases of severe injury, immediate medical treatment takes precedence over contamination surveys and contamination control. The following procedure should be followed in these cases:

1. Notify the first aid nurse, the building radiation monitor, and supervision of the operating group immediately.
2. The injured should be made available at once for medical treatment if movement is permitted by approved first aid practices. If the injured is unconscious or for other reasons cannot get out of the zone by himself, others should enter to aid him. If the medical situation is urgent, protective clothing requirements and other radiological controls should be disregarded. The welfare of the injured is the important thing; contamination can be cleaned up later.
3. Whenever possible, the object causing the injury should be brought out of the zone for survey. Handle the object with care to prevent changing its contamination status.
4. Surveys of the injury, the object causing the injury, and any clothing pierced by the object in inflicting the injury, should be made, provided medical treatment is not delayed, and provided the injured is not further distressed as a result.
5. If significant radioactive contamination is indicated on clothing, uninjured skin areas or hair, consideration must be given to preventing spread of the contamination into the wound, or to the first aid station or hospital where it might

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C. Severe Injuries (cont'd)

seriously handicap medical treatment.

6. If surveys indicate that the wound is not contaminated, the first aid nurse should be informed.
7. If surveys of the wound or the object causing the wound indicate that the wound is contaminated or probably contaminated, flushing of the injury, and decontamination should be performed only under the direction of Industrial Medicine personnel.
8. The injured should be accompanied to first aid, or to whatever temporary first aid station may be set up, by a radiation monitor equipped with a mica-window GM, or Samson type survey meter, to provide any monitoring service that Industrial Medicine may request.
9. If the wound is probably contaminated, so inform the Industrial Medicine physician.

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FORMAL INVESTIGATION OF RADIATION OCCURRENCES

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It is mandatory that all occurrences involving personnel exposure to radiation in excess of control limits be formally investigated. Under certain conditions it is also advisable to investigate radiation occurrences when no personnel exposure in excess of control limits occurred. The following material outlines the procedure for the formal investigation of radiation occurrences within the Irradiation Processing Department.

I. Occurrences Involving Personnel Exposure in Excess of Control Limits, or Internal Deposition Affecting the Radiation Work Status of the Individual

- A. A formal Radiation Occurrence Investigation should be held promptly after each such occurrence. The investigation should be conducted by the Level 4 Manager involved, assisted by a committee of which he is chairman, with the Supervisor, Radiological Engineering as secretary. The committee should also include the manager responsible for the radiation monitoring function and the Radiation Analyst of the operation in which the incident occurred. The committee should also include at least one other member from a Level 5 Operation other than the one affected. The Exposure Evaluator, Radiation Protection Operation, Hanford Laboratories, although not an official member of the investigating committee, should be invited to attend these investigations for the primary purpose of contributing official dosimetry data. All official dosimetry for these investigations will be provided by the Composite Dose Studies and Records Operation, Hanford Laboratories. This group will also maintain a consecutive numbering system for all HAPO exposures in excess of control limits. A number should be obtained for each occurrence involving personnel exposure in excess of control limits. This number may be obtained from the Exposure Evaluator (call 3625).
- B. In addition to intra-operation distribution, copies of the report of the investigation should be distributed to individuals with bonafide interest, including:

General Manager - Irradiation Processing Department
Manager - Manufacturing Section
Manager - Radiation Protection Operation, HL
Reactor Operation Managers
Reactor Processing Operation Managers
Manager - Research and Engineering Section
Manager - Process and Reactor Development, Subsection
Manager - Production Operation
Supervisor - Radiological Engineering
Exposure Evaluator - Radiation Protection Operation, HL
Radiation Monitoring Analysts - Processing Operations

Since these reports form an important part of the permanent radiation record, they should contain the names and payroll numbers of personnel involved. Sufficient copies should be sent to the Exposure Evaluator to allow insertion of a copy of the report in the radiation record folder of each employee involved in the occurrence.

All Radiation Occurrence Investigation Reports should be assigned an HW document number for file record purposes.

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IRRADIATION PROCESSING DEPARTMENT

DOCUMENT NO.

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II. Occurrences Not Involving Personnel Exposures in Excess of Control Limits

- A. The extent of investigation of radiation occurrences of this type is left to the discretion of the Level 4 Manager involved. Some such occurrences are relatively minor, have causes readily understood and corrected, and informal treatment is sufficient. Other occurrences of this type may have a large potential for personnel exposure in excess of control limits or involve circumstances of an unusual nature, and prompt formal action is clearly merited. If the action to be taken is not clearly indicated, the Supervisor, Radiological Engineering, should be consulted regarding the potential seriousness of the occurrence.
- B. If a formal Radiation Occurrence Investigation is decided upon, it should be conducted by the Level 5 Manager involved, with the assistance of a committee which includes a Radiological Engineering representative and the Radiation Analyst of the facility involved, who shall serve as secretary. The Exposure Evaluator, Radiation Protection Operation, should be notified of these investigations. He may attend as an observer and will submit the dosimetry statement for the formal report.
- C. In addition to intra-operation distribution, copies of the report of the investigation should be distributed to individuals with bonafide interest, including:

Reactor Operation Managers
Reactor Processing Operations Managers
Manager - Manufacturing Section
Manager - Research and Engineering Section
Manager - Process and Reactor Development Subsection
Supervisor - Radiological Engineering
Exposure Evaluator - Radiation Protection Operation, HL
Radiation Monitoring Analysts - Processing Operations

Since these reports also become a part of the permanent radiation record, they should contain names and payroll numbers of personnel involved. Sufficient copies should be sent to the Exposure Evaluator to allow insertion of a copy of the report in the radiation record folder of each employee involved in the occurrence. These Radiation Occurrence Investigation Reports should also be assigned an HW document number for file record purposes.

- D. Conducting investigations of radiation occurrences which clearly warrant such action is to be encouraged. A large number of investigations held by an operation does not necessarily indicate poor radiation control; rather, it may result from concerted effort to improve radiation control within the operation. For this reason, the total number of investigations of occurrences (which do not involve exposures in excess of control limits) will not be used as a measure of an operator's radiation control performance.

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III. Cause, Responsibility, and Recommendations

- A. In addition to the other information included in the report, the Radiation Occurrence Investigation Report should classify the occurrence as to cause. This cause should be determined by the investigating committee from the standard Cause Responsibility List included in Radiation Control Procedure 6.2.2. Whenever possible, the investigating committee should also determine the Operation or Operations responsible for the occurrence.
- B. One of the prime purposes of each investigation is to determine how reoccurrence can be prevented. The investigating committee should report its recommendations for prevention of reoccurrence.

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RADIATION OCCURRENCE REPORTING

CRITERIA

Radiation Control Standard 10.7 describes those situations which are required to be reported as Radiation Occurrences.

REPORT FORMS

Use Radiation Occurrence Report form A-5300-053 to record gathered facts and in preparation of the report. Use Radiation Occurrence Report, multilith master, form BM-5300-026 (9-63) to issue the final report.

NUMBERING

Each Processing Operation shall number Radiation Occurrence Reports in chronological order beginning with 1 at the start of a new calendar year. The year and letter(s) of the reactor in whose jurisdiction the situation occurred shall be indicated. Thus, the first Radiation Occurrence at KE Reactor during 1964 shall be numbered KE-64-1.

INFORMATION REQUIRED

- A. The Radiation Occurrence Facts must include the date and time of the occurrence and a brief but accurate description of the location of the occurrence. The description section should be used to describe any subsequent transportation or spread to other locations. Check the appropriate box to indicate whether the reactor was operating or not.
- B. The Type of Radiation Occurrence should be indicated by the number and letter of the specific criteria in RCS 10.7 which was used to judge the situation as a Radiation Occurrence, i.e., 2.d. refers to "Nasal smears exceeding 1000 c/m." If more than one criterion is appropriate, they should be indicated in the remaining space.
- C. The complete Description of the occurrence must adequately describe how the situation developed and the course of events while the off-standard condition existed. It must also describe the resulting conditions so that appropriate follow-up action may be taken to correct any future similar situations.
 1. Include in the report all pertinent information about the radiological conditions for all individuals involved so that there is a basis for further radiological measurements. All raw data should be reported in detail. Dose rate information in terms of meter dial readings of both open and closed chamber windows should be recorded. All correction factors used must be clearly shown. Source to instrument distances and source to individual distances are important as well as source size and shape.

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2. The time interval of exposure to the person is of the utmost importance. If this cannot be accurately determined, a time bracket of known times before and after the event must be shown.

Contamination levels and conditions must also be precisely recorded.

3. Positively identify all persons who received or potentially received contamination or exposure at or above the criteria level. Names of individuals should not appear in the description but only in the Employees Involved space. Reference to these individuals should be by means of appropriate footnotes. All radiological data, however, should appear in the description section in such a manner that each individual's exposure may be determined as closely as possible.
- D. The Action Taken should include all steps taken to return the out-of-standard condition(s) to normal. Planned or extended programs to prevent recurrence do not have to be included but may be where such a plan is obvious and necessary.
- E. Personnel Involved are those who have received or may have received contamination or exposure at or above the criteria level. The complete name, payroll number, and payroll suffix must be stated for each employee involved in order that a copy of the occurrence report may be included in his radiation file. All radiological data, however, should appear only in the description section.

EVALUATION

Enter, in accordance with RCS 10.7, values and assignments for:

Severity -	RCS 10.7, Section IV
Cause -	RCS 10.7, Section V
Component Responsible -	RCS 10.7, Section III

APPROVAL

Approval of the report and its evaluation by the Processing Manager is to be indicated by his signature on the master of the final report issued.

DISTRIBUTION

The final report is to be issued within seven days to:

- A. Supervisor, Radiological Engineering - One copy.
- B. Exposure Investigator, RPO, HL (3705 Bldg.) - One copy, plus one copy for each person listed under Employees Involved.

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- C. Manager of the component assigned responsibility for the occurrence - One copy.
- D. Manager of each Processing Operation and Supplemental Crews - One copy each.
- E. Supervisor of each Radiation Monitoring group - Two copies (IPD & N).
- F. Additional copies may be distributed as appropriate.

RESPONSIBILITIES

The Radiation Monitoring group on duty for a facility is obligated to collect and record the INFORMATION REQUIRED. The shift Radiation Monitoring Supervisor should oversee the collection and recording of the INFORMATION REQUIRED, when it is arranged by the Processing Building Supervisor. The prime purpose in overseeing is to assure the accuracy and completeness of the information and to see that it is properly relayed to the facility Radiation Monitoring Supervisor. Except when the facility Radiation Monitoring Supervisor is present, the over-all responsibility is the Processing Building Supervisor's.

All the information available shall be recorded by the group responsible during or immediately following the shift of the occurrence. The recorded information shall be turned over to the facility Radiation Monitoring Supervisor at the beginning of his next working shift.

All communications required by RCS 10.8, "Radiological Communications," are to be completed as scheduled. Some communications may be necessary shortly after an occurrence.

The facility Radiation Monitoring Supervisor is to:

1. be notified at the earliest opportunity by phone or personal contact.
2. coordinate information where it must be gathered from multiple shifts or facilities.
3. prepare and issue the final Radiation Occurrence Report as approved by the facility Processing Manager.

RADIATION INCIDENTS

In cases where formal investigations of occurrences are required because of their classification as Radiation Incidents according to RCS 10.7, Section I, the Radiation Occurrence Report should be completed and issued except for cause and responsibility assignments. It will serve as source material for the investigating committee. In place of a severity number, the words "Radiation Incident" shall be inserted.

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RADIATION OCCURRENCE REPORTING

GENERAL

The effectiveness of the radiation control program in the Irradiation Processing Department can materially influence production, cost, safety, and employee morale. Therefore, it is important that management be kept informed of any undesirable situation regarding radiation control. The proper method of supplying this information is through the use of a Radiation Occurrence Report. The Radiation Occurrence Report also serves as a personnel radiological record in the radiation protection system.

Other Radiation Control Standards and Procedures may be required in determining actions needed in conjunction with Radiation Occurrences.

RCS 10.5, "Radiological Records"

RCP 4.1, "Decontamination of Personnel and Personal Effects"

RCP 4.2, "Obtaining Samples in Cases of Possible Ingestion or Inhalation of Radioactive Material"

RCP 4.3, "Determination of Personnel Dose from Skin or Clothing Contamination"

RCP 4.5, "Recovery from a Contamination Spread"

RCP 6.3, "Action at the Time of a Radiation Occurrence"

RCP 6.1, "Formal Investigation of Radiation Occurrences"

Other records which have to be prepared include:

1. A Radiation Survey Report or a Routine and Repetitive Survey Record for any survey made of a potential Occurrence but which does not meet the criteria.
2. Skin Decontamination Record card for each case of skin contamination other than effluent vapors whether an Occurrence Report is mandatory or not.

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ACTION AT THE TIME OF A RADIATION OCCURRENCE

Whenever control of exposure to radiation or radioactive contamination is temporarily lost, prompt action should be taken to accomplish the following objectives:

1. Prohibit further radiation exposure to involved personnel.
2. Determine the extent of radiation exposure to all personnel involved.
3. Notify supervision responsible for radiation protection, and representatives of other interested HAPO components, so that further exposures can be controlled, necessary medical treatment can be initiated, and property damage can be limited.

A. Possible Exposure in Excess of Operational Control Limits From a Known Event ¹

1. If the conditions which caused the exposure or contamination still exist, personnel must immediately leave the affected area and isolate it against uncontrolled entry. The affected area shall be re-entered only with adequate radiation monitoring. If feasible, the conditions causing the occurrence should be maintained until radiation surveys are made to estimate the degree of personnel exposure.
2. Notify supervision responsible for radiation protection, and supervision of the personnel affected.
3. Survey the location, if possible, to provide a basis for estimating the magnitude of the dose to all personnel affected.
4. Question personnel involved as to their positions, times, and actions to enable the situation to be reconstructed accurately at a later date.
5. Record all information obtained in the survey log, including dosimeter results, if available.
6. Instruct supervision of the affected personnel, in writing, to remove them from radiation work until further notice. See Radiation Control Standard 1.3 (Removal of Personnel From Radiation Work and Return).
7. Complete the "Radiation Occurrence Report" form. (BD-5900-001)
8. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), parts B2 and C9.

B. Possible Exposure in Excess of Control Limits as Indicated by Personnel Dosimeter Readings ²

In the event that readings from a personnel dosimeter indicate that the individual may have received a radiation dose in excess of control limits, an investigation shall be initiated to determine the circumstances by which the reported dose was received. The following should serve as a guide for the investigator:

I Revised 5/10/61 to delete reference to 7 day limit, personnel meter program and revise nomenclature.

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1. Review the individual's exposure estimate card.
2. Determine the radiation work done by the affected individual during the period of interest, and the planned dose for the individual for that time.
3. Determine whether the personnel dosimeters were mishandled in any way.
4. Examine written procedures, and survey records, and interview R.M. personnel who provided monitoring for the individual during the period of interest.
5. Relay all investigation results to supervision responsible for radiation protection as soon as possible.
6. If it appears that the individual may have received a dose in excess of that planned, instruct supervision of the affected person, in writing, to remove him from radiation work until further notice. See Radiation Control Standard 1.3 (Removal of Personnel from Radiation Work and Return).
7. Report any case where exposure was received in excess of the amount planned on a Radiation Occurrence Report form.
8. Record pertinent information in detail for use on the form "Investigation of Personnel Radiation Monitor Result," or for use at a subsequent investigation.
9. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), parts B2 and C9.

C. Lost or Damaged Personnel Dosimeters

Personnel meter results are the permanent plant record of radiation exposure to employees. Every effort must be made not to lose these dosimeters, and every effort shall be made to recover the film if a badge is damaged. Description and handling of personnel dosimeters is covered in Radiation Control Standard 1.5 (Personnel Dosimeters), and Radiation Control Procedure 1.5 (Personnel Meter and Bioassay Procedures).

1. When a person loses or damages his film dosimeter, a radiation monitor shall be contacted immediately.
2. When it is discovered that personnel dosimeters have been lost or damaged, the person involved should obtain new dosimeters without delay. Pencils should be exchanged if they have been dropped, if they have received any severe jars or jolts, or if they have been subjected to moisture, heat, or severe vibration. Badge film should be changed if it has become wet, if it has been subjected to extreme heat, pressure, or, if for any reason, it is suspected that the film packet may be damaged. This exchange or replacement of personnel dosimeters should be made at once.

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3. If an individual's film dosimeter becomes contaminated, an effort should be made to save the readings. When a badge has become contaminated, the film should be removed immediately, before the contamination adds to the darkening of the film. The packet is removed by breaking through the picture at the top and releasing the slide catch, being careful not to damage the packet itself. The packet shall be surveyed before being taken to the 3705 Building. If the film packet is not contaminated, place it in an envelope labeled with the individuals name, payroll number, the area, add a statement that the packet was removed because of badge contamination. Deliver this envelope to External Dosimetry at the 3705 Building, 300 Area. If the film packet is found to be contaminated, it may be decontaminated with a cloth dampened with water or alcohol. During these decontamination attempts, care must be used not to break, damage, or water-soak the paper wrapping of the film packet. If decontamination attempts are unsuccessful, the Radiation Analyst will prescribe the method of disposal of the film packet and parts of the badge.
4. If a film packet has become wet, it must be kept wet until it is developed; if it is allowed to dry, the reading will be lost. In such a case, tape the paper wrapping shut with masking tape to prevent accidental opening of the packet, and wrap the packet in a small piece of wet cloth. Place the wrapped packet in an envelope labeled "wet film packet" and deliver it promptly to External Dosimetry, 3705 Building, 300 Area.
5. Report any case where personnel dosimeters are lost, or where personnel dosimeter readings are lost on a Radiation Occurrence Report form.

D. Clothing Contamination

1. When contamination levels are low the radiation monitor should evaluate the radiation exposure due to the contamination while the clothing is being worn; however, if the contamination level is high enough to affect the dose rate to the individual, he should be removed from the Radiation Zone at once and the clothing removed immediately. Care should be exercised during removal to prevent the transfer of contamination to the skin, or other clothing, and to preserve the source intact for further investigation as necessary to establish the dose received. The proper identification and segregation of the protective clothing involved shall be the responsibility of the radiation monitor at the site.
2. Handle personal effects which become contaminated as described in Radiation Control Procedure 4.1 (Decontamination of Personnel and Personal Effects) part IV.
3. Determine, if possible, the total time the individual was exposed to the contamination.

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4. Record any survey instrument deflections obtained, together with the type of instrument, distance at which the reading was obtained, and an estimate of the source size.
5. Estimate the dose received by the individual, considering shielding by the clothing and distance. See Radiation Control Procedure 4.3 (Determination of Personnel Dose From Skin or Clothing Contamination).
6. Notify supervision responsible for radiation protection.
7. If initial estimates of the dose indicate that the control limits may have been exceeded, the individual's supervisor should be instructed, in writing, to remove the man from radiation zone work pending evaluation of the dose. See Radiation Control Standard 1.3 (Removal of Personnel from Radiation Work and Return).
8. If film studies are required to establish the received dose, prepare the clothing for shipment, and notify the Exposure Evaluator that the clothing is ready for pickup. The film studies will be performed by RPO personnel.
9. Report any case of personal clothing contamination, or any case where protective clothing is contaminated to the extent that it affects the dose rate of the individual on a Radiation Occurrence Report form.
10. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), part C9.

E. Skin Contamination

In every case where skin contamination is detected, a radiation monitor should be contacted immediately. As soon as skin contamination is reported, the following action should be taken by the monitor:

1. If contamination levels are high enough to contribute significant dose, quickly obtain the maximum reading with a dose rate meter, and immediately attempt to remove the source intact, with masking tape. If the source is successfully removed, wrap and identify it properly, and notify the Exposure Evaluator that the source is ready for pickup. If attempts to remove the source intact are unsuccessful, decontaminate the area using approved methods and techniques. Notify supervision responsible for radiation protection immediately. An estimate of the source size should be made to aid in determining the true received dose.
2. After dose contributing areas have been reduced, make a complete survey of the individual including his clothing. If the individual has already donned his personal outer clothing after working in a grossly contaminated zone, this outer clothing should be removed and another survey made.

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3. While surveying, question the individual involved to determine:
 - a. Radiation Zones in which the individual has worked
 - b. Work done
 - c. The time when the contamination is believed to have occurred
 - d. The date and time the contaminated skin area was last known to be clean, because of a survey, or because the area was washed.
 4. Estimate the dose received by the individual. See Radiation Control Procedure 4.3 (Determination of Personnel Dose from Skin or Clothing Contamination).
 5. If initial estimates of the dose indicate that the control limits may have been exceeded; or that contamination is near an injury, skin break or body opening or may have entered them, instruct the individual's supervisor, in writing, to remove the man from Radiation Zone work until further notice. See Radiation Control Standard 1.3 (Removal of Personnel from Radiation Work and Return).
 6. Continue the decontamination as described in Radiation Control Procedure 4.1 (Decontamination of Personnel and Personal Effects). If decontamination to the minimum detectable limits can not be achieved using the prescribed agents, or because skin damage from the decontamination process appears imminent, notify Radiological Engineering, who will notify a physician so that further treatment may be initiated, and the Exposure Evaluator, HLO. Normally the decontamination should continue until no detectable contamination remains, as determined by survey with the most sensitive alpha and beta particle detection instruments available. In all cases not involving any open break in the skin, radiation monitoring personnel shall make the final survey of skin decontamination and release the person.
 7. Personnel and their personal clothing must be free of detectable contamination (< 100 c/m beta-gamma, < 500 d/m alpha) before they are released to go home, except with the specific approval of responsible supervision.
 8. Record the data of the survey and complete the skin decontamination record.
 9. Complete the Radiation Occurrence Report form.
 10. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), part B2, B3, C1 and C9.
- F. Possible Ingestion or Inhalation of Radioactive Material (Except Noble Gases)
1. Follow Radiation Control Procedure 4.2 (Obtaining Samples in Cases of Possible Ingestion or Inhalation of Radioactive Material).

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2. If it appears that the individual may have inhaled or ingested a significant amount of radioactive material other than noble gases, instruct supervision of the individual involved to remove him from radiation work until further notice. See Radiation Control Standard 1.3 (Removal of Personnel from Radiation Work and Return).
3. Record in detail all results obtained, for future use. Include an estimate of the length of time the man was exposed.
4. Complete the Radiation Occurrence Report form.
5. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), parts B3, C3, C4, and C5.

G. Contaminated Injury

1. Follow Radiation Control Procedure 5.1 (Radiation Zone Injury Procedure).
2. Complete the skin decontamination record card.
3. Record all survey readings taken on the survey record card.
4. Complete the Radiation Occurrence Report form.
5. Notify Radiological Engineering as described in Radiation Control Standard 10.8 (Radiological Communications), parts C2, and C5.

H. Failure of Administrative Control

If personnel perform Radiation Zone work,

1. without adequate timekeeping,
2. without adequate monitoring,
3. without personnel dosimeters,
4. without adequate protective clothing,
5. in violation of the written procedure

the following action should be taken:

1. Instruct involved personnel to leave the Radiation Zone immediately.
2. Notify supervision responsible for radiation protection, and supervision of the personnel affected.
3. Estimate the dose received if unknown. If the incident involves a possible exposure in excess of operational control limits, see Section A of this procedure.

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4. Perform personnel contamination surveys if contamination control is involved. If clothing, skin or internal contamination may be involved, see Sections D, E or F of this procedure.
5. Record all information obtained in the survey log and on the skin contamination card.
6. Complete the Radiation Occurrence Report form.

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RADIATION ALARMS

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GENERAL

A radiation control program is comprised of a balanced utilization of fixed monitoring devices, personnel dosimeters, and personnel monitoring methods and techniques.

Within the limitations associated with stationary devices, monitoring of the radiation levels of specific work locations is augmented by the addition of alarm units. The radiation level at which the alarm is actuated must be based on criteria common to all facilities and compatible with requirements.

Fixed radiation alarms serve two primary functions: 1) to provide warning that dose rates in a given location may be of sufficient magnitude to result in harmful effects to personnel, and 2) to provide warning that dose rates in a given location have increased significantly above background levels to jeopardize compliance with established administrative radiation controls. Distinct and separate alarms must be provided for each of these two functions.

APPLICATION

Within IPD reactor facilities, two radiation alarm systems are utilized; i.e., a Radiation Emergency Alarm and a Radiation Control Alarm. These alarms have also been referred to as the high level or critical alarm and the intermediate level alarm, respectively. Radiation Control Standard 9.6 defines the acceptable alarm devices and the required personnel response. The number of alarm units needed and their placement should be individually determined for each installation. They should provide notification of the high-level radiation to all personnel in the zone and to those who might enter or are proximate to the zone. To ensure maximum reliability of the devices and to further implement the Radiation Protection Program, maintenance and application procedures are given here.

I. Radiation Emergency Alarm

- A. Radiation Detector Locations: To reduce the variables that arise when there is a significant difference between the source-to-detector distance versus the source-to-personnel distance, the desirable locations are shown as (a); acceptable alternates are shown as (b).

Issued by:

L. R. Walker

Approved by:

CC Schneider
Manager, Manufacturing

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1. Front Face

- a. On the work platform center line evenly spaced across the nozzle pattern.
- b. On the rear wall of the work area.

2. Rear Face

- a. On the work platform center line evenly spaced across the nozzle pattern.
- b. On the rear wall near the center of the nozzle pattern.

3. Irradiated Metal Storage Area

- a. On the area center line between center and the pickup chutes as high as possible above the floor.

B. Alarm Trip Settings: The trip setting, detector location, and alarm howler location should be posted at the trip controller and amplifier. The following trip settings apply to detector locations as shown in I-A.

1. Front Face

- a. Work platform - 3R/hour
- b. Work area rear wall - 1R/hour

2. Rear Face

- a. Work platform - 3R/hour
- b. Rear wall - 1R/hour

3. Irradiated Metal Storage Area

- a. Storage area center - 1R/hour
(Installations at the transfer or dummy elevator pit should use the same trip setting)

4. Top of Unit

- a. VSR enclosure surveillance - 3R/hour

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C. Alarm Bypassing: During activities wherein a trip of the radiation emergency alarm is anticipated, temporary disarming of the alarm should be controlled by the following measures:

1. Irradiated Fuel Discharge

a. The CM relay circuit should be used to deactivate the rear-face howler.

2. Spline Removal and Other Causes

a. Circuit to be disabled by the Processing Supervisor. This should be done by use of a "deadman" or a key-lock switch.

b. Annunciation of the imr ed fault in the system should be shown on the control annunciator.

c. Entrances to the involved area should be barricaded and posted. Posting legend should be specific; for example, "Splining Operation - Emergency Alarm Turned Off - No Unmonitored Entry."

D. Performance Testing: The system should be source checked once each month and recorded on Alarm Performance Test, Form 6A. The unit in the reactor rear face is to be checked on the first entry into the discharge area after a reactor shutdown. This should be done regardless of reactor outage frequency.

When necessary, it is acceptable to down-range the pico-ammeter to accomplish a system actuation with the available sources.

1. The performance test should be authorized by the Processing Supervisor on duty after:

a. The location involved has been cleared of personnel other than those involved in the test

b. All building occupants have been forewarned for the test actuation.

2. The Processing Supervisor should verify proper actuation of the howler and record it in the Processing Shift Log book.

3. Tests should be performed during low-building occupancy periods; that is, night shifts or week ends.

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E. Malfunction: Report any malfunction (no response, false alarm trip, incorrect trip setting, etc.) of a radiation emergency alarm system on the precarboned form entitled "Radiation Emergency Alarm," No. 5A.

1. Responsibilities

- a. Processing Supervisor. The Shift Supervisor on duty will initiate the report by having the Subject Section of the form completed. Detach the yellow sheet and send it to the Supervisor, Radiation Practices.

Enter the incident in the Processing shift log by time, date, and location; and include in the remarks section of the Reactor Operations Daily Report.

Initiate corrective action to put the equipment back into proper operation. The oncoming supervisor assume the responsibility for returning the equipment to service and completion of the requirements in Form 5A, if the original shift is succeeded.

When it has been determined that the system is operating correctly, complete the bottom half of the malfunction report form.

Detach the pink copy and forward it to the addressee, Supervisor, Radiation Practices Engineering.

- b. Maintenance. The involved maintenance groups should expedite all needed repair. All work should be done as specified in applicable Equipment Maintenance Standards.
- c. Radiation Practices Engineering. Radiation Practices Engineering will maintain a file of all reported Radiation Emergency alarm malfunctions. Review and evaluation for system defects should be done routinely. Report malfunctions to Radiological Engineering, R&E.

II. RADIATION CONTROL ALARMS

- A. Locations: The following list illustrates fixed monitor installations required to conform with Radiation Control Standard No. 9.6:

1. Front work platform
2. Rear work platform
3. Pickup chutes
4. Wash pad
5. Transfer area
6. Work area
7. Top of unit
8. Experimental level
9. Tube examination pit

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This list is not to be construed as being all inclusive nor is it necessarily applicable to all facilities. As an example, a deactivated tube examination pit would not require a fixed monitor installation.

Approved, portable alarm devices, such as the Sentinel or Gammalarm, may be utilized whenever and wherever a fixed installation may be impractical.

- B. Trip Settings: Trip settings, as required by RCS No. 9.6, should not allow more than a 50% increase in the planned dose. The radiation monitoring supervisor at each facility is responsible for determining the alarm trip settings for each installation. These trip points are to be recorded on the Alarm Performance Test form (6A) in the Routine and Repetative log book.
- C. Performance Tests: The frequency of making source response checks of alarm installation is a function of the occupancy factor. All alarms should be source tested at least once a month. Response checks are to be recorded on the Alarm Performance Test form 6A. Work locations with high occupancy factors, such as the pickup chutes, wash pad, and front work platform should be done on a daily basis. The building survey form (BM-5900-036) provides space for this frequency of performance tests. The radiation monitoring supervisor for each facility should determine the locations requiring the daily source check.

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SUBJECT

RESIDENCE SURVEYS

GENERAL

Residence surveys are those performed on private property. The following conduct is mandatory for monitoring personnel when performing this type survey, since persons involved may be under emotional stress:

1. Be considerate of all private property.
2. Tact and good judgement in all contacts with involved persons is essential.
3. Information concerning survey results is to be given only to those involved by a duly authorized Company representative.

When there is reason to believe that radioactive contamination may have been transported to an employee's home, a residence survey may be requested by a Plant manager or his delegated representative.

A. Survey Request

When a residential survey is requested the following information shall be provided:

1. Employee's name and payroll number.
2. Residence address and telephone number. (Directions for locating residence should be provided if P.O. box or RFD mailing address is given.)
3. Description of the incident requiring the survey, including the type of radioactive contamination to be expected and its probable location.
4. Information concerning the best time to conduct the survey. Normally, the affected employee should be present when the survey is made.
5. The name of the management representative authorizing the survey.
6. Community Relations representative (see Call List #1) shall be informed prior to the survey, and in the event that the Field Survey Crew cannot resolve a problem requiring legal, financial or other management assistance.

Issued by:

L. R. Williams

Approved by:

[Signature]

Manager, Manufacturing

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B. Survey Crew

1. When a residence survey has been ordered, a monitor and one of the individuals on the call list #2 should conduct the survey.
2. If the affected employee is present and is a female or if the employee is absent and only a female member of the family is at the residence, a female employee should accompany the survey team. The person should be conversant with personal survey and decontamination techniques.

C. Transportation

All Locations: A vehicle without Plant identification should be obtained from the bus dispatcher, 1170 Building, phone 6-5266. The appropriate level 4 manager's name and the user's signature is satisfactory for use on the trip ticket.

D. Supplies and Equipment

1. Supplies and equipment taken along for possible use at the residence should include that which is in the residence survey kit stored in a cabinet in the locker room of the 1170 Building. In addition to the kit, a beta-gamma detection meter is stored in the same cabinet adjacent to the kit. The key for the cabinet is on the key board in the dispatcher's window.

The kit includes these items:

Low-level beta source
Masking tape (2 rolls)
Two cloth towels
Rags (1 plastic bag full)
Surgeon's gloves (3 pairs)
10' steel tape
Plastic bags (12 19"x21", Stores stock 37-0550-210)
Receipt book and clip board
Survey note cards (4)
Writing pencils (2)
China marking pencil (2)
Small portable hand vacuum cleaner

NOTE: The only equipment that should be taken to the door at the time of introduction is a GM with earphones. All other equipment shall be left in the vehicle and only removed as necessary.

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E. Survey Action

1. No contamination detected:

The resident should be informed that no radioactive contaminant was found.

2. Contamination detected:

- a. The general nature of the findings shall be explained to the resident. Use tact and judgement to avoid arousing unnecessary fear and anxiety.
 - b. A sample of the contaminant should be obtained by smearing or, if necessary, by gaining permission to remove a contaminated object.
 - c. If feasible, and with the concurrence of the resident, on-site decontamination of household items should be attempted.
 - d. If decontamination is unsuccessful, permission of the resident must be obtained for removal of items for decontamination or replacement as appropriate.
 - e. Receipts shall be given to the resident for any items removed from the premises. Receipts are to indicate the reason for removal; i.e., confiscation, on-plant decontamination, etc. The Douglas United Nuclear, Inc. representative shall retain a carbon copy of all receipts for accountability purposes.
3. Representative of Community Relations shall be informed of survey results.

F. Followup

1. Contaminated material that is confiscated should be sent to the area from where the contamination is believed to have originated. On-plant decontamination should also be performed at that area.
2. Information concerning the status of said material should be communicated to the concerned party within 48 hours of confiscation.

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RESIDENCE SURVEYS

G. Call List

1. Communications:

a. Community Relations

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
E. T. Murphy	2-5302	944-2382
J. A. Nelson	2-5456	947-2792

2. Radiological:

The desired order of call is: The Radiation Monitoring supervisor of the incident area, progressing to group b and c in order, as needed or available.

Group a - Radiation Monitoring

<u>Name</u>	<u>Work Phone</u>	<u>Home Phone</u>
W. G. Westover (B Area)	2-4309	264-2891 (Benton City)
R. J. Meyer (K Area)	2-4660	948-9867
W. J. Tatum (D Area)	2-5774	582-5894
A. E. Brown (300 Area)	3311	943-3757

Group b - Radiation Practices Engineering

L. R. Wallis	2-5360	945-7783
J. H. Soehnlein	2-5130	943-1744
R. H. Smith	2-5162	264-2471 (Benton City)
R. E. Slater	2-5428	946-6226

Group c - Radiological Engineering

P. C. Jerman	2-5488	944-8977
F. E. Owen	2-5525	946-6305
M. L. Smith	2-5871	582-8434

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SUBJECT

DISPOSAL OF PURGE EFFLUENT

SUPERSEDES ISSUE DATED

8-23-57

I GENERAL

Fundamental to the use of the Columbia River to dilute and disperse reactor effluents is an obligation to minimize the wastes released to whatever degree is feasible. Control of waste release is assumed and measurement of wastes is required.

II CONTROL PROCEDURE

- A. Dispose of effluent from a diatomaceous earth purge to the 107 crib, if possible.
- B. Measure the amount of phosphorus-32, arsenic-76, neptunium-239, zinc-65 and chromium-51 in purge effluent that is released to the river, not to the 107 crib.

III MEASUREMENT PROCEDURE

- A. Collect a continuous sample of reactor effluent water during the purge. Adjust sample collection rate so that a total sample volume between one and two gallons will be collected.
- B. Label sample bottles as follows:
 - 1. Reactor
 - 2. Date and time of sample
 - 3. Total volume of reactor effluent represented by the sample
 - 4. Radiation symbol
- C. Deliver samples to Purex Analytical Control Laboratory, 202-A Building, 200 East Area. Routine sample delivery may be used if (1) the dose rate from the samples is 50 mrad/hr or less and less than 100 c/m smearable contamination is present, and (2) routine delivery will take place within three days of sampling time.

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SUPERSEDES ISSUE DATED
 5/21/63

SUBJECT

COOLANT WATER EFFLUENT SAMPLING

I. GENERAL

Reactor coolant effluent samples are analyzed in the Purex laboratory to determine the effluent concentration of certain radionuclides. The primary purpose of the sampling analytical program is to inventory the radioactive materials sent to the river. A secondary purpose of the program is to provide data to evaluate the influence process changes have on the radionuclide concentrations in the effluent.

Radiological Engineering is responsible for designing and coordinating the program and issuing periodic reports. Radiation Practices Engineering will issue procedures and will serve as consultant on problems. Processing Operations are responsible for taking the samples and maintaining the sampling equipment.

There are two types of routine coolant effluent samples sent to the laboratory. The first is called a "Daily Grab Sample." To obtain a representative or valid grab sample, it is necessary to have a free-flowing line from a rear riser and to take the sample without interrupting this flow. The second type of effluent sample is designated as a "Weekly Composite Sample." These samples are also taken from lines to the near and far risers. A solenoid valve installed in a free-flowing line with an electric switch timer is used to periodically sample the effluent.

II. SAMPLINGA. Daily Grab Sample

1. One-quart samples will be taken from each rear riser each day, Monday through Friday (except holidays) that the reactor is operating.
2. Take samples no earlier than 6:30 a.m. and place them in the portable instrument box in time for the sample pickup. Pickup starts 8:10 a.m. at F Area.
3. Take samples only from free-flowing sample lines. If a change in sample line flow rate is necessary, the new flow rate is to be established and the line flushed for at least 1/2 hour before a sample is taken.
4. Record on each bottle label the date and time of sampling as well as the reactor and riser designations.
5. Survey samples and insure compliance with Standard Radioactive Shipment Procedure No. 19.
6. Maintain a reserve supply of quart bottles (store stock No. 57-5155-032) at each reactor. Replace the discolored bottles which have been returned for reuse.

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Approved by:

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B. Weekly Composite Sample

1. Tuesday at each compositing station, replace bottles that are partially filled with effluent water.
2. Record on bottle label the name of the reactor, the date and time the sample collection was started and completed. If the reactor was purged during the sampling period, note it on the label.
3. If the sample bottle overflows, or if the sample is less than 1 quart:
 - a. Discard the sample.
 - b. Resume sampling.
 - c. Indicate on the label the new sample starting period.
 - d. Send a DSI to Radiological Engineering notifying them of the period that the sample was lost or not taken.
4. Do not record the reactor down time.
5. Survey samples and insure compliance with Standard Radioactive Shipment Procedure No. 19.
6. Deliver composite sample bottle(s) to the portable instrument box on Tuesday.
7. The 2-gallon plastic sample bottles will be supplied by the laboratory and delivered to the portable instrument boxes. Chemical reagents have been added and the bottles will be identified with "composite sample bottle" stickers. Do not use substitutes for these bottles.
8. Visually check the performance of the compositing equipment daily and report malfunctions to the process and RM supervisors. The samples should be composited at an average rate of a half ml per minute, or 720 ml/day. The sampling interval should be as short as practical and should be no more than 15 minutes.
9. Samples are collected only during reactor operation:
 - a. Turn off compositing equipment when reactor is shut down, as soon as practical.
 - b. Turn on compositing equipment during the first shift of reactor startup.
 - c. Flush sample lines on startup.
10. Sampling is to continue without interruption throughout purging when reactor is in operation.

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III. ATCOTROL TIMER CALIBRATION

A. Description

The Atcotrol timer is equipped with two dials; the top one indicates the time interval in minutes between sampling periods and the bottom one, the duration of sampling time in seconds. Each dial has a setting pointer that remains at the set position and a traveling pointer that moves to zero and resets automatically. Make interval settings only when the reset switch (on the side of timer) is in "off" position.

B. Timer Adjustment

1. With the reset switch off, set the minutes timer to a 1-minute sampling interval.
2. Adjust the seconds timer by trial and error until the desired volume of water per cycle is collected in a graduated cylinder.
3. Shut off the timer and set minutes dial to the desired sampling interval.

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SUBJECT

MONITORING REACTOR STACK EFFLUENT

SUPERSEDES ISSUE DATED
New

GENERAL

The purpose of sampling the stack effluent is to keep a record of the radioactive emissions to the environs. In the 100 areas this is normally a very small amount, but the capability for measuring it is needed both for the normal small amount of discharge and for large unusual cases of discharge from the 105 stacks.

PROCEDURES - MONTHLYA. Totalizer - Gross Activity Stack Emission

1. Record the cumulated down-stream particulate measurement indicated on the totalizer, the time and the date.
2. Switch the totalizer to "off" and reset to zero.
3. Switch the totalizer to "on" for 1 minute and record.
4. Switch the totalizer on again.
5. Observe and record the measurement indicated on the downstream particulate recorder.
6. Notify instrument maintenance if the 1-minute totalized count varies from the downstream particulate recorder by more than 10%.
7. Send the recorded and calculated information to Radiation Practices Engineering, T-26 Building, White Bluffs, on a Totalizing Counter Report form (forms available from Radiation Practices Engineering).
8. Calculation for curies (Ci) totalized:

$$Ci = \frac{\text{total counts}}{\text{total minutes}} \times \frac{d/m}{c/m} \times \frac{1}{2.22 \times 10^{12} d/m} \times \frac{\text{cfm stack}}{\text{cfm sample}}$$

Assume:

$$1 \text{ month} = 4.3 \times 10^4 \text{ min}$$

$$\frac{d/m}{c/m} = 100 \text{ (or 1\% efficiency)}$$

$$\frac{\text{cfm stack}}{\text{cfm sample}} = 2 \times 10^4$$

Issued by:

L.R. Wallis

Approved by

*[Signature]**[Signature]*

Manager, Manufacturing

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Then:

$$Ci = \text{total counts} \times 2.1 \times 10^{-11}$$

B. DOWNSTREAM PARTICULATE AIR SAMPLE - LONG-LIFE ACTIVITY STACK EMISSION

1. Move the strip paper to a new sampling position.
2. Cut off and trim the sample paper for the past sampling period.
3. Record the date and time removed on the air sample record sheet.
4. Observe the rate of flow of air being sampled indicated on the flow meter.
5. Count the air sample filter in the air sample counter after a 24-hour decay period.
6. Calculate the long-life activity in Ci out of the stack.
7. Report the result to Radiation Practices Engineering, T-26 Building, White Bluffs.
8. Calculation of curies (Ci) long-life particulates:

$$Ci = \left[\frac{\mu Ci}{cc} \right] \times 10^{-6} \frac{Ci}{\mu Ci} \times 2.832 \times 10^5 \frac{cc}{cu ft} \times cfm \text{ stack exhaust} \times \text{total minutes}$$

Calculate $\left[\frac{\mu Ci}{cc} \right]$ as done for all air samples.

Assume:

 $10^5 \text{ cfm} = \text{stack exhaust}$
 $4.3 \times 10^4 \text{ min} = \text{minutes per month}$

Then:

$$Ci = \left[\frac{\mu Ci}{cc} \right] \times 1.22 \times 10^9$$

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SUBJECT

THEORY OF IONIZATION TYPE INSTRUMENTS

SUPERSEDES ISSUE DATED
 New

A. General

Most radiation instruments utilize the ionization chambers principle. Ionization chamber instruments to detect radiations are based on the principle of ionization in gases, that is, the formation of ion pairs as a charged particle passes near atoms in a gas. When an electrically charged nuclear particle, such as an alpha or beta particle or a proton, passes through a substance, it will occasionally come close enough to an atom to ionize it, hence the term ionizing radiation. In this process, one of the atom's electrons (which are negatively charged and moving in an orbit about the nucleus) is separated as a negative ion from the rest of the atom. The atom, with one negative electron removed, is left with a net positive charge, and is called a positive ion. The radiations that are electrically neutral -- x-rays, gamma rays, neutrons -- react with matter and produce ionizing particles which can be detected in the same manner as alpha and beta particles.

The formation of ion pairs is the mechanism by which radiation damages living cells and tissues. This same process provides a means by which radiation can be detected and measured.

All substances will ionize, but gases are best suited for use in radiation monitoring instruments. When a potential difference is applied across the gas in a chamber (normally by connecting a battery to it), the negative ions, usually electrons, move to the positive electrode, and the positive ions move to the negative electrode. Since the chamber is connected to an external circuit, the flow of ions causes an electric current to flow in this circuit. The magnitude of the current depends upon the number of electrons which reach the anode. This current is measured by a very sensitive ammeter which may be noted in the circuit diagram in Figure I.

No ionization, no electron flow in chamber circuit, no indication on ammeter.

radiation through chamber, electrons drift to positive electrode, positive ions to negative wall, current flows in chamber circuit, reading on ammeter.

FIG I

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THEORY OF IONIZATION TYPE INSTRUMENTS

As would be expected, an increase of the voltage across such a chamber will bring about an increase in the flow of electrons or current. The various types of detectors can best be explained by referring to a graphical representation of voltage versus current. Figure II illustrates this relationship. Any actual values of the curve will depend upon the nature and pressure of the gas used and on the structure of the chamber.

FIG II

B. Ion Chamber Action

The speed, or mobility, of the ions in a chamber depends upon the nature and pressure of the gas and the electrostatic force (voltage) on the ions. If this force is not great enough, as in region I of Figure II, some of the ions will recombine and form neutral atoms before reaching the electrodes in the chamber. In the region II there is enough force (voltage) applied so that all of the ions formed reach the electrode and produce pulses. In this region, the current is essentially independent of the voltage applied. The voltage required to reach this constant current is called the saturation voltage. In the saturation region II, a given amount of ionization produces a certain pulse size (current) and the size of the pulse depends only upon the amount of ionization produced by the primary ionizing source in the chamber. This portion of the curve is used in all HM chamber, CP, Juno, Beckman, Zeuto, TP and Neut operations.

C. Proportional Counter Action

If the voltage on the chamber is increased into region III of Figure II the effect becomes different from that in the ion chamber region. The pulses which are now observed are larger than those in the ion chamber region. In the ion chamber instrument the ionizing source caused a certain number of electrons to be freed, which migrated to the anode causing an electric current to flow. In the proportional counter the increase in the voltage will bring about a greater attraction of the electrons toward the positive electrode. The negative ions are thus accelerated more rapidly and gain enough energy to ionize additional molecules in passing. Furthermore,

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these secondary ions may also produce more ions, and so on. If an ion produced in an instrument by the primary radiation gives rise to 999 others, the amplification factor of the chamber is said to be 1000. Amplification factors normally vary from 100 to 100,000. Over a wide range of amplifications, the pulse size is proportional to the energy of the original particle; hence the name -- proportional counters.

The secondary ionizing action of the proportional counter is important in that it becomes possible to count particles of a certain size while rejecting all others. A one MEV beta particle, for example, will produce 50 ion pairs per centimeter of path while an alpha particle will produce 25,000 ion pairs in the same distance. If the amplification factor is 100 in a certain instrument, the alpha particle in one centimeter of path will produce a pulse equivalent to 2,500,000 ion pairs and the beta particle only 5,000. By adjusting the circuit, only the alpha pulses are counted. This principle is applied in the Poppy and Standard alpha counters and the BF_3 neutron counter.

D. Geiger Counter Action

When the amplification factor of an ionization chamber is increased beyond a certain point by increasing the electrical field between the electrodes, ion multiplication spreads so rapidly through the chamber that ionization of all available gas molecules takes place almost instantaneously. (Regions V, Figure II). This is called "discharge" of the chamber. An ionization chamber used in this way is called a Geiger counter. In this instrument the size of the electrical pulse registered is no longer proportional to the number of electrons which initiate it. A single beta particle can trigger the discharge.

In a GM tube the pulse size is essentially constant and the tube is used to measure pulse rate or ionizing particles per unit time from an ionizing source. The maximum pulse rate obtainable is dependent upon the "dead time" of the counter. The negative members of the ion-pairs are mainly electrons, and these reach the central wire anode in a very short time. The positive ions, on the other hand, consist of charged gas molecules which move more slowly toward the walls of the tube, which act as the cathode. These heavy positive ions form a sheath around the anode and prevent another count until they have migrated to the cathode and are neutralized. This, essentially, is the "dead time" and a GM tube will only count pulses received at a rate slower than this "dead time".

FIG III

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The Geiger counter plateau region, (Figure III) is usually from 200 to 300 volts long in the region from about 800 to 1500 volts. The operating voltage is usually chosen so as to be somewhat less than the value at the middle of the plateau because as the tube ages, the breakdown voltage decreases. Ideally the plateau would be horizontal, but in actual practice there is an upward slope. This slope must be small however, if the operation of the counter is to be satisfactory.

If there are any stray electrons in the counter after a discharge, another avalanche (See Figure IV) will be started independent of the external ionizing source. To prevent this phenomenon, the counter is quenched, that is, the voltage is reduced in some manner to below that voltage required to produce a discharge. Quenching may be accomplished by external circuitry adjustment or by adding a quenching gas, usually some organic vapor or halogen to the counter gas used in the tube that prevents the formation of stray electrons. If the voltage is increased beyond the breakdown voltage, the tube will discharge continuously and counting is not possible. Sustained operation in this region will generally damage the tube.

ION CASCADE OR AVALANCHE IN GM TUBES

In a very short period of time, the avalanche will spread through the entire chamber.

Fig. IV

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The life of a GM tube is dependent upon the number of counts that it has received. As long as there is a voltage across the electrodes the tube will count. For this reason the counter should not be left in a high radiation field, nor should a radioactive sample be left in a laboratory type counter. The operating characteristics of the GM counter also prevent its use in extremely high fields of radiation. In such cases, the counter will usually "jam", that is, discharge continuously, and read zero scale deflections. This operating phenomenon is extremely important, particularly in the evaluation of air sample activities.

E. Electroscopes and Electrometers

The electroscope is the simplest and earliest instrument used to detect ionizing radiations. The electroscope in its simplest form constitutes a short, vertical metal rod with a metal sphere or plate at its upper end; to its lower end are attached two small rectangular sheets of gold leaf hanging vertically. If an electric charge is applied to the sphere or plate, it is transferred through the metal to the gold leaves. Since these both now carry charges of the same sign, they repel each other. If the air in the vicinity is ionized by radiation, it becomes an electrical conductor and thus permits the charge on the leaves to leak away. In other words, the electroscope becomes discharged. The repulsive force between the leaves then disappears and the leaves return to their original vertical positions.

The Lauritsen quartz-fiber electroscope is used widely in radiation detection. It consists of a very fine metal-coated, quartz fiber, parallel to a rigid horizontal metal wire and to which it is connected. This is mounted within, but insulated from an aluminum case which acts both as the ionization chamber and one of the electrodes. The system of fiber and rigid wire, which represents the other electrode, is charged with respect to the metal case by connecting for a short time to a battery of 100 to 200 volts. The repulsive force thus produced displaces the fiber from its original position. When exposed to ionizing radiation, the charged wire and fiber collect ions which reduce the charge and decrease the repulsive force. The fiber gradually returns to its normal position. The rate of movement as observed with an attached microscope is proportional to the ions collected and to the ionizing radiations.

If the Lauritsen electroscope is calibrated with a known value of ionizing radiation, the Lauritsen may then be used to determine the value of any other such radiation. The Lauritsen electroscope and Self Reading dosimeters are examples of the application of electroscopes in radiation monitoring use.

The electrometer utilizes the electroscope principle but differs from the electroscope in that there is a constant voltage applied between two electrodes with a third electrode such as a quartz fiber suspended between them. If the central electrode is at a zero potential with respect to the two fixed electrodes, and if it is connected to an ionization chamber, the charge that it collects will determine its position between the two fixed electrodes. The suspended fiber is so arranged that it may be viewed through a transparent scale and its deflection measured. This electrometer is the type that is used in the Minometer for reading pocket dosimeters (pencils).

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In the quadrant electrometer, opposite polarity fixed potentials are applied to adjacent quadrants of the instrument. The Chang and Eng fast neutron survey meter also used the quadrant electrometer principle.

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A. General

When a radiation monitoring instrument is placed in a field of radiation, the instrument responds to the radiation by means of the ionization-of-gases phenomena in the case of ion-chamber, proportional counter, or geiger instruments. (In the case of scintillation type instruments, the fluorescence caused in a transparent material is measured). Survey instruments of any of these types can very easily be made to detect the presence of radiation, however for dose rate monitoring purposes, measurement of total ionization rather than particle counting is required. For this reason, ion chambers are used when dose rates are to be determined; geiger and proportional counter instruments are not used for beta-gamma dose rate measurement.

B. Sources of Error

There are many factors which influence the ability of an ion chamber instrument to respond to radiation; some of these factors are fixed in the design of the instrument and the selection of materials of which it is made. Others are dependent upon the type and energy of the radiations to be measured, and on the geometry of the source-instrument system. For example, because the walls of most ion chamber instruments are fairly thick to give them structural strength, alpha radiation will be absorbed in the walls of the chamber. Since alpha cannot pass through into the gas, it will create no ionization in the gas, and therefore, cannot be measured. The same limitations prevent measurement of low energy beta radiation by thick-walled ion chambers.

Source-instrument geometry affects the measurement of radiation in a somewhat different way. Radioactive sources give off radioactive particles and rays in all directions, so that the radiation field around small sources may be considered as a sphere. When a radiation measuring instrument enters this sphere of radiation, only a small part of the total radiation actually enters the instrument chamber and is measured. Therefore, the dose rate which the instrument measures will be less than that to which a person would be exposed if he actually came in contact with the source.

The calibration of an ion chamber dose rate instrument involves adjusting the instrument (or providing correction factors) to allow the accurate evaluation of any radiological situation which is the same in all respects as the radiological environment in which the instrument was calibrated. If the instrument is calibrated for three different environments, then the calibration data can be used without further correction to evaluate those three situations. In any other situation, additional correction will be required to get a true measurement. Obviously it is impractical, if not impossible, to calibrate survey instruments for all radiological situations encountered in survey practice; a knowledge of what corrections must be made in various situations is therefore a part of the monitor's job.

Some of the more significant factors affecting the ability of an ionization chamber instrument to measure radiation are:

1. The Chamber Volume and Composition and Pressure of the Chamber Gas

Exposed to the same radiation field, a large chamber will produce a larger ion

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current than a smaller chamber; a large chamber is more sensitive than a small chamber, other things being equal. The amount of ionization caused by radiation in a gas is also dependent on the chemical identity of the gas. The number of molecules present which are capable of being ionized (a function of the pressure as well as the volume) also affects the sensitivity of the instrument. Most survey instruments use air at atmospheric pressure as the chamber gas. Neither the composition nor the pressure of the air vary enough to have any significant effect on the instrument response. (Increased sensitivity may be obtained in a special instrument by using a selected gas under pressure).

2. Wall Effects

a. Photoelectric

Gamma photons and x-rays are capable of reacting with materials through which they pass, causing the material to eject electrons with appreciable energy. The ease with which these secondary electrons are ejected is dependent upon the material involved, and the energy of the radiation. Any of these rapidly moving secondary electrons emitted from the inner surface of the chamber wall will produce ionization in the chamber, in addition to the desired ionization caused in the gas by direct action of the radiation. Light (low atomic number) materials are usually chosen from chamber walls because they exhibit low photoelectric emission characteristics.

b. Shielding

Alpha

The penetrating power of alpha particles is very low; therefore at least one side of the chamber (the window) is made of extremely thin (0.7 mg/cm) material to allow alpha particles to enter the chamber. Some material over the window is usually required to avoid air currents inside the chamber, which cause a very unstable response, and to serve as the outer electrode of the chamber. Since the maximum range of an alpha particle is only 3 or 4 centimeters in air, only sources very close to this chamber window will be detected at all. Because of their very low penetrating power, alpha particles are not an external hazard; contamination levels will usually be of interest rather than dose rates. Therefore ion chamber instruments are particle detectors rather than dose rate instruments, insofar as alpha radiation is concerned. Alpha survey instruments are calibrated in disintegrations/minute and correction for the window shielding effect is included in the calibration.

Beta

The penetrating power of beta particles varies widely. Very "soft" (low energy) beta particles have penetrating power similar to alpha particles, while very "hard" (high energy) beta particles can penetrate as much as several hundred mg/cm² of material. The chamber window of a beta survey instrument must be dense enough to prevent alpha particles from penetrating into the chamber, yet thin enough to allow the majority of the beta particles to pass into it. Beta particles too soft to penetrate 7 mg/cm² are not of interest from an external dose point of view, since this thickness is

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equivalent to that of the normal dead layer of human skin. For this reason, when determining an external beta dose rate to personnel, an instrument having a beta window about 7 mg/cm^2 in thickness should be used.

For use in a beta contamination survey, an instrument should be chosen which has a window thin enough to admit at least half of the beta particles emitted by the isotope of interest. (See 4 below). Beta dose rate monitoring instruments are calibrated using uranium in equilibrium with its daughter decay products as the source. In reading uranium beta, no window shielding error will be involved since this is the environment for which the instrument is calibrated; in reading beta of different energy, some error will be introduced. (See 4 below).

Special beta survey instruments which use a probe with an open side have been developed for detecting extremely soft beta radiations. In use, this open side is placed against the surface to be surveyed and any beta (and alpha) on the surface can cause ionization in the chamber. The "pete" is an example of this type of soft beta survey instrument.

A different error is involved in cases where the dose rate from a large beta source is to be measured with a survey instrument, such as the CP, which has a beta window at the end of a deep chamber. Beta radiation from the edges of the source will be blocked by the thick chamber sidewalls causing the instrument to read low. The angle of the apex of the cone from which beta radiation will be accepted by the chamber is called the "beta acceptance angle". Since the amount of correction required in any such case is a function of the size of the source, the distance from the source to the chamber, and the beta acceptance angle of the instrument used, this correction must be determined and applied by the surveyor.

Gamma

The chambers of our common survey instruments have walls and beta window shields thick enough to stop all but the most energetic beta particles (440 mg/cm^2 CP, 700 mg/cm^2 Juno). Gamma radiation of energies above 20 KEV can penetrate this thickness with very little loss, however gamma photons having energies of less than 20 KEV will be severely attenuated by the walls of our common survey instruments. A survey instrument calibrated with a Radium source will properly measure Radium gamma. However, if gamma of another energy is measured, a small error will be introduced.

3. The Type of Radiation

The errors introduced by the walls of the chamber are different for the various types of radiation. (See 2 above). In addition, the various ranges of beta and gamma in air result in various degrees of non-uniformity of ionization within the chamber. (See 5 below)

For these reasons, an ion chamber will have a different response to different types of radiation. In using the instrument in a mixed radiation field, the monitor must determine the deflection due to each type of radiation separately, and apply the necessary corrections to each.

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4. The Energy of the Radiation

The response of an ion chamber is dependent upon the energy of the radiation for two reasons: 1) because the errors introduced by the chamber walls is a function of the energy of the radiation; and 2) because the path length (and therefore the degree of non-uniformity of ionization) within the chamber is a function of the energy of the radiation. When an ion chamber is used to measure radiation of a different energy than that employed in its calibration, an error will be introduced. Since our instruments are calibrated with sources which emit radiation with an energy approximately equal to that of the radiation encountered in IPD facilities no correction is normally required. Energy sensitivity data on some of the more common survey instruments is presented in the discussion of these instruments in other parts of this manual.

5. Non-Uniform Ionization Within the Chamber

An ionization chamber can only measure the total ionization in the chamber, and therefore, the average dose rate over the volume of the chamber. If the ion density is not uniform throughout the chamber (as would be the case when measuring very small specks, small beams, or sources of soft beta), we cannot directly determine the true dose rate at any point. (The dose rate indicated by the instrument does exist at some unknown point within the chamber, however). In these cases, errors can be minimized by using very small chambers, thus making the ion density more uniform throughout the chamber volume. The common survey instruments have rather large chambers, and large corrections must be made when using these instruments in measuring dose rates from beams, specks and soft beta sources. The monitor must be able to determine, and apply, the necessary corrections required in each specific case.

6. Variations in Voltages Supplied to the Instrument Circuit

A change in voltages supplied to the amplifier by the batteries will result in a change in amplification afforded by the amplifier and therefore will change the deflection obtained. It is important that the instrument performance be checked frequently to insure that batteries are in good condition.

7. Condition of the Component Parts of the Instrument Circuit

It is obvious that broken, damaged, or corroded connections and parts will affect the instrument reaction. The aging of parts and insulation, or the replacement of parts, will change the response characteristics of the instrument.

8. External Influences Other than Radiation

Some instruments may give erratic or false indications in strong electromagnetic fields. This is not due to ionization, but is due to the interaction of the electromagnetic field with the instrument circuit.

Extreme cold will make an instrument's reaction sluggish, but heat, below that point where actual physical damage to the instrument might result, has no undesirable effect.

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Summary

- (1) The volume of the chamber, and the composition and pressure of the gas are fixed in the design of the instrument, and need not be considered.
- (3) The deflection due to each type of radiation must be determined by the monitor before any further corrections are made.
- (2-4) When measuring beta radiation, the monitor must select an instrument with a thin window to admit the radiations from the source involved.

When measuring large beta sources, the monitor must correct for errors introduced by the limited beta acceptance angle of the instrument.

If gamma sources are encountered which emit radiation significantly different in energy from that emitted by radium, an energy sensitivity correction may be necessary.
- (5) If measurements of beams, small sources or soft beta are required, the monitor must determine and apply the necessary corrections.
- (6-7) Instruments must be recalibrated periodically to insure that they are in good operating condition. After any repair or maintenance, an instrument must be recalibrated. For this reason, field maintenance, repairs or changes shall not be made to any instrument which is calibrated in the 300 Area. Such work must be performed in the 300 Area, and be followed by recalibration of the instrument.

All instruments which are normally calibrated by radiation monitoring in the field must be recalibrated after any maintenance or repairs. This is in addition to the scheduled routine calibrations.

In addition to the routine calibrations, instruments must be checked for weak batteries and defective components before each job.
- (8) The monitor must guard against electromagnetic fields and extreme cold.

C. Limitations and Precautions of Ion Chamber Instruments

1. Response Time, or Time Constant

"The time constant" of a survey instrument is the time required for the meter needle to reach 90% of the true dose rate when suddenly exposed to radiation.

This factor must not be overlooked in surveying, since the commonly used instruments such as the CP or Juno require several seconds to reach a steady reading. It is quite possible to miss radioactive contamination or beams entirely by surveying the area too rapidly. The ability to get a positive indication when radiation is present, or be able to report the absence of radiation in the shortest time, is a skill which must be acquired by experience.

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2. Temperature

Survey instruments may respond quite sluggishly in extremely cold weather. Heat conditions are no particular problem barring actual physical damage to the window and shield of the chamber.

3. Humidity

High humidity such as is encountered in the effluent system will cause an ion chamber instrument to become inoperative after a short time, even when the instrument has been carefully wrapped.

4. Contamination

A contaminated instrument will give erroneous readings. This is especially important if the screen is contaminated or if radioactive gases have entered the chamber.

5. Zeroing Adjustment

Approved survey instruments are not particularly position-sensitive, but if very exact readings are desired, the selector switch should be turned to the "Set" position and the zero knob used to obtain a zero adjustment in whatever vertical or horizontal position the instrument is used. This adjustment can be made in a field of radiation.

When the range selector switch is on one of the operating ranges, the zero knob will still alter the needle position. On some instruments, a very slight contact with the zero knob is sufficient to produce a drastic change of needle deflection. For this reason the zero adjustment should always be checked whenever a survey is resumed after the instrument has been left unattended or carried in such a way that contact with the zero knob is probable.

Zero adjustment should also be made periodically when an instrument is used for sustained periods. An up-scale drift will occur, due to weakening batteries, and erroneous readings will be obtained.

6. Handling the Instrument

Quite apart from the contamination aspects, contact of the instrument with objects being surveyed may have undesirable results. Some of the problems are listed below:

- a. Pressure upon the thin window will cause erroneous readings.
- b. Rupture of the thin window will lead to subsequent false readings caused by air currents or drafts entering the chamber.
- c. Contact with a metal surface may momentarily short out the response, causing the needle to drop abruptly to the extreme left of the dial.
- d. Dripping water on the instrument may penetrate the case and lead to shorting out of the circuit.

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7. Jamming

Ionization chamber instruments do not present, as do GM instruments, the hazard of readings falling off to zero in the presence of a source too intense for the chamber to measure. However, since any deflection of off-scale on the X100 range of a CP indicates a radiation level of at least 5 r/hr, extreme care should be exercised. To avoid damage to the meter, the instrument should be extended slowly toward the source until a maximum or an off-scale reading is obtained, and not thrust suddenly into such a field. The rate at which the needle "bangs the peg" will increase as the radiation intensity increases, but there is no quantitative method for using this fact.

8. Electrostatic Conditions

Ionization chambers, like GM tubes, are subject to erroneous readings in the presence of strong electrostatic fields. In the vicinity of operating electric motors, generators, or other electrical equipment, or in the vicinity of automobile ignition systems, erroneous readings may be obtained.

D. Interpretation of Ion Chamber Instrument Readings

Almost every monitoring situation encountered in the reactor building requires measurement of both beta and gamma radiation. The proportions of beta and gamma radiation vary widely, and may range from almost all beta, and little gamma, to almost all gamma and little beta. So long as the amount of either component is great enough to give a significant meter deflection, the dose rate due to that component may be determined with reasonable accuracy.

The meter deflection is an indication of the average ion density within the chamber. Since this average ion density exists somewhere in the chamber, the instrument deflection is a measure of the dose rate somewhere in the chamber; but unfortunately we do not know where. Correction factors have been derived to correct this indicated dose rate to the true dose rate at the beta window. If the beta window is placed at the point of interest, the deflection obtained, multiplied by the correction factor will give the desired dose rate.

Keep in mind that beta and gamma radiations require different correction factors, and that various source sizes also require different correction factors. To determine true dose rates in complicated situations requires determining the deflection due to each source and type of radiation, and correction of each part of the instrument reading before adding them all together.

1. Sources at a Distance which is Large Compared with the Chamber Depth

a. Gamma

Regardless of the source size, the ionization within the chamber will be relatively uniform and a "field" reading is said to exist; the instrument deflection (x scale factor) is a good measure of the dose rate throughout the

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chamber and at its surfaces; therefore no correction is required.

$$\text{gamma dose rate} = (\text{Deflection WC} \times \text{scale factor})$$

b. Beta

If the sidewalls of the chamber are thin enough (i.e. 7 mg/cm^2) to admit all beta radiation contributing to dose, the beta deflection is a good measure of the dose rate (no correction factor required). In this case, all of the interior surfaces of the chamber can "see" all points on the source. However, the most commonly used survey instruments have thick sidewalls which block all beta impinging on the sidewalls. We say that the chamber cannot "see" the whole source. A point on the skin can receive this radiation, however, so a correction to the instrument reading is required. This correction is determined by the relative size of the angle through which beta is arriving at the chamber, as compared with the beta acceptance angle of the instrument.

For a given distance, the correction factor will be larger for a larger source. For a given source size, the correction factor will increase for smaller source to chamber distances. In any case, the correction factor should be applied to the deflection obtained with the beta window facing the effective center of the source.

$$\text{beta dose rate} = \left[(\text{deflection wo} \times \text{scale factor}) - (\text{deflection wc} \times \text{scale factor}) \right] \times \text{beta acceptance angle correction factor}$$

2. Sources at distances which are short as compared with the chamber depth

a. Gamma

When the chamber is placed close to a source of radiation, the ionization within the chamber is not uniform, being more dense in the portion of the chamber close to the source, and less dense in the portion of the chamber away from the source; the instrument deflection corresponds to the average ionization in the chamber, and therefore gives the dose rate at some unknown point in the chamber where the average ion density exists. In the case of large sources, this non-uniformity is small; close to small sources, the non-uniformity is very great. Therefore, correction factors will be large for small sources and small for large sources. They also will be larger for short source to screen distances and smaller for large source to screen distances. See Figure 1.

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FIGURE I

γ correction factors of a typical ion chamber as a function of source size and source-chamber distance

$$\text{Gamma dose rate} = (\text{deflection wc} \times \text{scale factor}) \times (\text{source size correction factor})$$

b. Beta

The effect described in gamma above is also involved in the case of beta. However, the correction factors will be somewhat larger because the relatively rapid attenuation of the beta particles results in greater non-uniformity of ionization for a given source size and distance than in the case involving gamma. Since common survey instruments have thick chamber sidewalls, the beta acceptance angle factor is also involved, when the source is larger than the beta window.

Correction factors including all of these effects vary in an unusual manner with source size and distance. At short distances and at contact, the correction factor is large for small sources, falling to a minimum when the source size is the same as, or larger than, the window size. At greater distances, the acceptance angle effect is more significant, and the correction factor increases with increasing source size. See Figure II.

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FIGURE II

B correction factors for a typical ion chamber as a function of source size and source-chamber distance

$$\text{Beta dose rate} = \left[(\text{deflection } w_o \times \text{scale factor}) - (\text{deflection } w_c \times \text{scale factor}) \right] \times \text{source size correction factor}$$

3. Beams

It is impractical to calibrate survey instruments for various sizes of beams. Since survey instruments are calibrated for a uniform field, the meter indication is correct for such conditions, i.e., with ionization occurring uniformly throughout the volume of the chamber. Beams produce ions only in the chamber volume which they traverse and therefore a "beam correction factor" is required.

a. Gamma

In taking a radiation measurement of a well defined beam too small to fill the ionization chamber completely, the indicated result will be low by a factor proportional to the ratio of chamber volume irradiated by the beam to total chamber volume, i.e.:

$$\text{Correction factor} = \frac{\text{True Dose Rate}}{\text{Indicated Dose Rate}} = \frac{\text{Volume of Chamber}}{\text{Volume of Beam within Chamber}}$$

and if the chamber is coaxial to the beam:

$$\text{Correction factor} = \frac{\text{True Dose Rate}}{\text{Indicated Dose Rate}} = \frac{\text{Area of Chamber End}}{\text{Cross Sectional Area of the Beam}}$$

The size of the beam may sometimes be apparent from visual examination but may be checked approximately by moving the instrument laterally across the beam and observing the rate at which the meter needle swings up to a maximum deflection and then down again. Assuming uniform rate of movement of the instrument, the faster the needle movement, the smaller the beam. The degree of definition of the beam may be roughly measured by repeating this lateral movement of the chamber through the beam at increasing distances from the

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SUBJECT

ION CHAMBER DOSE RATE MONITORING INSTRUMENTS

point where the beam emerges into the open air.

Gamma beams from reactor holes will usually be well collimated, and the dose rate within the beam will therefore remain essentially constant over a distance of several feet along the length of the beam.

$$\text{Gamma dose rate} = (\text{deflection wc} \times \text{scale factor}) \times (\text{beam factor})$$

b. Beta

If a beta beam were perfectly collimated, the true dose rate in the beam would be obtained by applying the appropriate correction factor (as in the equation in a. above) to the beta deflection, i.e.:

$$\text{Beta dose rate} = [(\text{deflection wo} \times \text{scale factor}) - (\text{deflection wc} \times \text{scale factor})] \times \text{beam factor}$$

The dose rate in this well collimated beta beam would not remain constant along the beam because of air shielding effects. Most of the beta beams which we encounter around the reactors will not be well collimated due to air scatter. Because of these two effects, air shielding and scatter, the use of the beam correction factors would be highly conservative. In normal monitoring, the beam correction should not be applied to the beta component. Therefore, use:

$$\text{Beta dose rate} = (\text{deflection wo} \times \text{scale factor}) - (\text{deflection wc} \times \text{scale factor})$$

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SUBJECT

THE CP (MODEL H-4-2209), AND THE EXTENDED CP

New

The CP (Cutie Pie) is a pistol shaped portable dose rate meter using a cylindrical ionization chamber as a detector. The outer end of the cylindrical ionization chamber is covered with plastic, making a "window" thin enough to admit beta radiation. A bakelite shield attached to the chamber may be placed over the beta window for beta-gamma differentiation. With the shield covering the beta window, the CP will detect only gamma radiation. With the shield removed from the window, beta radiation (E max greater than .18 MEV) is also admitted to the chamber. The window is too thick to admit alpha particles.

The CP has three ranges as follows:

- 0 - 50 mr/hr on range marked X1
- 0 - 500 mr/hr on range marked X10
- 0 - 5,000 mr/hr on range marked X100

The extended CP is identical to the CP in all respects except that the chamber is not mounted directly on the body of the instrument, as in the case of the CP; rather, it is mounted on the end of a rod placing the chamber about 36 inches from the body of the instrument. In some cases, a connecting cable is used in place of the rod. The use of a cable permits the location of the chamber at great distances from the rest of the instrument.

Characteristics of the Ion ChamberChamber dimensions:

Right cylinder, 3 inches of 7.62 cm diameter,
 40.2 in³ or 658 cm³ in volume, 5-11/16 inches or 14.44 cm long

Window dimensions:

3 inch diameter window in the end, 7.06 in² or 45.5 cm² in area
 effective beta acceptance angle 25°

Materials:

Wall thickness - 1/8" bakelite, 440 mg/cm²
 Beta window thickness - 0.002" waterproof cellophane, 6.2 mg/cm²
 Beta shield thickness - 1/8" bakelite, 440 mg/cm²
 Inside of chamber and screen coated with aquadag

Performance Requirements

Sensitivity, linearity and accuracy -

must read between: in a field of:

14.0 - 16.5	15 mr/hr, 150 mr/hr and 1500 mr/hr
28.5 - 33.0	30 mr/hr, 300 mr/hr and 3000 mr/hr
42.5 - 49.5	45 mr/hr, 450 mr/hr and 4500 mr/hr

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SUBJECT

THE CP (MODEL H-4-2209), AND THE EXTENDED CP

Random meter fluctuations, capacity effects, zero fluctuations -
must be less than ± 1 mr/hr on X1, ± 10 mr/hr on X10,
 ± 100 mr/hr on X100.

Zero drift -

must be less than $7\frac{1}{2}\%$ of full scale/hour, after 10 minutes warmup;
drift must be upscale

Switching transients -

must not go off-scale in either direction, and must return to zero in
2 seconds or less.

Position sensitivity -

When the instrument is turned to any position from the normal
horizontal chamber position, no prolonged downscale pointer movement
should result, and upscale movement should not exceed 5% of full
scale (2.5 mr/hr on X1).

Response time - 7 seconds or less

Preparation For Use

The following steps are taken to place a CP in use:

1. Inspect for mechanical defects such as; broken screen; shield missing, binding or loose; loose knobs (especially the range selector knob, since if it is loose, it may indicate a range other than the one actually in use. When the range selector switch has been turned counter-clockwise as far as possible, the knob should point to the "off" position. When the range selector switch is turned clockwise as far as possible, the knob should point to the "X 100" position.
2. Turn selector switch from "off" to "on" and allow 15 seconds warmup.
3. Turn switch to "set" and adjust zero knob until dial needle is on zero. If the needle cannot be brought downscale to zero with maximum counter-clockwise adjustment of the zero knob, or if it cannot be brought upscale to zero, the instrument should be tagged out for return to calibrations.
4. Re-adjust to zero and switch to X1 range. Observe for switching transients. Vary the position of the instrument, observing for needle fluctuation. Now return the instrument to normal operating position, check the zero adjustment, and using the Sr-Y beta source (wedge-shaped lever source), check the deflection on the X1 range, window open, with the source lever raised to the first shielded hole. A meter reading between 20 and 30 should be obtained. Check other ranges in turn, by turning the source to the proper position for each range as indicated on the source. These checks should include driving the instrument off-scale on each range by positioning the source properly. The instrument is driven off-scale, on each range, by placing the open window over the source

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position next higher than the one used to check the instrument calibrations on that range. The reason for this test is to determine the ability of the instrument to respond over the full scale range, and to make certain that the meter does not stick at any point. Particular care should be exercised to have the instrument in place before raising the source lever, because the instrument, acting as a shield, will prevent the instrument handler from receiving unnecessarily high level dose rates during the field check procedure.

5. The instrument, when checked out as above, is ready for survey work, however, all instruments which are used in areas of high level contamination must be protected from such contamination by placing them in plastic bags provided in each radiation monitoring office.

CP - Limitations and Precautions

1. Sensitivity: The CP cannot be used interchangeably with detection type instruments, since the most sensitive scale of the CP is roughly equivalent to the least sensitive scale of portable GM instruments.
2. Temperature: The CP reacts quite sluggishly in extremely cold weather. Heat conditions are no particular problem barring actual damage to the thin windows by steam.
3. Zeroing adjustments: The CP may be used in either vertical or horizontal positions without worrying about the effect of the change in position upon the needle for most practical survey work. If very exact readings are desired, the range selector switch may be turned to "set" and the zero knob used to adjust the needle to zero. This may be done in a field of radiation if necessary.

Even if the selector switch is on one of the three ranges for survey use, the zero knob will still change the position of the needle if touched. Frequently a very slight contact with the zero knob is enough to give a drastic change of needle deflection. For this reason, the correct zero should always be checked whenever survey is resumed after the instrument has been left unattended or carried in such a way that the zero knob may have been touched.

4. Contact of Instrument: In addition to contamination spread, contact of the instrument with objects being surveyed may have other undesirable results:
 - (1) Pressure upon the thin window will cause false readings.
 - (2) If the thin window is broken, air currents entering the chamber will give false readings.
 - (3) Contact with a metal object may short out the response, with the needle dropping sharply to the extreme left of the dial.
5. Directional Limitations: Since the CP will respond to beta radiation only when they open window is pointed toward the source, the person surveying must point the instrument at all possible sources about him for maximum protection.

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THE CP (MODEL H-4-2209), AND THE EXTENDED CP

6. Correction Factors: In situations other than those for which the instrument is specifically calibrated, correction factors must be applied to the instrument deflections.
7. Off-scale readings: The CP will not show zero radiation when the source is too intense for the range of the instrument. However, the instrument should not be extended too fast toward a source of radiation to prevent damage from the needle going rapidly off scale.
8. Electrostatic fields: CPs may give false readings in a strong electrostatic field such as that found near electric generators and motors.

Discrimination between Radiations

Gamma deflections are obtained with the beta shield over the window: Gamma Deflection = (wc meter reading) x (Range Factor)

The beta deflection is the difference between the deflection with the beta shield over the window (wc), and the deflection with the beta window open (wo): Beta Deflection = [(wo meter reading) x (range factor)] - [(wc meter reading) x (range factor)]

Where there is no significant difference between the wo and wc deflections, it may be assumed that no beta component is present.

The CP will not measure alpha or neutron radiation.

Energy Sensitivity

1. Gamma

The response of the CP to Low Energy Gamma and x radiation is shown by the following graph:

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THE CP (MODEL H-4-2209), AND THE EXTENDED CP

2. Beta

- a. The beta window of the CP will admit at least half of the beta particles from isotopes or mixtures having an average ($E_{\max}/3$) beta energy of .065 MEV. If the average beta energy is less than .065 MEV, the CP should not be used for contamination level measurement.
- b. The CP window will admit all beta particles which contribute to personnel external exposure.

Correction Factors

The correction factors applying to the CP are presented on the attached chart.

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SUBJECT

THE JUNO

New

The Juno is a dose rate meter electrically similar to the CP, but boxlike in shape. The ionization chamber is located in the bottom forward part of the box. The bottom of the chamber is equipped with a very thin plastic window and two sliding shields which may be used to cover the window. With the outer (aluminum) shield covering the window, the instrument will measure only gamma radiation. With only the inner (plastic) shield covering the window, the Juno will measure beta radiation in addition to gamma. With both shields withdrawn, the thin window of the chamber will permit alpha and very low energy beta particles to enter the chamber, as well as the more energetic beta particles and gamma radiation.

The Juno has three ranges as follows:

- 0 - 50 mr/hr on the range marked X1
- 0 - 500 mr/hr on the range marked X10
- 0 - 5000 mr/hr on the range marked X100

Characteristics of the Ion Chamber

Nominal chamber dimensions:

Depth - 1-3/4" or 4.45 cm (screen to back of chamber)
Width - 5-1/4" or 13.35 cm (side to side on instrument)
Length - 3-9/32" or 8.30 cm (front to back on instrument)
Volume - 30 in³ or 493 cm³

Nominal window dimensions:

Alpha & soft beta window - 3-1/8" x 4-13/32" or 7.94 cm x 11.17 cm
Area 13.75 in² or 88.6 cm²

Beta window - 3" x 4-5/16" or 7.62 cm x 10.95 cm
Area - 13 in² or 83.8 cm²

Materials:

Beta shield - 0.102" aluminum (35-H14) - 700 mg/cm²
Beta window - 0.002" cellulose acetate - 6.2 mg/cm²
Soft beta window - 0.0002" rubber Hydrochloride - 0.6 to 0.77 mg/cm²

Performance Requirements

Same as for the CP (See 8.2.1)

Operation

The following steps are taken to place a Juno in use:

1. Turn selector switch from "off" to "on" and allow 30 seconds warmup.
2. Turn switch to "set" and adjust zero knob until dial needle is on zero. If the

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THE JUNO

needle cannot be brought downscale to zero with maximum counter clock-wise adjustment of the zero knob, or if it cannot be brought upscale to zero, the instrument should be tagged out for return to calibrations.

3. Re-adjust to zero and switch to X1 range. Observe for switching transients. Vary the position of the instrument, observing for needle fluctuation. Now return the instrument to normal operating position, check the zero adjustment, and using the Sr-Y beta source (fan-shaped lever source), check the deflection on the X1 range with the source lever raised to the first shielded hole. A meter reading between 20 and 30 should be obtained. Check other ranges in turn, by turning the source to the proper position for each range as indicated on the source. These checks should include driving the instrument off-scale on each range by positioning the source properly. As is the case in checking function of the CP, the Juno is driven off-scale by placing the open window over the source position next higher than the one used to check instrument calibration on that range. Likewise, this test of the Juno serves to determine the ability of the instrument to respond over the full scale range, and to make certain that the meter does not stick at any point. Particular care should be exercised to have the instrument in place before raising the source lever, so that the instrument, acting as a shield, will prevent the instrument handler from receiving unnecessary beta exposure during the field check procedure.
4. The instrument, when checked out as above, is ready for survey work. However, all instruments which are used in areas of high level contamination must be protected from such contamination by placing them in plastic bags provided in each Radiation Monitoring office.

Discrimination between Radiations

Gamma deflections are obtained with both shields closed: $\text{Gamma Deflection} = (\text{wc meter reading}) \times (\text{range factor})$

The beta deflection for dose rate monitoring purposes is the difference between the deflection with both shields closed (wc) and the deflection with the outer shield open (wo): $\text{Beta Deflection} = \text{wo meter reading} \times \text{range factor} - \text{wc meter reading} \times \text{range factor}$.

When there is no significant difference between the above wo and wc deflections, it may be assumed that no beta component is present.

The Juno may be used to detect alpha and extremely soft beta radiation by opening both shields.

Energy Sensitivity

1. Gamma

The response of the Juno to low energy gamma and x radiation is shown in the following graph:

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THE JUNO

New

2. Beta

With the outer shield open, at least half of the beta particles from isotopes or mixtures having an average (or $\frac{E_{max}}{3}$) beta energy 0.08 MEV will be admitted to the chamber.

With both shields open, at least half of the beta particles from isotopes or mixtures having an average (or $\frac{E_{max}}{3}$) beta energy of 0.041 MEV will be admitted.

For purposes of establishing personnel dose rates, beta readings should be taken with only the outer shield open.

Many locations within IPD facilities are contaminated with low energy (or "soft") beta emitting isotopes. The Juno (with both windows open) is used extensively for contamination surveys in these locations.

3. Alpha

Although it can be used for alpha measurements, the Juno is less satisfactory than the Poppy or the Samson, except when high levels of contamination are involved.

Correction Factors

Correction factors applying to the Juno are presented on the attached chart.

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THE JUNO

BEAM CORRECTION FACTORS	BEAM DIAMETER	
	BEAM DIAMETER	FACTOR
	1/4"	360
	1/2"	90
	3/4"	40
	1"	20
	PROCESS TUBE	8
	2 1/4"	4
	> 4"	1

BETA FIELD MEASUREMENTS AT > 6"	BETA FIELD MEASUREMENTS AT > 6"	
	RATIO: DIAM. DISTANCE	FACTOR
	1 OR LESS	1
	2-3	1.3
	4-6	1.5
	8 OR MORE	1.7

IRRADIATION PROCESSING DEPARTMENT
JUNO CORRECTION FACTORS TO OBTAIN DOSERATE AT THE SCREEN

SOURCE TO SCREEN DISTANCE	G A M M A										B E T A									
	SOURCE DIAMETER										SOURCE DIAMETER									
	< 1/2"	1/2"	3/4"	1"	1 1/2"	2"	3"	4"	> 4"		< 1/2"	1/2"	3/4"	1"	1 1/2"	2"	3"	4"	> 4"	
CONTACT	20	15	10	7	5	2 1/2	1 1/2	1	1 1/2		100	90	50	30	15	10	5	3	2	
@ 1/2"	4										7	7	6	5	4	3	2	2	1 1/2	
@ 1"	1.5										2							1 1/2		
@ 2"																			1 1/2	

CIRCULAR SURFACE SOURCE

BD-5300-083(4-61) ARGONNE RICHMOND, WASH.

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SUBJECT

THE CP-TP

The CP-TP is a high range instrument for detecting and measuring high level beta and gamma radiations. It is similar in appearance to an extended CP except that the ionization chamber is quite small, measuring about 1-1/4" diameter, 2-3/4" long. The electrometer tube, range resistors, and switching tube and associated components are located in the probe. The remainder of the circuitry is located in a regular CP type power pack case. The probe is normally mounted directly to the front of the case, however 3 foot extension rod segments or cables up to 80 feet in length, can be used to minimize exposure to the surveyor. Each probe is calibrated with a specific power pack case, therefore, they must not be interchanged between instruments.

The ionization chamber will respond to beta and gamma radiations from essentially all directions. This characteristic may lead, in some cases, to overestimating of personnel beta dose rates. The CP-TP is calibrated for gamma only. The beta-gamma response is 1:1, provided the energy of the beta radiation is > 0.25 Mev. A "slug can" beta shield may be used to discriminate between beta and gamma radiation.

The CP-TP comes in two versions, differing only in the ranges provided. Each CP-TP has 3 ranges as follows:

	High range CP-TP	Low range CP-TP
X1 range -	0- 5 rad/hr	0-500 mrad/hr
X10 range -	0- 50 rad/hr	0- 5 rad/hr
X100 range -	0-500 rad/hr	0- 50 rad/hr

Characteristics of the Ion Chamber

Nominal Chamber Dimensions:

Cylinder with a hemispherical end
 Diameter 1.218" or 3.26 cm
 Length over-all 2.75" or 7 cm
 Length (cylinder portion) 2-1/8" or 5.4 cm
 Volume 3 in³ or 49.2 cm³

Materials:

Wall thickness nominally 0.015" lusteroid - 80 mg/cm²
 Inner surfaces of chamber coated with aquadag or rubalt

Performance Requirements

Sensitivity, linearity & accuracy (Hi range version):

In a field of:

must read between:

1.5 r/hr, 15 r/hr and 150 r/hr

1.43 - 1.65

3 r/hr, 30 r/hr and 300 r/hr

2.85 - 3.30

4.5 r/hr, 45 r/hr and 450 r/hr

4.28 - 4.95

(For low range version, as above, except dose rates are 1/10 of the above)

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THE CP-TP

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Random meter fluctuations, capacity effects, zero fluctuations: must be less than ± 100 mr/hr on X1, ± 1000 mr/hr on X10, and $\pm 10,000$ mr/hr on X100 on the H1 range version (± 10 mr/hr on X1, ± 100 mr/hr on X10, ± 1000 mr/hr on X100 on low range version).

Zero drift: must be less than $7\frac{1}{2}\%$ of full scale/hour, after 10 minute warmup. Drift must be upscale.

Switching transients: must not go off scale in upward direction, and must return to zero in 2 seconds or less.

Position sensitivity: when the instrument is turned to any position from the normal horizontal position, no semi-permanent downscale pointer movement should result, and upscale movement should not exceed 5% of full scale (250 mr/hr on X1 on H1 range CP-TP).

Response time: must be 7 seconds or less.

Operation

To operate the TP, the range selector switch is turned to on and a 15 second warmup period is allowed. Turn the range selector switch to the zero position, and adjust the meter pointer to zero. The range selector switch is then turned to the desired range to be used. For purely detection type survey work, e.g., location of a small source of high level radiation, further warmup is unnecessary. If the instrument is to be used to establish dose rates, an additional warmup period of 15 minutes is recommended. A second zero adjustment should be made before the instrument is used. This warmup period reduces the tendency for the instrument to drift when in use.

Limitations of the CP-TP

1. The CP-TP cannot be used for determining surface or contact dose rates.
2. The beta acceptance angle of the chamber is greater than the 180° or 2π solid angle desired for personnel dosimetry.
3. The chamber wall is too thick to admit all beta radiations which are of dose significance.
4. The CP-TP with extension rods in use may be quite unwieldy and the chamber cannot be held sufficiently motionless to take readings at precise locations. Extension rods may break if not properly assembled.
5. The probe is easily damaged by crushing or striking against solid objects.
6. Because certain circuit parts are located in the probe itself, each probe must be used with the particular power pack case on which it was calibrated.

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THE CP-TP

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7. The time constant of the CP-TP is 7 seconds, that is, it will take 7 seconds for the instrument to reach 90% of the actual radiation dose rate present. Survey work with the CP-TP in high radiation fields should be carried out with extreme caution on the part of the monitor.

8. The CP-TP is vulnerable to moisture, especially at cable connections.

Discrimination Between Radiations

"Slug can" beta shields are provided to discriminate between beta and gamma radiation. The instrument will not respond to alpha radiations.

Energy Sensitivity1. Gamma

The response of the CP-TP to low energy gamma and X radiation is shown by the following graph:

2. Beta

The wall of the TP chamber will admit at least half of the beta particles from isotopes or mixtures having an average $(E_{max}/3)$ beta energy of 0.25 Mev.

The chamber wall will not admit all beta particles which contribute to personnel dose; therefore, if significant amounts of soft beta are present the beta dose rate measured may be low. Beta dose rates measured with the TP are reliable only when the personnel exposed are completely covered with protective apparel at least as thick as the instrument chamber wall. This condition exists for example when water-proof suits and full face masks are being worn.

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SUBJECT

THE SAMSON

GENERAL

The Samson is a portable, battery operated, ion chamber instrument capable of detecting alpha, beta and gamma radiations, but not capable of discriminating between them.

It has two controls, off-on-X25-X5-X1, and a zero set. A neon light is provided to indicate that the instrument is operating.

The Samson is useful for detecting and measuring low level contamination. It responds well to low energy beta emitters such as Cl^{35} and S^{35} . The Samson should not be used for personnel dose rate monitoring inasmuch as it responds to radiations which are not of dose significance.

Sensitivities are about as follows:

Full Scale Reading

Range	Gamma (radium)	Beta (> 0.050 Mev)	Alpha (> 2 Mev)
X25	17.5 mr/hr	--	12,500 c/m
X 5	3.5 mr/hr	20.0 mrad/hr	2,500 c/m
X 1	0.7 mr/hr	4.0 mrad/hr	500 c/m

The instrument is normally 6" x 8-1/2" x 8", and weighs about 5 pounds.

CHARACTERISTICS OF THE ION CHAMBER

The ion chamber is located at the bottom front of the case.

Nominal Chamber Dimensions

Depth -	1-11/16" or 4.3 cm (screen to back of chamber)
Width -	5-1/8" or 13 cm (side to side on instrument)
Length -	4-7/8" or 12.4 cm (front to back on instrument)
Volume -	42 in ³ or 693 cm ³

Nominal Window Dimensions

4" x 4-1/4" or 10.2 cm x 10.8 cm
Area - 17 in² or 110 cm²

With the instrument on a flat surface, the window is 3/16" or 0.5 cm above that surface

Materials

Sides of chamber - aluminum

Window - .0002" rubber hydrochloride or mylar, 0.66 mg/cm²

The inner surface of the thin window is coated with aquadag. A wire screen is used to protect the delicate window.

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SUBJECT

THE SAMSON

New

PERFORMANCE REQUIREMENTS

1. Accuracy and Linearity - The linearity and accuracy of reading vs radiation intensity will be acceptable if the following requirements are met:

Range X1 (500 d/m, full scale):

- a. Exposure to a Uranium alpha source of 150 d/m causes a reading within the limits of 140 d/m and 165 d/m.
- b. Exposure to a Uranium alpha source of 300 d/m causes a reading within the limits of 285 d/m and 330 d/m.
- c. Exposure to a Uranium alpha source of 450 d/m causes a reading within the limits of 425 d/m and 495 d/m.

Range X5 (2500 d/m full scale):

Same as Range X1 except that all figures quoted shall be increased by a factor of 5.

Range X25 (12,500 d/m full scale):

Same as Range X1 except that all figures quoted shall be increased by a factor of 25.

2. Sensitivity Adjustment - Sensitivity adjustments should be provided for each range to meet the requirements of Accuracy and Linearity above. The range of these adjustments shall be wide enough to permit meeting the specification with a new set of batteries and with a set which has been used for 100 hours of continuous operation.
3. Zero Fluctuations - Random fluctuations of the needle pointer shall not exceed $\pm 5\%$ of full scale deflection from the zero scale line when the instrument is in a "radiation free" location. Fluctuations may not deflect the pointer downscale to the meter stop.
4. Zero Drift - Zero drift should not exceed 5% of full scale per hour after a 15 minute warmup and drift must be upscale. This applies to all ranges.
5. Rise and Fall Times - The time to reach 90% of final reading when the chamber is exposed suddenly to a radiation source should not exceed 15 seconds. The time to return 90% of the way to zero from an equilibrium reading, when the radiation source is removed should not exceed 15 seconds.
6. Switching Transients - Switching from On position to any range, or switching from one range to any other range should not drive the pointer off scale in either direction and the pointer should return to zero reading in two seconds or less.

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7. Capacity Effects - Lifting the instrument, moving it from any position to any other, pressing on any part of the case or control knobs, lifting control knobs lightly or any other manipulation which is associated with normal operating procedure shall not cause deflection of the pointer in excess of 2% full scale on any range selector switch setting.
8. Geotropic Effects - When the meter is adjusted to zero with the chamber axis held in a horizontal plane, any change in instrument orientation shall cause no semi-permanent downscale pointer movement and upscale movement shall not exceed 5% of full scale.
9. Light Effects - The instrument should be capable of operating in direct sunlight (sunlight will not impinge directly on the chamber opening) with less than 2% of full scale variation from corresponding conditions in a dark room. This applies to all ranges.
10. Extra-cameral Ionization Effects - The effects of irradiating the instrument case shall be negligible compared to those observed when the ionization chamber is irradiated. This characteristic is tested by "scanning" the complete instrument with a 2 mm wide 200 KVP X-ray beam of intensity sufficient to produce 3/4 full scale reading on range X1. The reading at any point on the instrument case may not exceed $\pm 18\%$ or -3% of the average reading obtained from the beam directed through the chamber, and the total area under the scanning curve obtained with the beam directed through the case shall not exceed $\pm 6\%$ or -1% of the area under the chamber scanning curve, both corrected for background level.
11. Chamber Uniformity - When the ionization chamber is scanned with a 2 mm wide 200 KVP X-ray beam, the reading at any point on the chamber shall not deviate from the average reading by more than $\pm 10\%$.

OPERATION

Turn on the instrument to allow a 5 minute warmup period. The zero drift decreases with increased warmup time.

This instrument cannot be zeroed in the radiation field to be measured. Zero the instrument in the position of use, then introduce the sample to be measured. Switch to the range giving an on-scale reading (usually the X5 range). When the needle becomes stationary, tap the meter gently and read the deflection.

Each Samson is calibrated for alpha, beta, and gamma by the Calibrations Unit. To convert deflections to d/m, mrad/hr and mr/hr refer to calibration charts provided.

Generally it is good practice to start on the X5 range when monitoring for contamination. On this range, encountering unusually "hot" areas will not likely damage the needle on the meter by sudden off-scale swing. Contamination on the order of 500 cpm or less will still give adequate deflection on this range and if areas encountered have activity of this order, then the instrument can be switched to the

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X1 scale for a more accurate reading.

Normally, the bottom of the Samson case can be held $1/4"$ - $1/2"$ above the surface it is monitoring. Where alpha contamination on the order of 3 Mev or less is suspected, the Samson should then be placed on the surface. Speed at which the instrument is moved across the surface should be commensurate with the meter time constant. About one foot/sec is satisfactory.

LIMITATIONS

The Samson is useful in detecting beta and gamma contamination, but is not to be used for personnel dose rate monitoring. The Samson will not discriminate between α , β , and γ .

The Samson is position sensitive. Care must be exercised when surveying to avoid sudden movement of the instrument.

The Samson is susceptible to false readings when used in areas where strong air currents are present. This limitation must be considered when surveying in such areas.

The Samson has a rather large time lag when returning to zero position after a full scale dial reading is obtained. For this reason, it should not be thrust suddenly upon a source but rather moved toward the source slowly, switching to the X10 range if full scale is obtained on X1.

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The Pete is an ionization chamber with one wall open and the collecting electrode close enough to the surface to be surveyed that the ionization produced by a weak beta will be drawn to the electrode. It is the only survey instrument available for measuring the soft beta emitted by tritium.

The Pete was developed from the Poppy; however, even the thin nylon screen used on the Poppy probe is too thick for this weak beta to penetrate, and furthermore, the pulses created by the ionization are too weak to travel through the cable to the amplifier and scaler. As a result a preamplifier had to be built into the probe to send signals down the cable. To offset the differences of potential on the surfaces to be surveyed, it was necessary to add a grounding screen of copper wire over the open window.

A mixture of Argon and Methane gases is used to increase the ionization density without appreciably increasing the fire hazard. The flow of gas must be regulated to stabilize the counting rate. Fuzzy surfaces and other projections will cause erratic counts so care must be taken to keep the screens not only free of contamination, but free of fuzz, lint, etc.

The Pete can only be used for surveying flat surfaces. For this reason it is generally used as a stationary instrument and used to count smears. Smears should be taken per standard smear survey technique.

1. Pre-Instructions for Use of the Pete

- a. A voltage plateau must be run for each new probe-amplifier combination, using a standard source to be sure the probe is operating normally. The voltage should then be adjusted to give the proper counting rate for the source. Normally a setting of 70 on the gain control switch should be satisfactory.
- b. The switch labeled X10, X5 and X1 is an auxiliary to the gain control and should normally be in the X10 position.
- c. The switch marked "scale" controls the number of ionization events that must be counted before the mechanical register counts. Normal setting for this switch is scale of 128.

2. Operating Instructions

- a. Plug the Pete into 110 volts A-C
- b. Turn on low voltage switch and allow a 10 to 15 minute warming period before surveying.
- c. Check to see if the Pressure Reducing valve is closed, then open bottle valve slowly observing the pressure on the bottle gage. The bottle valve should be turned wide open.

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- d. Turn on high voltage switch and turn voltage control fully on with the probe on a clean horizontal surface. This, without gas, will burn off moisture, fuzz, etc. from the collecting wire.
- e. After allowing 5 minutes for above step, set the voltage to the proper value which is normally indicated on the probe.
- f. Turn on gas using the PRV, setting probe pressure to 2 pounds.
- g. Set clock to zero, turn on counting switch and run a background to determine that the Pete is counting background properly.
- h. If background count is normal reset clock, indicator lights and register all to starting position.
- i. Place probe on a source properly and again reset clock, lights and register to zero.
- j. Surveys must be made with the entire probe window over a flat surface which causes a partial seal and stabilizes the gas. Place the probe over the surface or smear to be counted. Turn on count switch for the desired time (generally 1/2 minute longer).
- k. Record total counts from the register and lights. Subtract from this the background count and correct for the counting period; e.g., if a 30 second count was made, multiply the net counts by 2 to obtain c/m.

3. Decontamination of the Pete

- a. Screen: Each instrument should have several screens available. If one screen becomes contaminated while surveying, replace with a new one. Screen may be decontaminated by using soapy water and a soft brush and then rinsing and drying.
- b. Probe: When the ionization chamber of the probe becomes contaminated or dirty from fuzz and lint, the probe should be disconnected and the screen removed. Using a solvent-soaked swab clean out the trough around the collecting wire. Care should be taken not to break this wire. Clean the rest of the chamber the same way, making sure no lint from the swab remains on the face of the probe or the trough.

If the wire should break, finish cleaning the probe, strip off the rubber and send the probe in for repair. The probe case itself should never be opened in the field.

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PORTABLE GM COUNTERS

New

DESCRIPTION

The GM counters are count-rate instruments which count individual particles or photons of radiation. The instruments are usually box-shaped with a handle on top. The handle is equipped with clips for holding the detection probe when it is not in use.

The probe is attached to the instrument by a high-voltage cable several feet long. The probe is fitted with a tubular metal cage which fits around and protects the GM tube from damage, and a tubular metal shield which slides to cover and uncover the GM tube.

With the shield covering the tube, the instrument will detect only gamma radiation. With the shield slid back, uncovering the tube, the instrument will detect beta radiation, also. Using the standard metal or glass-walled GM tubes, the instrument will not detect low energy beta radiation or alpha radiation. However, the HGM is equipped with an interchangeable thin (end) window GM tube which may be used for low energy beta detection.

A selector switch is turned from "off" to one of three ranges. An integrating circuit shows the counting rate on a dial, and the counting events can also be heard by use of earphones.

OPERATION

1. Inspect the instrument for mechanical defects such as a broken tube, loose knob, frayed cable, etc. Earphones should always be used with these instruments.
2. In a radiation-free area, switch to the most sensitive range (usually marked X1). There will be a certain audible noise if earphones are used and in most cases a visible fluctuation of the needle, due to background from natural causes. This background should be observed long enough to note the maximum fluctuation and the apparent average reading. If this is more than about 400 c/m, check for a radiation source(s) nearby, or for contamination on the probe.
3. Check the instrument with a source of approximately known strength, such as a radium dial wristwatch or uranium chip. Observe not only the final reading obtained, but also the length of time necessary to obtain the final deflection. The length of time necessary to obtain 90% of the final deflection is known as the "time constant" of the instrument. The time constant for a HGM is 14 seconds, EGM, 13 seconds, and for a TGM, 14 seconds.

Also note the length of time necessary for the needle to return to the normal background position after the source is removed.

4. Pass the probe across the source to determine how fast the probe may be moved and still obtain a visible needle deflection above background or an audible warning from the earphones. The earphones will generally give the first indication at more rapid probe speeds. In making the actual survey, however, it should be remembered that the desired detection limits will probably be much less than the source strength.

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5. Proceed with the survey, holding the probe as close as possible without actual contact. If a positive response is obtained, allow sufficient time for full deflection to be reached. C/m may be read directly off dial. The metal shield on the probe may be used to shield out beta radiation, and determine the gamma component.
6. After obtaining a positive reading, allow sufficient time for needle to return to the normal background before continuing survey. This loss of time is eliminated if earphones are used.
7. If no positive readings above background are obtained, report results as "less than 100 c/m at one inch". If a radiation source other than the object or surface surveyed causes a background above the natural background, results are reported in such a way as to indicate this, e.g., "value handle 2000 c/m above 100 c/m background" or nothing detectable above 400 c/m background", etc.
8. Whenever detection surveys for beta and gamma indicate the possibility of significant unevaluated rates being present, the survey must be supplemented with a dose rate instrument survey. Such a dose rate evaluation should be made if any GM reading of 5000 c/m or greater is obtained.

LIMITATIONS AND PRECAUTIONS

1. Because GM tubes detect numbers of ionizing particles or rays without regard to the degree of ionization the particles or rays might cause, and since all dose rate units are defined in terms of degree of ionization, GM instruments cannot be used as dose rate meters unless the energy of the ionizing particles is known. The curve shows the dose rate which would result from a given count rate on a GM, as a function of the energy.

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Experienced monitoring personnel will soon learn the approximate relationship of GM meter readings and dose rate meter measurements from sources frequently surveyed. Gamma radiation found in the IPD facilities will usually run about 4000 c/m equal to 1 mr/hr, fission product beta from 1000 to 5000 c/m equal to 1 mrad/hr. Although these relationships are not used to establish dose rates, knowledge of them is useful in making rapid evaluation of radiological conditions.

2. GM meters are insensitive to alpha and soft beta radiation except as noted in the case of the HGM.
3. Changes in the internal gas pressure of the GM tube may cause erroneous readings in areas of extreme temperature. The metal tubes are particularly vulnerable to extreme cold and have been known to collapse.
4. Chipping or cracking the opaque aquadag coating of the glass GM tubes may make the tubes sensitive to light. Such instruments frequently work satisfactorily indoors, but give false readings, even as high as off-scale on the least sensitive range, when taken into sunlight. This condition can be temporarily remedied by taping a piece of carbon paper over the tube.
5. The wall of the GM tube is very thin and great care must be taken to avoid physical shock to the probe during survey, particularly when the tube is not protected by a screen or grill. GM tubes are completely inoperative if the tube wall is broken or collapsed.
6. The GM tube will respond only to a fixed total number of counts (on the order of 10^9), so to prolong the life of the tube it should not be exposed to a source above the range of the least sensitive range, or left turned on, particularly in a field of radiation. When the tube is exposed continuously to a very strong source, with no time for it to "recover" between counts, it soon ceases to give any signal at all and will indicate zero c/m. The tube life under such conditions depends on the design of the tube, and its age.
7. Spurious results may be obtained if GM meters are used to survey equipment producing strong electrostatic fields, such as generators.
8. When the tube is exposed continuously to a very strong source, it may cease to give any signal at all and indicate zero c/m. As a rough rule of thumb, if a GM meter is suddenly exposed to a source more than ten times as intense as the upper limit of the least sensitive scale, (i.e., 1,000,000 c/m or about 300 mr/hr gamma) it cannot be depended upon to give any warning to the user, since the meter will drop back to zero.

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BF₃ NEUTRON COUNTER AND DOUBLE MODERATOR

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 New

THE BF₃ DETECTOR

The BF₃ (or Boron Trifluoride) detector consists of a proportional counter type chamber filled with Boron Trifluoride gas. When a slow neutron penetrates the chamber and strikes a boron 10 atom, an alpha particle is emitted, i.e., ${}^{10}_{5}\text{B} + n \rightarrow {}^{7}_{3}\text{Li} + \alpha$. The rate of alpha particle emission is proportional to the neutron flux density. The alpha particles are counted, and if the instrument has been properly calibrated with a source of known strength, a determination of the number of slow neutrons present can be made. By use of a moderator around the BF₃ tube, fast and intermediate neutrons may also be detected.

THE PORTABLE BF₃

The portable BF₃ is a small instrument similar in outward appearance to a portable GM, and because of its convenience over cart type equipment is used almost exclusively in IPD for neutron dose measurements. The circuit consists of a discriminator to reject gamma pulses, and count rate meter circuit driving a meter. The meter has two scales, the lower scale referring to slow neutrons, or intermediate neutrons when used with a moderator, the upper scale for fast neutrons when the instrument is used with a double moderator. A switch turns the instrument on, and selects X1, X10 or X100 ranges. The BF₃ probe is attached to the instrument case by a short cable.

The probe holder contains a cadmium shield which serves to shield the probe from slow neutrons. With the probe in this shield, an indication of the gamma response of the instrument is obtained. There are no adjustments to be made in the field.

THE DOUBLE MODERATOR

The double moderator consists of two cylindrical aluminum jacketed paraffin filled sleeves into which the BF₃ probe may be inserted. The smaller or inner cylinder is called the Fluxmeter and is about 6-1/2" in diameter and 12" long. It provides about 2.5" of paraffin around the BF₃ probe. The larger cylinder fits around the Fluxmeter, increasing the thickness of the paraffin around the BF₃ probe to about 4 inches. The assembly of the inner and outer sleeves together is called the Dosimeter. The assembly is about 10-1/2" in diameter and 12" high and weighs 37 pounds.

NEUTRON ENERGIES

For monitoring purposes, neutrons may be classified by energy as follows:

Thermal neutrons - 0.025 ev (at 20°C)
 Slow neutrons - 0.025 ev to 100 ev
 Intermediate neutrons - 100 ev to 25 Kev (0.0001 Mev to 0.025 Mev)
 Fast neutrons - 25 Kev to 10 Mev (0.025 Mev to 10 Mev)

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NEUTRON DOSE RATE MEASUREMENTS USING PORTABLE BF₃ AND DOUBLE MODERATOR

Check Instrument for Proper Operation

1. Turn the instrument on and allow it to warm up for 10 minutes before taking readings.
2. In a low background area observe the reading with the probe in the cadmium sleeve. The reading should be less than 0.01 read on the lower scale (marked SLOW) with the instrument set on the X1 range. If this reading exceeds 0.01 return the instrument to calibrations for repair.

Slow Neutron Measurements

1. Keep the probe at arms length from the body and as far as practicable from any other object or material that may cause neutron scattering.
2. Remove the probe from the holder and hold the probe in free air. Do not use the Fluxmeter or Dosimeter or any other moderator for slow neutron measurements.
3. Read the slow neutron dose rate directly in mrem/hour on the lower scale of the meter (scale marked SLOW).

Fast Neutron Measurements

When determining fast neutron dose rates all readings are taken on the upper meter scale (FAST neutron scale).

1. Insert the probe in the Fluxmeter. Locate the highest neutron flux in the area to be monitored, or position the probe at the point of interest. Note and record the reading on the upper scale.
2. Assemble the Dosimeter and take a reading on the upper scale in the same location as in step one. Make certain that the probe is in the same position as before.
3. Divide the Dosimeter reading by the Fluxmeter reading. The result is the ratio "r."
4. Multiply the reading on the upper scale by the correction factor corresponding to "r" on the graph attached to the side of the instrument.
5. If the ratio, "r," is less than 0.22, refer to the instructions for Intermediate Neutron Measurements. Instances when the ratio "r" is less than 0.22 are expected to occur only rarely. Notify the Manager, Calibrations Operation each time this occurs.

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BF₃ NEUTRON COUNTER AND DOUBLE MODERATORIntermediate Neutron Measurements

When the ratio "r" (as determined by following steps (1), (2) and (3) under Fast Neutron Measurements) is less than 0.22, the effective energy of the neutron flux is in the Intermediate range. To measure Intermediate neutrons place the probe in the Fluxmeter only and read the dose rate in mrem/hour on the lower scale (scale marked SLOW).

The Total Neutron Dose Rate

If "r" is greater than 0.22: Slow Neutron DR Fast Neutron DR = Total Dose Rate in mrem/hour.

If "r" is less than 0.22: Slow Neutron DR Intermediate Neutron DR = Total Dose Rate in mrem/hour.

RESPONSE OF THE DOUBLE MODERATOR TO MONO ENERGETIC NEUTRONS

The portable BF₃ together with the double moderator can be used to estimate the energy of monoenergetic neutrons, or to estimate the effective energy of a neutron flux consisting of a broad spectrum of energies.

Determine the ratio "r," by dividing the upper scale reading obtained using the Dosimeter by the upper scale reading obtained using the Fluxmeter. Knowing "r," find the effective energy from the table below. If "r" is less than about 0.6, the following equation may be used:

$$\frac{r - 0.215}{0.366} = E \text{ (Mev)}$$

Ratio "r" ($\frac{\text{Dosimeter}}{\text{Fluxmeter}}$)	E (Mev)	Ratio "r" ($\frac{\text{Dosimeter}}{\text{Fluxmeter}}$)	E (Mev)
.224	.05	.544	.90
.226	.03	.581	1.00
.230	.04	.710	1.50
.233	.05	.804	2.00
.237	.06	.886	2.50
.241	.07	.956	3.00
.244	.08	1.081	4.00
.248	.09	1.173	5.00
.252	.10	1.260	6.00
.270	.15	1.312	7.00
.288	.20	1.366	8.00
.307	.25	1.407	9.00
.325	.30	1.434	10.00
.361	.40	1.460	11.00
.398	.50	1.482	12.00
.435	.60	1.505	13.00
.471	.70	1.525	14.00
.508	.80		

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SUBJECT

BETA-GAMMA HAND-SHOE COUNTER

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New

A. General

The beta-gamma hand-shoe counter is utilized to detect the presence of beta-gamma contamination on the hands and shoes of personnel who have worked in or near zones where radioactive contamination exists. Personnel working in these areas are required to take a hand-shoe check on leaving a radiation zone and before eating or leaving the area.

The counter contains 12 Geiger-Mueller tubes, four for each hand and four for the shoes, which read out on three registers. Figure 1 shows the locations of these GM tubes.

FIGURE 1

HAND-SHOE COUNTER

G-M TUBE POSITIONS

Each set of tubes is connected through a scale of 4 or 8 to a register. The length of the count is determined by a preset timer which automatically shuts the counter off at the end of the counting period. The actual distance from the tubes to the skin or shoe varies from about an inch from the nearest point on the palm to four or five inches from parts of the bottoms of the shoes. A grating is provided over the shoe tubes to support the person's weight, and screens are provided for the hand tubes to prevent breakage. A roll of paper for the feet, and paper bags for hands may be used to keep dust and dirt out of the counter and to prevent contamination of the screens.

Switching components located on the lower front panel of the counter include:

1. A power switch with three positions; off, low voltage, and high voltage. Normally, this switch remains in the high voltage position unless the counter is out of service. The high voltage meter should indicate the proper operating voltage, usually written on a small tag affixed to the meter dial. On some occasions, a line voltage fluctuation or circuit failure will cause the high voltage to trip out. If the high voltage has tripped out, is in excess of the posted value or fluctuates, turn the counter off and notify Instrument Maintenance. All adjustments will be made by Instrument Maintenance.

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2. A control switch located on the right lower panel, which functions as follows:

- a) "Hands" position. With the switch in this position, the instrument starts counting when the treddle switches in both hand slots are pushed down simultaneously, counts for the time indicated by microflex timer, and turns off automatically. This is the normal use position. The register must be reset to zero before a new count can be started. If resetting the registers starts a new count without the use of the trip switches, the trip switches may need adjustment or the paper bags, if used, may be rigid enough to hold them in the "On" position at all times. If the counter continues to start a new count, tag the instrument "Out of Order" and notify Instrument Maintenance.
- b) "Background" position. With the switch in this position, the instrument will start counting automatically, count for the time indicated by the microflex timer, and turn off automatically. After the first count has been completed, a second count will be started after the registers are reset to zero.
- c) "On" position. With the switch in this position, the instrument will count continuously until the switch is turned to the off position.

For the counter to serve its purpose properly it is necessary for:

1. Each of the GM tubes to respond to beta and gamma radiation.
2. The counts received by the GM tubes to clear through the registers.
3. A warning level to be posted which will be low enough to alert personnel to the presence of contamination, and high enough above background so that false alarms will not be caused by the statistical variation in the background count.

It is also desirable to have the warning level remain constant and not require adjustment because of statistical variation in counts.

B. Initial Set-Up of a Beta-Gamma Hand-Shoe Counter

1. Set the microflex timer to 10 seconds.
2. Check the response of each of the GM tubes with a point source. (Source: Size $< 1/2$ " in diameter, value about 10,000 c/m, as determined with a portable GM).
3. Determine the average background count. (The average of 10 counts). If high, check to see that the instrument is not contaminated, and that the high count is not due to airborne contamination.
4. From the Statistical Table (Fig. 2) determine the Warning Level corresponding to Average Background count.
5. Post the Warning Levels for the hands and shoes.

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C. Daily Operational Check for Beta-Gamma Hand-Shoe Counter

1. Check to see that the microflex timer is set on 10 seconds.
2. Observe the pilot lights. Pilot lights for line voltage, high voltage and automatic operation should be lit at all times.
3. Operate reset switch to insure that all registers reset to zero.
4. Check each GM tube with the point source and observe that it responds to the register. Record on the GM tube response check card. (BD-5300-064).
5. Report any faulty operation to Instrument Maintenance.

D. Shiftwise Background and Warning Level Check

1. Take one 10 second background count and record on Hand-Shoe Counter Control card. (BD-5300-064).
 - A. If background falls within the Background Limits corresponding to the posted Warning Level as listed in the Table (Fig. 2), the posted warning level is satisfactory.
 - B. If background falls outside the limits, run a second background count.
 1. If the background is within limits on the second count, the warning level as posted is satisfactory.
 2. If the background count is still outside limits, check to see that the instrument itself is not contaminated.
 3. If the instrument is not contaminated and the background is not high because of airborne activity, but the count is still out of limits, run 10 background counts, average, determine and post new Warning Levels as in B3, 4 and 5 above.

E. Disposition of Record

Hand-Shoe Counter control cards (BD-5300-064) are to be included in the instrumentation record (File # HA326-141).

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5/25/59

SUPERSEDES ISSUE DATED

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SUBJECT

BETA-GAMMA HAND-SHOE COUNTER

FIGURE 2Averaged
BackgroundBackground
LimitsWarning
Level.

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7	3-11	14
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9/26/60

SUBJECT

MINOMETER PENCIL READER

SUPERSEDES ISSUE DATED

New

DESCRIPTION

The Victoreen Projecting String Electrometer (Minometer) is used to measure the residual charge on gamma pencils. It also recharges the pencils for further use. It consists of a string electrometer, a light source and lens system to project the shadow of the string on a graduated scale, and a voltage supply.

A gold coated quartz thread with a loop in one end is supported between a fixed brass support and a piece of spring brass. Both supports are mounted on a grounded, aquadag-coated, brass rod. Tension on the quartz thread, and therefore the calibration of the instrument is controlled by a nut which moves the spring brass support. As the quartz loop flattens, it applies more tension on the thread. Another aquadag-coated brass rod, insulated from ground by polystyrene, is located parallel to the grounded rod so that the quartz thread is between them. An electrical charge applied to this rod, either from pencil meters or the standardizing unit, results in a movement of the quartz thread proportional to the applied voltage.

Light from a bulb operated from a 6.3 volt transformer winding shines through a condensing lens onto the quartz thread. The shadow of the quartz thread is projected onto a scale by two lenses, the second of which may be adjusted by a Focus Adjust screw to focus a sharply defined shadow on the scale. The scale of the electrometer has two sets of markings, 0 to 280 units and six red voltage calibration marks above the 0-280 scale. These red lines correspond to 150, 140, 130, 120, 110 and 100 volts, respectively, reading from left to right. Thus zero units equals 150 volts. Each instrument is an individual and as such has its own hand calibrated scale, both in units and voltages. Full deflection of all instruments, designated by a Z at the right of the scale, is the same: 76 millimeters from 150 volts to complete discharge or zero volts.

"Z" set of the instrument is accomplished by means of a screwdriver adjustment located within the right side of the case. The adjustment moves the whole electrometer assembly in the desired direction with respect to the light source and scale.

Charging voltage is provided by a type 80 tube used as a half wave rectifier to supply rectified voltage to two type 874 voltage regulators connected in series. A potentiometer Voltage Adjust is connected across the 874 tubes. The charging voltage is taken from the potentiometer center tap and is connected to the electrometer charging rod through a 50 megohm resistor. Pushing the charge button impresses the charging voltage on the insulated brass rod in the electrometer assembly and thence to a pencil meter inserted in the "well" on the instrument panel.

The instrument is turned on by means of an "OFF-ON" switch located on the front panel. For reliable operation the electrometer should remain turned on and warm. No attempt should be made to calibrate the unit until it has warmed up for at least one hour.

CALIBRATION PENCILS

Two calibration pencils are provided in R.M. office. These pencils will not have pocket clips and can be further identified by two strips of red tape around the barrels. These pencils should be kept charged when not in use. In addition, these pencils must not be used as personnel dosimeters.

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SUBJECT

MINOMETER PENCIL READER

CALIBRATION PROCEDURE

Each minometer should be calibrated each day according to the following procedure:

1. Check minometer for zero reading and drift. This is accomplished by depressing the charge button momentarily and noting the reading. The reading must be taken after the charging button has been released. There should be no observable drift. Any adjustment of zero should be made with the charging button depressed.

Note: This may necessitate adjusting the fiber a little off zero, since there may be some change in its position upon releasing the charging button.

2. Check the calibration pencil for leakage by inserting the pencil in the minometer well. Record pencil number used on minometer log sheet (Form BD-7800-051).

Any unusual reading should be noted; the use of this pencil discontinued.

3. Discharge calibration pencil and charge minometer.

4. Insert calibration pencil in well and record reading in minometer log.

Note: In a properly adjusted minometer, this reading will be off-scale and should be noted as such.

5. Remove pencil and recharge minometer.

Note: Do not charge or discharge calibration pencil.

6. Insert calibration pencil and record reading. This is the second reading and in a properly adjusted minometer it will be between 140 to 160 mr.

7. Repeat Steps 5 and 6 until calibration pencil is charged so as to read zero.

Record each reading on the minometer log sheet. The approximate ranges of these readings will be:

3rd reading	40 - 60 mr
4th reading	10 - 25 mr
5th reading	0 - 10 mr
6th reading	0 mr

8. On the nomograph, place a straight edge so as to intersect the 3rd reading on the righthand scale and 2nd reading on the lefthand scale. Record the number which is intersected by the straight edge on the center scale. Record this number in the minometer log and on the correlation work sheet.

9. If this number is greater than 410 or less than 330, repeat the above procedure with the second calibration pencil.

10. If minometer still fails to meet this test, report it to your supervisor and do not use it for reading or charging personnel pocket chambers.

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SUBJECT

PULSE PENCIL READER

GENERAL

The principle used in a pulse pencil reader to measure the beta-gamma dose absorbed by the pocket ionization chamber is as follows:

1. A very stable charging voltage is built into the reader, and this charge voltage provides the voltage pulse required to recharge the pencil ionization chamber.
2. A measuring circuit is provided which measures the magnitude of the voltage pulse required to bring the pencil back to full charge.
3. The difference between full charge and the charge remaining on the pencil is related to dose by the volume and capacitance of the pencil. The Victoreen Model 362 pencil used has a 2.5 mr dose received for each one volt drop in the charge. Example: The pencil is charged to 100 volts and exposed to a gamma field and recharged. If the voltage pulse required to recharge the pencil is 50 volts, then $2.5 \text{ mr/volt} \times 50 \text{ volts} = 125 \text{ mr}$.

DESCRIPTION

The pulse pencil readers have been provided with two dual dial potentiometers inside the control door. The upper potentiometer adjusts the voltage to the pencil calibrate socket. The lower potentiometer controls voltage applied to the pencil reading socket.

There is a zero adjust potentiometer on the left side of the control panel. A gain adjust potentiometer and a screwdriver operated coarse gain adjust potentiometer are located on the right.

The pencil reading socket is located on the front panel. The pencil reading is displayed on a 250 degree meter mounted in the front panel. The range adjust dual dial potentiometers are located on the top of the chassis. The range selection switch is located just in front of these potentiometers. The range one switch position makes 250 mr represent full scale on the meter when a charge voltage of 100 volts is applied to the pencil. The gain must be adjusted to make the meter indicate half scale when the pencil is inserted in the reading socket after it has been charged to 50 volts in the calibrate socket. The minor divisions on the meter represent one volt each, and thus also represent 2.5 mr each. With the range switch in the range two position, the full scale reading will represent 25 mr, when the charging voltage is set at 30 volts and the calibrate voltage is set at 25 volts. The gain must be set to give a half scale meter indication, when a calibrate voltage of 25 volts is applied to a pencil and inserted in the reading socket.

OPERATION

The sensitivity of the reader can be adjusted to make full scale on the pencil reader represent the desired milliroentgen dose. The dials on the charging and calibrate voltage potentiometers are calibrated using a Fluke differential voltmeter to insure

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PULSE PENCIL READER

accuracy in setting the voltage to within half a volt when using the dials.

The pencil readers should be set up uniformly throughout IPD for reading the daily pencils worn by personnel. For special studies or job evaluation, the pencil reader can be set at a desirable full-scale reading, using range one for full-scale response greater than 25 mr and range two for below 25 mr full-scale response. For full-scale response, smaller than 5 mr, larger ionization chambers should be used.

On range one, the zero adjust should be set by charging a pencil, and repeated by re-charging the pencil in the pencil reading socket and adjusting the zero adjust potentiometer so that the small deflection of the meter caused by charging the capacitance of the system just caused the meter hand to come up to zero.

A routine check of the pencil reader should be made prior to reading pencils. This check should consist of the following:

1. Applying a calibrate voltage to a pencil
2. Inserting the charged pencil into the reading socket to insure that the reader is responding correctly (with a zero reading)
3. Completely discharging a pencil by repeatedly shorting the electrodes
4. Inserting the discharge pencil into the reading socket to insure that the reader is responding correctly (with a full-scale reading)

NONROUTINE OPERATION OF THE PULSE PENCIL READER

The pencil reader can be used to make accurate measurements of either lower or higher doses than those routinely measured. Some examples of nonroutine setting of the reader are given below:

Example 1:

Assume that it is desired to make 100 mr represent a full-scale reading on the pulse pencil reader, using the Victoreen 362 pencil ionization chamber. The sensitivity of the pencil is such that there will be a one volt drop in the charge on the pencil per each 2.5 mr of exposure to gamma radiation.

$$\frac{100 \text{ mr full scale}}{2.5 \text{ mr/volt}} = 40 \text{ volts full scale}$$

The charging voltage can be set at 100 volts and the reader left on range one. The calibrate voltage must be set to give a half-scale response; in other words, the voltage difference must be one-half the full-scale voltage, thus:

$$2.5 \text{ mr/volt } (100-80) 2 = 100 \text{ mr full-scale response}$$

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Place a pencil in the calibrate socket, obtain the 80 volt charge, place the 80 volt charged pencil in the reading socket, and adjust the gain to give a half-scale response. Check the zero adjust to insure the recharged pencil in the charge socket will cause the meter to read zero when the pencil is inserted in the reading socket. Then recheck the gain to insure it is accurately set.

Example 2:

Assume that a background radiation level measurement is needed in a location to determine the dose received per day by operating personnel working in the location. The dose expected per day is less than 10 mr so it would be desirable to have 10 mr represent full scale using the Victoreen 362 pencil.

$$\frac{10 \text{ mr full scale}}{2.5 \text{ mr/volt}} = 4 \text{ volts}$$

The range switch would be set on range two, the charging voltage set on 30 volts, and the calibrate voltage set at 28 volts.

$$2.5 \text{ mr/volt } (30-28) 2 = 10 \text{ mr full scale}$$

Set the zero adjust to read zero on the meter, place a pencil in the charge socket and charge it several times, and carefully note the charge required to recharge the pencil and the capacity of the system. This reading must be subtracted from the pencil reading when using range two to obtain accurate results. Place a pencil in the calibrate socket allowing a few seconds for the charge to equalize (hold the pencil gently but firmly in the socket). Adjust the gain so that the two volt differential will cause a half-scale response when the pencil is placed in the reading socket. Recheck the zero and gain controls to insure the reader is accurately set. Make a note of all settings in case the reader is returned to normal use, so that the charging and calibrate voltage can be reset on the dial when the reader is again adjusted to read the pencils used to determine background radiation.

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SUBJECT

PERFORMANCE TEST FOR PENCIL DOSIMETER AND THE PULSE PENCIL READER

SUPERSEDES ISSUE DATED
9-12-62

To insure the integrity of the pencil dosimeter and the accurate reading of the dosimeter by the pulse pencil reader, the following tests shall be performed.

A. Daily Tests Prior to Reading Pencils

1. Apply a calibrate voltage of 50 volts and read in the pencil reading socket to insure the gain is set to make a half-scale response of 125 mR. If not, readjust the gain to give the proper response.
2. Discharge a pencil and read it to insure the reader will give a full-scale response to a discharged pencil. If not, ask the instrument foreman to have the necessary adjustments made.
3. Read a pencil in the read socket, and then repeat this to make sure the meter response will come up to zero on the meter when the pencil is repeatedly re-inserted in the reading socket. If adjustment is necessary, recheck the gain adjustment.
4. Place a pencil in the wing source pencil holder and expose to the wing source for two minutes. This should cause a reproducible response of about 100 mR on the meter. If this does not give the response indicated, try a second pencil and check the timing carefully. The average error to be expected in this test is less than ten per cent. Greater errors than this may indicate dirty sockets on the reader, improper positioning of the pencil holder, or a failure in the pencil reader.

B. Monthly

1. Each IPD gamma pencil dosimeter in the building shall be given:
 - a. A "noise" check
 - b. Source functional check
 - c. Hour leakage check once a month
2. Instructions:
 - a. "Noise" Check
 - (1) Open lid to pulse reader and switch to the number two range (toggle switch in front left corner of cabinet).
 - (2) Remove the cap from each pencil and move the pencil in and out of read socket and observe meter response. The response of pencils in good operating condition will give a fairly uniform response. This will be about 30 to 40 on the meter. If the meter deflection is more than a major division greater than the normal pencil, set it aside for repair.

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SUBJECT

PERFORMANCE TEST FOR PENCIL DOSIMETER AND THE FULSE PENCIL READER

(3) Return the range switch to range one and perform the daily performance tests to insure the operability of the pencil reader.

b. Source Functional Check

(1) Same as for daily test in A.4.

c. 24 Hour Leak Test

All pencils shall be charged and left standing for 24 hours in a location having a low radiation background and read to insure the pencil does not have abnormal leakage across the insulators. Pencils leaking off more than 10 mR of the charge should be removed from service and repaired.

3. General:

Use form number 1. for monthly IPD gamma pencil dosimeter checks.

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SUBJECT

AIR SAMPLE EVALUATION

Concentration $\mu\text{c/cc} = \frac{(\text{c/m})(\text{C.F.})}{(\text{cu.ft.})}$

c/m - counting rate of sample
 cu.ft. - volume sampled
 C.F. - conversion factor

Conversion Factor $\text{C.F.} = \frac{1.6 \times 10^{-11}}{(\text{Geom.})}$

Geom. = Geometry of counter
 = $\frac{(\text{c/m})}{(\text{d/m})}$ Standard source

∴ Example: $\frac{(395) \text{ c/m}}{(5240) \text{ d/m}} = 0.075 \text{ Geom.}$

$1.6 \times 10^{-11} = \frac{1}{(2.83 \times 10^4)(2.22 \times 10^6)}$

$2.83 \times 10^4 =$ cubic centimeters in a cubic foot
 $2.22 \times 10^6 =$ d/m in one microcurie

Control Chart

- Determine the average c/m for the Standard source. Take one 20-minute count and divide by 20.
- Determine 90 per cent confidence limits. $\pm 1.645 \sqrt{\text{average c/m}}$
- Plot: $\text{avg. c/m} + 1.645 \sqrt{\text{avg. c/m}}$
 avg. c/m
 $\text{avg. c/m} - 1.645 \sqrt{\text{avg. c/m}}$

Example: Standard source = 22,160 counts in 20 minutes

$\frac{22,160}{20} = 1108 \text{ c/m}$

90% confidence = $\pm 1.645 \sqrt{1108}$
 = $\pm 1.645 (33.3)$
 = $\pm 55 \text{ c/m}$

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AIR SAMPLE EVALUATION

Now

Upper limit = $1108 + 55 = 1163$

Average = 1108

Lower limit = $1108 - 55 = 1053$

4. Nine out of ten future counts of the Standard source should remain within these limits, if the counter is working properly.
- 5.a. Test the counter each shift that it is used with one one-minute count and record it.
- b. If the count falls outside the limits, take two more counts. If both of these fall within limits, counter is OK.

RADEF
19.4 Y HALF LIFE

Decay Factors

<u>Months</u>	<u>0</u>	<u>3</u>	<u>6</u>	<u>9</u>
<u>Years</u>				
0	1.00	0.991	0.982	0.974
1	0.963	0.956	0.948	0.939
2	0.931	0.923	0.915	0.906
3	0.898	0.890	0.882	0.875
4	0.867	0.859	0.851	0.844
5	0.836	0.829	0.822	0.814
6	0.807	0.800	0.793	0.786
7	0.779	0.772	0.765	0.758
8	0.751	0.745	0.738	0.732
9	0.725	0.719	0.713	0.706
10	0.700	0.693	0.687	0.681

$$A_t = (A_0) \times (\text{decay factor})$$

A_t = Activity in d/m at the present time

A_0 = Activity in d/m posted on source

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SUBJECT

LOG RADIATION MONITOR (LRM)

SUPERSEDES ISSUE DATED

GENERAL

The Log Radiation Monitor (LRM) monitors the input current from an ionization chamber. The input current is proportional to the radiation level in the area of the chamber; therefore, the LRM provides a direct readout in milliroentgens per hour (mR/hr).

In addition to the basic monitoring function, the LRM contains two trip circuits to control external warning devices in the event of radiation exceeding preset limits. The two trip circuits may be set independently to trip at any two points over the operating range of the LRM. The logarithmic meter spans a range from 1 mR/hr to 1000 R/hr in 6 decades.

1. The LRM has no "on" or "off" switch. It will be "on" at all times during which power is being supplied to it.

Issued by:

L. R. Wallis

Approved by:

Bme

Manager, Manufacturing

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LOG RADIATION MONITOR (LRM)

2. Obtain the dose rate by observing the location of the pointer on the meter scale.
3. Indicator lights that are on while the LRM is in operation:
 - a. DS-1, the Power On indicator light.
 - b. DS-2, the High Voltage On indicator light.
4. Indicator lights that are normally not on:
 - a. DS-3, the Control Alarm Trip indicator light.
 - b. DS-4, the Emergency Alarm Trip indicator light.
 - c. DS-5, the Control Alarm Integrity indicator light.
 - d. DS-6, the Emergency Alarm Integrity indicator light.
5. If the Control Alarm Integrity indicator light, DS-5, comes on:
 - a. Regard it as a radiation-caused trip.
 - b. The light will automatically reset to "off" status when the radiation level drops to below the trip point.
6. If the Emergency Alarm Integrity Indicator light, DS-6, comes on:
 - a. Regard it as an emergency-level radiation trip.
 - b. Press the Alarm Reset, S-5, to return the DS-6 light to "off" status.
 - c. If the light comes on again after pressing the Alarm Reset, S-5, the emergency radiation level remains above trip point.
7. To set the Control Alarm Trip point:
 - a. Move the R-95 pointer to the desired mR/hr level on the scale.
8. To set the Emergency Alarm trip point:
 - a. Unlock the R-100 pointer with a key and move it to the approved R/hr level on the scale.
9. To zero-check the IRN:
 - a. Hold switch S-2 to "Zero Check" position until the pointer comes to equilibrium on the meter scale, and observe.
10. To check the Control Alarm and Emergency Alarm Trip points:
 - a. Turn the trip test adjustment, R-50, to full CCW. Hold switch S-2 to the trip test position and slowly rotate the trip test adjustment, R-50, CW until the Control Alarm trip is indicated by the yellow light, DS-3. Compare the meter reading with the scale reading at the R-95 pointer location. The Control Alarm will not be actuated by this check.

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- b. Continue to hold the switch S-2 to the trip test position and continue to rotate the trip adjustment CW until the Emergency Alarm trip is indicated by the red light, DS-4. Compare the meter reading with the scale reading at the R-100 pointer location. The Emergency Alarm will not be actuated by this test.
11. To check the LRM Lo Calibration:
- a. Hold switch S-1 to "Lo Cal 10 mR/hr" until maximum reading is obtained. It should be 100 ± 1 mR/hr.
12. To check the LRM Hi Calibration:
- a. Hold switch S-1 to "Hi Cal 100 mR/hr" until maximum reading is obtained. It should be $100 \pm$ mR/hr.
13. To check Audible and Visible Alarms:
- A. Verify audible and visible alarms by applying a radiation source at the detector that exceeds the trip points.
- b. Reset the DS-6 light by pressing Alarm Reset, S-5.
14. The schedule for routine checks is outlined in Emergency Maintenance Standard No. 604. Report malfunctions to Instrument Maintenance for Repair.

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RICHLAND, WASHINGTON

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BULLETIN NO.

3-66**SUBJECT****RADIATION PROTECTION SERVICES FOR ITT FEDERAL SUPPORT SERVICES****INTRODUCTION**

This instruction is intended to clarify the services to be provided, responsibilities, required records, and financial agreements. The contact with ITT/FSS for this service is Radiation Practices Engineering.

A. Services to be Provided

1. Radiation monitoring service, as required, while performing work within DUN's zones of responsibility. Services shall include the providing of protective equipment (e.g., clothing, respiratory equipment, etc.), release surveys for personnel and equipment, and instructions for ITT/FSS personnel when entering radiation zones.
2. Consultation and guidance for investigation of radiation exposure to ITT/FSS employees known to have worked in DUN zones of responsibility.
3. Residence surveys for contamination known to have originated in or near DUN facilities when requested by ITT/FSS management. If buses or other vehicles are involved, they will be monitored and decontaminated, as necessary.
4. If ITT/FSS personnel are involved in a radiation incident while working in DUN's zones of responsibility, ITT/FSS management will be notified immediately when bioassay sampling, whole body counting or film badge processing is necessary and within 24 hours for any radiation incident.
5. Fire Protection personnel and their equipment will be monitored when radiation zones are involved or contamination is suspected.
6. Material and equipment originating in DUN facilities that is to be excessed or shipped should have the necessary declaration papers completed at the time of transfer to Stores. The shipper shall be responsible for proper packaging and identification to conform with appropriate ICC and AEC regulations.
7. Routine radiation surveillance services will be provided for facilities occupied by ITT/FSS personnel as specified in the DUN survey schedule.
8. Radiation training programs of DUN will be made available for training and retraining of ITT/FSS employees on a mutually agreeable basis.

ISSUED BY

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SUBJECT**RADIATION PROTECTION SERVICES FOR ITT FEDERAL SUPPORT SERVICES**

9. Provide film badge dosimeter service in the reactor areas, railroad and road maintenance facilities, and the Central Fire Station. Provide emergency portable monitoring instruments for the Central Fire Station.
10. Provide, on a monthly basis, a summary and/or copies of radiation surveys, air samples, etc., carried out for ITT/FSS facilities and personnel.

B. Responsibilities

1. Reactor Processing Operations and Production Fuels Quality Control are responsible for performing all service items 1 through 7 above in the same manner as service is provided DUN employees and facilities.
2. Radiation Practices Engineering is responsible specifically for items 8 through 10 and for the coordination of all services.

C. Required Records

1. All radiation protection services performed must be recorded on appropriate forms.
2. Each Processing Operation is to submit a monthly report to Radiation Practices Engineering including the status of services performed, building survey results, radiation occurrences, special survey requests, problem areas, and improvement suggestions.
3. Radiation Practices Engineering will submit a monthly summary report to ITT/FSS.

D. Financial Arrangements

1. Each area is to charge radiation monitoring manpower required for service via the TDR form to work order as follows:

<u>Servicing</u> (Component code)	<u>Customer</u>	<u>A/C Class</u>
	9X00	32000

Information regarding this work order may be obtained from Radiation Practices Engineering.

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E. Routine Survey Schedule

<u>Building</u>	<u>Description</u>	<u>Frequency</u>
151-B	Electrical Distribution Switch House	Quarterly
1701-B	Area Badge House and Patrol Headquarters	Monthly
1702-B	105-B Badge House	Monthly
1716-B	Garage and office	Monthly
1702-C	105-C Badge House	Monthly
151-D	Electrical Distribution Switch House	Quarterly
1701-D	Area Badge House and Patrol Headquarters	Monthly
1702-D	105-D Badge House	Monthly
1716-D	Garage and office	Monthly
1701-H	Area Badge House	Monthly
1709-H	Office Machine Repair	Quarterly
1716-H	Garage and office	Monthly
1701-KA	Exclusion Area Badge House	Monthly
1717-K	Garage and office	Monthly
1720-K	Area Badge House and Patrol Headquarters	Monthly
165-KE	Electrical Distribution Switch House	Quarterly
165-KW	Electrical Distribution Switch House	Quarterly
(Fuels Survey)		
3701-N	North Badge House	Monthly
303	South Badge House	Monthly
(100-D Survey)		
609	Fire Station - 100 Areas	Monthly
615	Road Maintenance Building	Quarterly
615-A	Road Maintenance Pump House	Quarterly
615-B	Road Maintenance Storage	Quarterly

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4-66

SUBJECT

REPRODUCTION OF RWP FOR 100-H HOT SHOP

RADIATION WORK PROCEDURE

LOCATION Hot Shop	NUMBER 102-H	REVISION 1	DATE 1-12-66	AREA 100-H
LOCATION All radiation zones in 100-H Hot Shop			TITLE - DESCRIPTION Rework, decontaminate, and store tools and equipment.	
RADIOLOGICAL CONDITIONS 1. Beta-Gamma contamination and radiation. 2. Possible air-borne contamination while sweeping, drilling, grinding, burning, or welding.			MONITORING Contact RM when: 1. Opening boxes having materials with smearable contamination > 1000 c/m. 2. At start of jobs involving dose rates.	
INSTRUCTIONS COMPLY WITH IPD RADIATION WORK PROCEDURES GENERAL INSTRUCTIONS.			PROTECTIVE CLOTHING	
1. Contact RM (5564) before opening boxed or wrapped material, unless dose rates are known and contamination levels are < 1000 c/m smearable.			☒ SINGLE * ☒ N.P.O.C. **	
2. Establish and maintain clearly marked radiation zones. Boundries will be limited to < 1 mR/hr.			*For working around rotating tools or equipment, Kerodex cream may be used by personnel without open wounds on hands or forearms instead of gloves. **No personal outer clothing.	
3. All items with over 500 c/m will be decontaminated or boxed when not in use.			☒ APRON For decontamination	
4. Respiratory protection for welding, burning, or grinding contaminated surfaces shall be as specified by RM.			☐ SUIT	
5. Materials and tools removed from RZ's will be checked for release by RM.			APPROVALS	
6. Floors and equipment in radiation zones will be decontaminated when smearable levels exceed 500 c/m.			D Processing J. J. Baker D Radiation Monitoring W. J. Toom Central Services N. H. Shashang	

RM-5500-D10 (1-63) AND-45 DESIGNER: WDC

ISSUED BY

Lynn R. Wallis

RADIATION PRACTICES ENGINEERING

A-5300-076 (12-65)

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SUBJECT

NEUTRON FILM BADGE DOSIMETER

Neutron energy spectrum studies have shown that the present dosimeter is relatively insensitive to the energies routinely encountered in the reactor areas. Based on this information, the use of neutron badges will be discontinued effective April 29, 1966. The present practice, which requires each individual to sign a Neutron Exposure Register form prior to entering a radiation zone where a neutron dose rate has been established, is to be continued. It will be necessary to sign this form only once each badge period in each reactor building. When work is completed in the radiation zone, the estimate of neutron exposure is to be recorded on the form by each individual. This estimate will be evaluated and entered in the Personal Exposure Record.

Radiation Standards and Control Procedures will be revised to reflect this change in dosimeter requirements.

ISSUED BY

Lynn R. Sallie

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SUBJECT

SHIPMENT OF RADIOACTIVE MATERIAL

Effective this date, all movement of radioactive or radioactively contaminated material or equipment to or from the following locations must be accompanied with a properly executed Radioactive Shipment Record (RSR), form No. 54-3000-219.

"Standard Radioactive Shipment Procedures" are not valid for these locations.

- a. 100-II area
- b. White Bluffs (Bldg. T-26)
- c. 105-F area

Prior to shipment into these areas, the Radiation Monitoring Service, 105-D, should be consulted regarding any special requirements or approvals for the shipment.

ISSUED BY

L. R. Wallis

RADIATION PRACTICES ENGINEERING

END

DATE FILMED

11 / 28 / 90