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Methods and Procedures for Internal Radiation Dosimetry at ORNL

E. D. Gupton

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Industrial Safety and Applied Health Physics Division

METHODS AND PROCEDURES FOR INTERNAL RADIATION DOSIMETRY AT ORNL

E. D. Gupton

Date Published - August 1981

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C O N T E N T S

	Page
Preface	vii
1. Internal Exposure Monitoring Rules and Regulations	1-1
1.1 General Requirements for Monitoring	1-1
1.2 ORNL Procedures	1-1
1.3 Supplemental Procedures	1-1
2. Internal Radiation Exposure Monitoring Techniques	2-1
2.1 Radiochemical Analysis of Urine	2-1
2.2 Radiochemical Analysis of Feces	2-1
2.3 Whole Body Counter	2-1
2.4 Other Techniques	2-1
3. Forms	3-1
3.1 Health Physics Body Fluids Analysis Request and Record, UCN-2716	3-1
3.2 Body Fluids Analysis - Special Report, UCN-3665	3-3
3.3 Health Physics Whole Body Counter (IVGS) Analysis Data, UCN-8562	3-5
3.4 Health Physics In Vivo Count Request and Preliminary Report, UCN-8561	3-7
3.5 Body Fluids Analysis Request, UCN-3712	3-9
3.6 Instructions for Preparing a Urine Specimen, UCN-2861A	3-11
3.7 Bioassay Report, UCN-3378	3-13
3.8 Bioassay Data, UCN-3855	3-15
3.9 Feces Sample Label, UCN-5155	3-17
4. Monitoring Procedures	4-1
4.1 General	4-1
4.2 Urine Sample Monitoring	4-2
4.3 Feces Sample Monitoring	4-3
4.4 Whole Body Counting	4-4
4.5 Body Tissue Analysis	4-4

5. Analytical Results---------- 5-1

5.1 Results of Urine Sample Analysis---------- 5-1
5.2 Results of Feces Sample Analysis---------- 5-1
5.3 Results of WBC Analysis---------- 5-1

6. Dose Evaluation---------- 6-1

6.1 General---------- 6-1
6.2 Whole Body Counter Data---------- 6-1
6.3 Feces Analysis Data---------- 6-1
6.4 Urine Analysis Data---------- 6-2

7. Records---------- 7-1

7.1 Health Physics Body Fluids Analysis Request and Record, Form UCN-2716---------- 7-1
7.2 Bioassay Report, Form UCN-3378---------- 7-1
7.3 Health Physics Whole Body Counter (IVGS) Analysis Data, Form UCN-8562---------- 7-1
7.4 Methods and Procedures for External Radiation Dosimetry at ORNL---------- 7-1
7.5 Weekly and Quarterly Bioassay Report---------- 7-1
7.6 Annual Bioassay Sample Result Report---------- 7-1
7.7 WBC Annual Report---------- 7-2
7.8 Personal Folder---------- 7-2
7.9 Methods and Procedures for Internal Radiation Dosimetry at ORNL---------- 7-3

8. Reports---------- 8-1

8.1 Bioassay Report, Form UCN-3378---------- 8-1
8.2 Body Fluids Analysis and Whole Body Counting, UCN-3665---------- 8-1
8.3 Health Physics In Vivo Count Request and Preliminary Report, Form UCN-8561---------- 8-1
8.4 Weekly Bioassay Sample Status Report---------- 8-1
8.5 Quarterly Bioassay Sample Result Report---------- 8-2
8.6 Annual Bioassay Sample Result Report---------- 8-2
8.7 Health Physics Whole Body Counter Analyses---------- 8-2
8.8 Individual Report of Overexposure---------- 8-3
8.9 Reports of ORNL Dose Data Requested by Previous Employees---------- 8-3
8.10 Annual Report of the ORNL Industrial Safety and Applied Health Physics Division---------- 8-4
8.11 Reports of Dose Data to DOE---------- 8-4

9. Standardization and Calibration---------- 9-1

9.1 Whole Body Counter---------- 9-1
9.2 Bioassays---------- 9-1

10. References----------10-1

Appendices----------A1.1

1.1 ORNL HPP No. 3.3, Personnel Monitoring----------A1.1
1.2 ORNL HPP No. 3.5, Personnel Contamination Monitoring----------A1.2
1.3 ORNL HPP No. 3.1, Radiation Protection Standards for Occupational Exposure----------A1.3
1.4 ORNL HPP No. 3.2, Personnel Exposure Control----A1.4
1.5 IS&AHP-IP No. 704, General Procedure for Bioassay Sampling, Analysis and Reporting-------A1.5
1.6 IS&AHP-IP No. 702, Priorities for IVGS and Bioassay Analyses----------A1.6
1.7 IS&AHP-IP No. 705, General Procedure for Requesting and Reporting Whole Body Counting (IVGS) Results----------A1.7
1.8 IS&AHP-IP No. 703, Procedure for Bioassay Request Cards----------A1.8
1.9 IS&AHP-IP No. 701, Procedure for Sampling Personnel Subjected to Internal Radiation Exposure as a Result of a Contamination Event----------A1.9
7.1 Weekly Bioassay Sample Status Report (DWG. 73-2400)----------A7.1
7.2 Whole Body Counter (IVGS) Analyses Report (DWG. 69-2039)----------A7.2
8.1 IS&AHP-IP No. 207, Compliance with DOEM 0525----A8.1
8.2 Radiation History Report----------A8.3

INTRODUCTION

Procedures, methods, materials, records, and reports used for accomplishing the personnel, internal radiation monitoring program at Oak Ridge National Laboratory are described for the purpose of documenting what is done now for future reference.

This document provides a description of the methods and procedures for internal radiation monitoring, dosimetry and records which are in effect at ORNL. A major consideration has been given to future retrieval of these data. Previous procedures are in "Methods and Procedures for Internal Radiation Dosimetry at ORNL," January, 1977, ORNL/CF-77/41; January 1, 1973, CF 73-1-65; January 1, 1971, CF 71-1-66; January 1, 1970, CF 70-1-58; and January 1, 1969, CF 69-1-58.

This document does not include procedures for nuclear accident dosimetry except insofar as routine techniques may apply also to nuclear accident dosimetry capability.

E. D. Gupton
Radiation Monitoring Section
Industrial Safety and Applied
Health Physics Division

1. Internal Exposure Monitoring Rules and Regulations

1.1 General Requirements for Monitoring

1.1.1 Persons who perform work with radioactive materials, or in an area where radioactive materials may be uncontained, are monitored for internally deposited radionuclides. The frequency and type of analyses are functions of the nature, relative hazard and half-life of the radioactive materials.

1.1.2 Persons who are likely to have been exposed or who are known to have been exposed are monitored as frequently as may be required to ascertain the degree of their exposure.

1.1.3 Persons who are unlikely to be exposed to radioactive materials may be monitored at a frequency of about once each three to five years to assure that exposure is unlikely.

1.2 ORNL Procedures

The ORNL policy and general procedures for internal exposure monitoring are included in the Health Physics Procedure Manual. Among the applicable procedures are:

Procedure 3.3, Personnel Monitoring (Appendix 1.1),
Procedure 3.5, Personnel Contamination Monitoring (Appendix 1.2),
Procedure 3.1, Personnel Radiation Exposure Limits (Appendix 1.3), and
Procedure 3.2, Personnel Exposure Control (Appendix 1.4).

1.3 Supplemental Procedures

Other procedures applicable to internal exposure monitoring are contained in the IS&AHP Internal Procedures Manual:

IS&AHP-IP No. 704-General Procedure for Bioassay Sampling, Analysis and Reporting (Appendix 1.5),
IS&AHP-IP No. 702-Priorities for IVGS and Bioassay Analyses (Appendix 1.6),
IS&AHP-IP No. 705-General Procedure for Requesting and Reporting Whole Body Counting (IVGS) Results (Appendix 1.7),
IS&AHP-IP No. 703-Procedure for Handling Bioassay Request Cards, Form UCN-2716 (Appendix 1.8), and
IS&AHP-IP No. 701-Procedure for Sampling Personnel Subjected to Internal Radiation Exposure as a Result of an Unusual Occurrence (Appendix 1.9).

2. Internal Radiation Exposure Monitoring Techniques

2.1 Radiochemical Analysis of Urine

Radiochemical urinalysis is used for detecting and evaluating the extent of internally deposited radionuclides and particularly those which emit relatively few X or gamma rays. The radiochemical procedures are documented in ORNL/TM-6372.[1]

2.2 Radiochemical Analysis of Feces

Radiochemical analysis of feces is used for estimating the extent of inhaled and/or ingested radioactive materials. The analytical procedures are in ORNL/TM-6372.[1]

2.3 Whole Body Counter (WBC)

The Whole Body Counter is used for estimating quantities of internally deposited radionuclides which emit X or gamma radiation or produce significant amounts of bremsstrahlung. The equipment and analytical techniques of the WBC are documented in ORNL/TM-7477.[2] This procedure is also referred to as in vivo gamma spectroscopy (IVGS).

2.4 Other Techniques

Radiochemical analyses may be performed on skin, blood, sputum, etc., in special cases of high level exposure to radioactive materials.

3. Forms

3.1 Health Physics Body Fluids Analysis Request and Record, UCN-2716 *

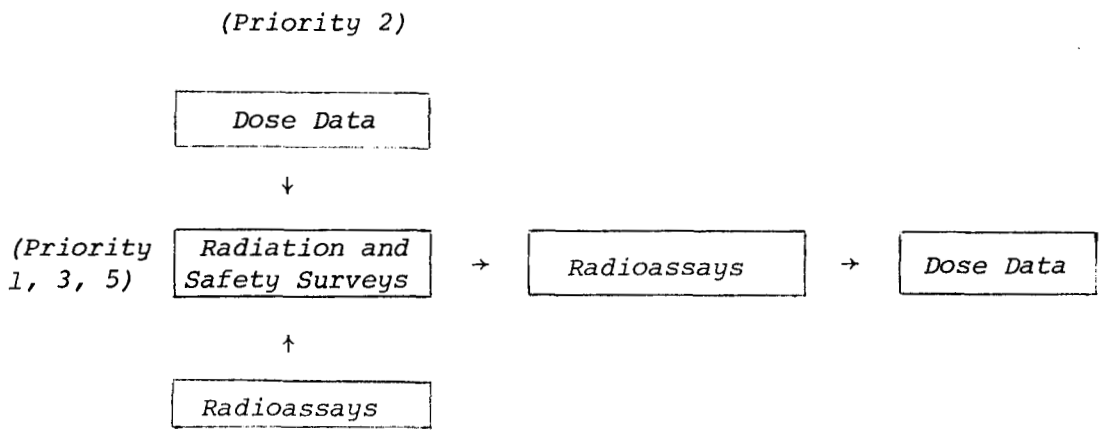
This form is used for requesting and identifying a bioassay sample, for recording the analytical data and results, and as a permanent record of the data.

3.1.1 Application -

a. Purpose -
(1) For priorities 2 and 4 (see Appendix 1.6) to notify the Radiation and Safety Surveys Section to request a sample,
(2) To notify the Radioassays Group that a sample has been requested,
(3) For identification of the sample for processing,
(4) For recording the processing data, and
(5) For a permanent record of the analysis.

b. Originated by -
(1) Radiation and Safety Surveys Section for priorities 1, 3 and 5,
(2) Radioassays Group for priority 4, and
(3) Dose Data Group for priority 2.

c. Transmittals - (See diagram below.)



d. Filed by - Dose Data Group.

e. Retention period - Permanently.

3.1.2 Procedure - (See IS&AHP-IP Nos. 702 and 703, Appendix 1.6 and 1.8)

All forms appear following their description.

HEALTH PHYSICS BODY FLUIDS ANALYSIS REQUEST AND RECORD

LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	HP AREA NO.

REMARKS

TYPE OF SAMPLE

☐ URINE ☐ FECAL ☐ _____

TYPE ANALYSIS

SAMPLE PRIORITY

☐ 1. Incident
☐ 2. Follow-up
☐ 3. Work Area
☐ 4. Background
☐ 5. Other

ANALYSIS REQUESTED

1. _____
2. _____
3. _____
4. _____
5. _____

SAMPLE DATE

SAMPLE HOURS

d/m SAMPLE

SAMPLE	DATE	TIME
START		
END		

REQUEST DATE:

REQUEST: ☐ First ☐ Second ☐ Third

HP SURVEYOR

d/m/24 HOURS

UCN-2716 (3 9-79)

TO BE FILLED IN BY REQUESTER

3.2 Body Fluids Analysis and Whole Body Counting Report, UCN-3665

This form is for special notification that additional sampling should be done because of results of previous sampling.

3.2.1 Application -

a. Purpose - To provide a summary of a special case and to notify those who may be immediately concerned.

b. Originated by - Dose Data Group.

c. Transmitted to - Divisional RCO, Divisional HPR and Radiation and Safety Surveys Area Leader. One copy retained temporarily by Internal Dosimetry Group. Other transmittals may be made according to circumstances.

3.2.2 Procedure -

a. Whenever, on the basis of data the Dose Data Group has collected, it appears that an employee may have sustained 10 or more percent of a permissible organ burden from a recent exposure, the Group Leader may originate form UCN-3665 which consists of five copies, one each white, blue, green, yellow, and gold. All pertinent information, including a resume of any previous analyses which may be applicable, should be filled in.

b. The Dose Data Group will retain the gold copy and forward one copy each to the Divisional RCO and the Radiation and Safety Surveys Area Leader of the employee of whom additional sampling will be requested.

3.2.3 Limitation - This form does not constitute a request for sampling but is for information only.

BODY FLUID ANALYSIS AND WHOLE BODY COUNTING REPORT

Date: _____

To: Associate Director, HP
Radiation Monitoring Section
RCO, _____ Division
HPR, _____ Area

From: HP&S Internal Dose Group

Ref.: RS Memo _____

_____, SSN. _____ – ____ – _____, has shown the analysis or measurement results as indicated. Follow-up samples or measurements are being requested. Further sampling or work recommendations will follow after additional analysis.

RECENT SAMPLE OR COUNTING RESULTS			NOTES
Date Submitted or Measured	Results d/m-day or nCi	Code Level or MPOB	

UCN-3665
(3 5-76)

3.3 Health Physics Whole Body Counter (IVGS) Analysis Data, UCN-8562

This form is for providing data for the computer-prepared IVGS report and is a summary record of the analysis.

3.3.1 Application -

a. Purpose - To provide data for computerized reports and to be a summary record of the analysis.

b. Originated by - Whole Body Counter Unit.

c. Transmitted to - Dose Data Group.

d. Filed by - Dose Data Group.

e. Retention Period - Permanently.

3.3.2 Procedure -

a. For each IVGS analysis the Whole Body Counter Unit will initiate a form UCN-8562, filling in all pertinent information, and forward it to the Dose Data Group as soon as practicable after the analysis. A three-letter alphabetical code is entered on the form for TYPE (of count):

WBC	Whole Body
LNG	Lung
THY	Thyroid
WND	Wound
WBL	Whole Body and Lung
WBT	Whole Body and Thyroid
ABD	Abdominal
WBA	Whole Body and Abdominal
WLA	Whole Body, Lung and Abdominal
SKL	Skull
WBS	Whole Body and Skull
OTH	Other

A handwritten note may be attached for communicating non-routine information.

b. The Dose Data Group will review the data, add items as needed under "Remarks," and initiate any follow-up analyses which may be required.

c. The Dose Data Group will key punch a data card for use in the WBC electrodata (EDP) record and report and file the form UCN-8562 as a permanent record.

HEALTH PHYSICS WHOLE BODY COUNTER (IVGS) ANALYSIS DATA

LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	HP AREA NO.

DATE OF COUNT

RESULTS OF ANALYSIS

- N ☐ INSIGNIFICANT
- O ☐ LESS THAN 15% MPOB*
- 2 ☐ LESS THAN 25% MPOB*
- 4 ☐ LESS THAN 50% MPOB*
- 6 ☐ LESS THAN 100% MPOB*
- 8 ☐ GREATER THAN 100% MPOB*
- S ☐ INDETERMINABLE

FOR ALL RESULTS > 10% MPOB

ISOTOPE	AMOUNT	% MP

REASON FOR ANALYSIS

1. ☐ INCIDENT
2. ☐ FOLLOW-UP
3. ☐ WORK AREA
4. ☐ BACKGROUND
5. ☐ OTHER

TYPE - SERIAL NO.

TYPE _____

SERIAL NO. _____

REMARKS

Due to Occupational Exposure at ORNL

_____ ANALYST

UCN-8562
(3 11-80)

3.4 Health Physics In Vivo Count Request and Preliminary Report, UCN-8561

This form is used as an appointment card and preliminary report of the results of WBC analysis.

3.4.1 Application -

a. Purpose - To provide a timely though preliminary report of a WBC analysis.

b. Originated by - Radiation and Safety Surveys staff for the area in which the employee works.

c. Transmittals -
(1) The Radiation and Safety Surveys staff gives the form to the
(2) Employee who takes it to the
(3) WBC for his analysis where it is filled in and forwarded to the
(4) Radiation and Safety Surveys area which originated the request, then to the
(5) Divisional HPR and then to the
(6) Divisional RCO.

3.4.2 Procedure - (See IS&AHP-IP. No. 705, Appendix 1.7.)

HEALTH PHYSICS IN VIVO COUNT REQUEST & PRELIMINARY REPORT

PRINT: LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	BLDG. NO.	H.P. AREA

YOU ARE SCHEDULED TO REPORT TO THE

WHOLE BODY COUNTER, BLDG. 2008

_____ AT _____
DATE TIME

REASON FOR COUNTING:

- ☐ INCIDENT
- ☐ FOLLOW-UP
- ☐ WORK AREA
- ☐ BACKGROUND
- ☐ OTHER

_____
REQUESTER

UCN-8561
(3 11-80)

PRELIMINARY RESULTS OF ANALYSIS

- ☐ NO OCCUPATIONAL DEPOSITION POSITIVELY DETERMINED
- ☐ LESS THAN 5% MPOB OF IDENTIFIABLE ACTIVITY
- ☐ LESS THAN 15% MPOB OF _____
- ☐ LESS THAN 25% MPOB OF _____
- ☐ LESS THAN 50% MPOB OF _____
- ☐ LESS THAN 100% MPOB OF _____
- ☐ GREATER THAN 100% MPOB OF _____
- ☐ RESULTS INCONCLUSIVE BECAUSE _____

_____

_____
ANALYST

3.5 Body Fluids Analysis Request, UCN-3712

This form is used for notifying an employee to collect and submit a urine sample.

3.5.1 Application -

a. Purpose - To provide notification and brief instructions for obtaining a sampling kit to an employee from whom a urine sample is requested.

b. Originated by - Radiation and Safety Surveys Group.

c. Transmitted to - Person of whom sample is requested.

3.5.2 Procedure -

a. The Radiation and Safety Surveys staff reviews employee's work assignments relative to potential exposure to radioactive materials and originates requests for urine samples in accordance with IS&AHP-IP Nos. 702 and 704, Appendix 1.6 and 1.5.

b. Form UCN-3712 is filled in and delivered to the employee by the area Radiation and Safety Surveys representative.

NAME	BADGE NUMBER	DIV. OR DEPT.	DATE

BODY FLUIDS ANALYSIS REQUEST

For your Health Physics monitoring record, you are requested to collect and submit a urine sample for radiochemical analysis. Please obtain a sampling kit from one of the dispensers at the ORNL Portals, or contact your Health Physics area surveyor to obtain a kit. Take the kit home with you; collect a sample following the instructions enclosed in the kit, and return the kit to the portal or to your HP area surveyor.

HEALTH PHYSICS AREA SURVEYOR	TELEPHONE NO.

UCN-3712
(3 7-74)

3.6 Instructions for Preparing a Urine Specimen, UCN-2861A

This form is used to provide instructions for collection of a urine sample.

3.6.1 Application -

a. Purpose - To provide instructions for collection and submission of a urine sample and to identify the sample for analysis.

b. Originated by - Donor of the sample.

c. Transmitted to - Radioassays Group with the sample.

d. Retention Period - Discarded after pertinent data have been transcribed onto form UCN-2716 (Section 3.1).

3.6.2 Procedure -

a. A form UCN-2861A is included in each urine sampling kit.

b. The donor of the sample fills in the card and replaces it in the kit with the specimen.

c. When the sample is logged in (see IS&AHP-IP No. 704, Appendix 1.5) the pertinent data are transcribed onto form UCN-2716 (Section 3.1).

INSTRUCTIONS FOR PREPARING A URINE SPECIMEN - II

This sampling kit includes bottles for collecting a urine sample. Your cooperation and care in collecting and submitting this sample is important, so that careful laboratory analysis of your specimen may be meaningful. Please do the following:

1. Keep the sample box and bottles as clean and free of radioactive contamination as possible.
2. Collect all the urine for 24 hours unless the bottles are filled in less time.
3. Tighten the bottle caps securely and replace the bottles in the box.
4. Fill in the information indicated on the reverse of this card and place this card in the box.
5. Return the kit to the sample collection point at the East or West Portal or where designated by your Health Physics representative.

UCN-2861A
(3 9-65)

(Over)

FILL IN THE FOLLOWING INFORMATION **(Please Print)**:

NAME
BADGE NO.
DIVISION
NAME OF YOUR HP REPRESENTATIVE

SAMPLE	DATE	TIME
START*		
END		

**Last voiding prior to use of Sample Kit.*

(SEE OTHER SIDE)

3.7 Bioassay Report, UCN-3378

This form is used for logging bioassay samples which are to be analyzed and to provide information of receipt of the sample.

3.7.1 Application -

a. Purpose -
(1) To serve as a temporary record of samples received for analysis,
(2) To provide a means of accounting for and assigning sample numbers for assays laboratory use, and
(3) To inform the Dose Data Group of samples received.

b. Originated by - Radioassays Group.

c. Transmitted to - Dose Data Group.

d. Filed by - Dose Data Group.

e. Retention Period - Three months.

3.7.2 Procedure -

a. Each bioassay sample which is received for analysis by the Radioassays Group is logged in on form UCN-3378.

b. If a sample is to have more than one analysis performed, each analysis is logged as a sample.

c. A serial number is assigned when the sample is logged in. Alphabetical suffixes, A, B, etc., are assigned to analyses when more than one analysis is to be performed.

d. The form is transmitted to the Dose Data Group.

BIO-ASSAY REPORT AND LOG

SAMPLE NUMBER	DATE REC'D	NAME	BADGE NUMBER	TYPE SAMPLE	TYPE ANALYSIS	d/m 24 hrs.	REMARKS

UCN-3378
(3 7-74)

3.8 Bioassay Data, UCN-3855

This form is for use by Radiation and Safety Surveys staff in scheduling and auditing receipt of bioassay samples.

3.8.1 Application -

a. Purpose - To provide Radiation and Safety Surveys staff a means of noting sampling schedules and auditing dates of request and receipt of bioassay samples from persons who may be exposed to radioactive materials because of the nature of their work.

b. Originated by - Radiation and Safety Surveys staff for area or areas in which the person to be sampled performs work.

c. Retention - This form is maintained in a Kardex file in the area Radiation and Safety Surveys office. It may be discarded whenever it is no longer useful in scheduling samples for the person.

3.8.2 Procedure -

a. Radiation and Safety Surveys staff will try to be knowledgeable of persons in their areas who may be likely to be exposed to radioactive materials.

b. Persons who are likely to be exposed should be sampled on a frequency based upon the nature of the work and the radioactive materials to which they may be exposed.

c. Card form UCN-3855 should be initiated and used as long as there is a need for routine sampling.

UCN-3855
(3 6-74)

BIO-ASSAY DATA

DATE REQUESTED	DATE SUBMITTED	SAMPLE ANALYSIS (d/m/24 hr. spec) URINE								d/m SAMPLE FECAL		SAMPLE FOR		
		Gr. α	U	Sr	Ra	Pu				Gr. α		REMARKS		

NAME	BADGE NUMBER	DIVISION	CAT.	Pg

3.9 Feces Sample Label, UCN-5155

This form is affixed to the carton in which a feces sample is contained so that the donor of the sample and the date of collection are known.

NAME _____

BADGE NO. _____

DATE _____

DIV. _____

WORK AREA _____

UCN-5155
(3 9-63)

4. Monitoring Procedures*

4.1 General

4.1.1 Responsibilities -

a. ORNL Divisions with the advice and recommendations of the Radiation and Safety Surveys staff are responsible for determining those employees for whom routine monitoring is required.

b. The Radiation and Safety Surveys staff is responsible for requesting all monitoring analyses of ORNL personnel.

c. The Radiation Monitoring Section is responsible for advising and recommending to the Radiation and Safety Surveys Section the types and frequency of monitoring and analyses for cases of suspected or known exposure.

d. The employee is responsible for complying with sampling requests.

4.1.2 Priorities for IVGS and Bioassay Analyses (as numbered):

Priority No. 1 - Analyses requested as a result of an incident or unusual occurrence (refer to IS&AHP No. 701, Appendix 1.9).

Priority No. 2 - Analyses requested as a follow-up to findings in previous analyses.

Priority No. 3 - Analyses requested because employee works directly with radioactive materials or in an area where radioactive materials may be present. The frequency of analyses should be related to the likelihood of exposure and the half-life of the radioactive materials.

Priority No. 4 - Analyses requested of persons who are not likely to have been exposed to radioactive materials in work at ORNL. Such analyses are for assessing background conditions at the Laboratory.

Priority No. 5 - Analyses for purposes other than those of Priorities 1 through 4.

---

*See also Appendices 1.5, 1.6, 1.7, and 1.8.

4.1.3 Specimen Kits

a. Urine specimen kits are prepared by the Radioassays Group. Form UCN-2861A (Section 3.6) is included in the kit.

b. The Shift and Area Surveys Group delivers and installs urine specimen kits in the dispensers which are located at the principal entry-exit portals of the Laboratory.

c. Feces specimen kits are prepared by the South Central Complex staff of the Radiation and Safety Surveys Section.

d. The Radiation and Safety Surveys staff installs feces specimen kits at the several feces sampling stations at the Laboratory.

4.2 Urine Sample Monitoring

4.2.1 A Radiation and Safety Surveys staff member of the ORNL area in which the employee works initiates a request for a urine sample.

a. Form UCN-2716 (Section 3.1) is filled in (requestor's portion) and forwarded to the Radiochemistry Laboratory.

b. Form UCN-3712 (Section 3.5) is filled in and given to the employee to be sampled.

c. The appropriate entry is made on form UCN-3855 (Section 3.8).

4.2.2 The employee complies with the sampling request.*

a. He picks up a urine specimen kit from a dispenser station.

b. He collects a sample in accordance with instructions in the kit (Section 3.6).

c. He fills in the information requested onto form UCN-2861A (Section 3.6).

d. He returns the kit to a dispenser station.

4.2.3 The Shift and Area Surveys Group collects the returned kits each day and delivers them to the Radiochemistry Laboratory.

4.2.4 The Radioassays Group logs the sample (Section 3.7), enters appropriate data on form(s) UCN-2716 (Section 3.1 and Appendix 1.8).

---

*If the employee does not comply with the initial request, repeated requests are made according to the need for the data.

4.2.5 The Radioassays Group analyzes the sample in accordance with Radiochemistry Procedures[1] and Appendix 1.8, and forwards form(s) UCN-2716 to the Dose Data Group.

4.2.6 The Dose Data Group makes any necessary calculations, records and reports.

4.2.7 The Dose Data Group initiates any necessary follow-up action.

4.3 Feces Sample Monitoring

4.3.1 A Radiation and Safety Surveys staff member of the ORNL area in which the employee works initiates a request for a feces specimen.

a. Form UCN-2716 (Section 3.1) is filled in (requestor's portion) and forwarded to the Radiochemistry Laboratory.

b. The employee is verbally requested to submit a specimen.

c. The employee is verbally advised how to collect the specimen, where to obtain a specimen kit, and to notify the Radiation and Safety Surveys staff when the specimen kit is ready for pick-up for analysis.

4.3.2 The employee complies with the sampling request.

a. He picks up a feces specimen kit from a sampling station.

b. He collects a sample in accordance with instructions.

c. He fills in the information onto form UCN-5155 (Section 3.9).

d. He notifies the Radiation and Safety Surveys staff member that the sample is ready for pick-up for analysis.

4.3.3 The Radiation and Safety Surveys Section staff member picks up the specimen kit and delivers it to the Radiochemistry Lab.

4.3.4 The Radioassays Group logs the sample (Section 3.7), enters appropriate data on form(s) UCN-2716 (Section 3.1 and Appendix 1.8).

4.3.5 The Radioassays Group analyzes the sample in accordance with Radiochemistry Procedures[1] and Appendix 1.8, and forwards form(s) UCN-2716 to the Dose Data Group.

4.3.6 The Dose Data Group makes any necessary calculations, records and reports.

4.3.7 The Dose Data Group initiates any necessary follow-up action.

4.4 Whole Body Counting

4.4.1 A Radiation and Safety Surveys staff member of the ORNL area in which the employee works initiates a request for WBC analysis (Section 3.4 and Appendix 1.7).

a. A scheduled date and time for the analysis is arranged.

b. Form UCN-8561 (Section 3.4) is initiated and given to the employee.

4.4.2 The employee complies with the appointment at the WBC Facility.

4.4.3 The WBC Unit performs analyses in accordance with WBC techniques and procedures[2] including completion of form UCN-8561.

4.4.4 The WBC Unit forwards form UCN-8561 to the appropriate Radiation and Safety Surveys field office, and form UCN-8562 (Section 3.3), when data are available, to the Dose Data Group.

4.4.5 The Dose Data Group initiates any required follow-up analyses and special reports, and forwards the forms UCN-8561 to the initiator.

4.4.6 The Dose Data Group makes any necessary records and routine reports.

4.5 Body Tissue Analysis

Analyses of other body tissues require the involvement of the ORNL Health Division.

5. Analytical Results

5.1 Results of Urine Sample Analysis

The Radioassays Group analyzes urine samples and determines results of the analysis. The results and data related thereto are recorded on the reverse of form UCN-2716 (Section 3.1).

The Dose Data Group completes, by transcription and calculation, the data entries related to results of analysis on the obverse of form UCN-2716.

5.1.1 Tritium Analysis - The results of analyses of urine specimens for tritium are reported and recorded in units of disintegrations per minute per milliliter of specimen.

5.1.2 Other Analyses - The results of analyses of urine specimens for other than tritium are recorded by the Radioassays Group in units of disintegrations per minute for a 24-hour sample, assuming the same concentration as that in the specimen analyzed.

5.2 Results of Feces Sample Analysis

The Radioassays Group analyzes feces samples and records and reports the results on the reverse of form UCN-2716 in units of disintegrations per minute per sample.

5.3 Results of WBC Analysis

There are three methods of noting or recording the results of routine WBC analyses by the Whole Body Counter Unit.

5.3.1 Preliminary Results - With visual observation of the spectrum display of an analysis, a rough evaluation of the case is made and one of the results on form UCN-8561 (Section 3.4) is checked.

5.3.2 Recorded Results - Following more detailed analysis, which may involve use of the computer program for body burden analysis,[2] one of the results on form UCN-8562 (Section 3.3) is checked. For amounts which exceed 10 percent of a permissible organ burden, the isotopes and amounts are recorded.

5.3.3 The printed data from the computer for a given analysis (Ref. 2, pp. 37-38) are filed and retained as the basic results of the analysis.

6. Dose Evaluation

6.1 General

The dose equivalent to the critical organ, from radioactive materials in the body, may be estimated by reference to Publication 2 of the ICRP[3] if the isotopic identity, quantity and solubility or location of the radioactive materials in the body are known. However, it is difficult to determine all these in vivo except for tritium and identifiable gamma ray emitters.

6.1.1 The techniques (Section 2) and results of analysis (Section 5) are used to infer fraction of body burden[3] and dose equivalent.

6.1.2 Dose equivalents or organ burdens are usually estimated if the dose equivalent may exceed 50 percent of that permissible within a calendar quarter, or if the organ burden may exceed 25 percent of the maximum permissible (DOE Manual, Chapter 0525) when averaged over a period of at least six months.

6.2 Whole Body Counting Data

The WBC may be used to identify, quantify and locate within the body most radioisotopes which emit significant amounts of gamma radiation. In Reference 2 is a list of the isotopes for which the WBC may be used.

Calculations of body burden and dose equivalent may be made, with reference to Publication 2 of the ICRP,[3] if the relative abundance and energies of the photons which originate within the body are such that the WBC may adequately detect and identify the isotopes.

6.3 Feces Analysis Data

The data of feces analyses may be of use, if sampling is begun soon after an acute exposure has occurred, in estimating the quantity of material inhaled or ingested. Feces analysis may be the only means of detecting and estimating organ burdens of relatively insoluble materials which emit only alpha or weak beta radiations, by comparison of these data with lung dynamics.[4] Feces analysis data are also an adjunct to concurrent urine analysis data, with which they are compared in dosimetric evaluations.

6.4 Urine Analysis Data

6.4.1 Tritium - The results of urine analysis for tritium may be used for determining the amount of tritium in the body and, thus, the resultant dose equivalent.

6.4.2 Plutonium-239 - A computer program has been written which may be used in some cases for ^{239}Pu body burden estimates.[5]

In the calculation it is assumed that the radioactive material is quite soluble in the body fluids and that bone is the critical organ.

6.4.3 Isotopes other than ^{3}H and ^{239}Pu - The body burden for other isotopes is conjectured from the results of the analysis, if the results of urine analyses are the only data which are available for estimating the body burden. ICRP Publication 10 is used as applicable.[6]

7. Records

7.1 Health Physics Body Fluids Analysis Request and Record, Form UCN-2716

The application and procedure for this form are related in Section 3.1.

7.2 Bioassay Report, Form UCN-3378

The application and procedure for this form are related in Section 3.7.

7.3 Health Physics Whole Body Counter (IVGS) Analysis Data, Form UCN-8562

The application and procedure for this form are related in Section 3.3.

7.4 Methods and Procedures for External Radiation Dosimetry at ORNL[7]

7.5 Weekly and Quarterly Bioassay Report

These reports are described in Section 8.4 and 8.5. They are retained for reference, temporarily, until the annual report (and record) is available.

7.6 Annual Bioassay Sample Result Report

This is a computer-prepared (EDP) tabulation which serves both as a record and a report. The report is described in Section 8.6.

7.6.1 Application -

a. Use - For record keeping purposes the annual report provides a tabulation of all the results of bioassay analyses of samples submitted during the calendar year.

b. The Annual Report is filed and retained indefinitely by the Dose Data Group.

7.6.2 Procedure - Two copies of the EDP Annual Report in the alphabetical (non-departmental) format (Section 8.6) are identified, filed and retained by the Dose Data Group.

7.7 WBC Annual Report

This is a computer (EDP) prepared report which serves also as a record. An example of the information in the record is shown in Appendix 7.2. The report is described in Section 8.7.

7.7.1 Application -

a. Use - For record purposes the annual report provides a tabulation of the results of all the WBC analyses performed during the calendar year.

b. The annual report is filed and retained indefinitely by the Dose Data Group.

7.7.2 Procedure - Two copies of the annual EDP report (Section 8) in the alphabetical (non-departmental) format are identified, retained and filed by the Dose Data Group.

7.8 Personal Folder

The Personal Folder is a manila folder which is identified for the person to whom it pertains.

7.8.1 Application -

a. Use - The folder is used for filing all forms, memos, reports, etc., which are related to the radiation exposure record of the person and which are not accumulated in other record files. Routine data are not filed in the Personal Folder, thus, persons with only routine data may not have a Personal Folder.

b. Originated and filed by - The Dose Data Group.

c. Retention - Permanent.

7.8.2 Procedure -

a. On the first occasion that there is a record item to be filed in a Personal Folder, the Dose Data Group initiates a folder for the person.

b. Folders are filed in alphabetical order by name of the person.

7.9 Methods and Procedures for Internal Radiation Dosimetry at ORNL.

This is a compilation into a report of the methods and procedures used by the Industrial Safety and Applied Health Physics Division for internal radiation monitoring and dosimetry. The document of which this is a part is so entitled.

7.9.1 Application -

a. Use - To describe and document the methods and procedures used for internal radiation dosimetry at ORNL.

b. Originated by - The Radiation Monitoring Section of the Industrial Safety and Applied Health Physics Division.

c. Filed by - The Dose Data Group.

d. Retention Period - Permanent.

7.9.2 Procedure -

a. At or near the beginning of each calendar year the Radiation Monitoring Section supervisor will, if changes warrant, prepare and have published a document entitled "Methods and Procedures for Internal Radiation Dosimetry at ORNL" in which will be related such methods and procedures in effect at the beginning of that year and any such methods and procedures which were inaugurated and superseded or discontinued during the previous year. The document will, in any case, be updated within five years.

b. The Dose Data Group will maintain a file of these documents.

c. Copies of these documents will be distributed to the ORNL groups involved in the procedures therein.

8. Reports

8.1 Bioassay Report, Form UCN-3378

This report is described and the application and procedure for it are related in Section 3.7.

8.2 Body Fluids Analysis and Whole Body Counting Report, Form UCN-3665

This report is described and the application and procedure for it are related in Section 3.2.

8.3 Health Physics In Vivo Count Request and Preliminary Report, Form UCN-8561

This form is described and the application and procedure for it are related in Section 3.4.

8.4 Weekly Bioassay Sample Status Report

This report is for providing information of sample status and results of analyses completed during the week of the report. The report includes listings by name, alphabetically, in the following sets: (1) complete alphabetical, (2) by ORNL division, and (3) by Health Physics Area number. Each of these sets consists of four categories of listings: (1) samples on request, with date of request noted, (2) samples in process, (3) samples received for processing during the week, and (4) results of samples analyzed during the week. An example of the information contained in this report is in Appendix 7.1.

8.4.1 Application -

a. Use - For keeping all interested groups informed of the status of requested bioassay samples on a weekly time basis.

b. Originated by - The Dose Data Group.

c. Distribution - Copies of the Health Physics Area sets are sent to the respective Health Physics Areas. Copies of the divisional sets are sent to the Divisional RCO and the Divisional HPR; copies of the alphabetical set are retained for use by the Radiation Monitoring Section.

8.4.2 Procedure -

a. The Dose Data Group accumulates information in accordance with the procedures for form UCN-2716 (Section 3.1) and form UCN-3378 (Section 3.7), and key punches the data into appropriate cards and format.

b. The Dose Data Group organizes the punch cards, deleting those of overdue samples, each Friday and sends them to the Computer Center for preparation of the report.

c. The Dose Data Group sorts and distributes the sets of the report.

8.5 Quarterly Bioassay Sample Result Report

This report is for providing information of results of bioassay samples analyzed during the calendar quarter of the report. The report includes listings by name, alphabetically, in sets (1) complete alphabetically, (2) by ORNL division, and (3) Health Physics Area, of the data related to results of the samples.

8.5.1 Application -

a. Use - For cumulating the information of results from weekly reports (Section 8.4) into a single report for each calendar quarter.

b. Originated by - The Dose Data Group.

c. Distribution - Copies of the Health Physics Area sets are sent to the respective Health Physics Areas, copies of the divisional sets are sent to the Divisional RCO and the Divisional HPR, and copies of the complete alphabetical set are retained for use by the Radiation Monitoring Section.

8.5.2 Procedure -

a. The Dose Data Group accumulates the punch cards of bioassay results (Section 8.4.2) during each calendar quarter.

b. Following the end of the quarter, the punch cards are sent to the Computer Center and the report is prepared.

c. The Dose Data Group sorts and distributes the report.

8.6 Annual Bioassay Sample Result Report

This report includes all the information of results of bioassay analyses which were performed during the calendar year. Except that all results for the calendar year are included, the content, form, application and procedure for this annual report are the same as those for the quarterly report (Section 8.5).

8.7 Health Physics Whole Body Counter (IVGS) Analyses

This is a computer (EDP) prepared report which is a tabulation of the information from form UCN-8562 (Section 3.3). The report includes listings, alphabetically by name of person analyzed, in sets (1) by ORNL Division, (2) by Health Physics Area, (3) by Serial No. of the analysis and (4) complete alphabetic. The report is prepared and distributed quarterly, and the data are cumulated during a calendar year, so that the report for the fourth quarter is also an annual report and record (Section 7.7). An example of the information contained in this report is in Appendix 7.2.

8.7.1 Application -

a. Use - For informing interested groups, on a quarterly basis, of the results of WBC analyses.

b. Originated by - The Dose Data Group.

c. Distribution - Copies of the Health Physics Area sets are sent to the respective Health Physics Areas, copies of the divisional sets are sent to the Divisional RCO and the Divisional HPR, and copies of the complete alphabetical set are retained for use by the Radiation Monitoring Section.

8.7.2 Procedure -

a. The Dose Data Group key punches the data from forms UCN-8562 into appropriate punch cards and format.

b. Following the end of each quarter within a calendar year, the cards for that quarter are organized and sent to the Computer Center which prepares the report.

c. The Dose Data Group distributes the report.

8.8 Individual Report of Overexposure

This is an individualized report which is made in compliance with DOE Manual, Chapter 0325 requirements. The procedure is IS&AHP-IP No. 207 (Appendix 8.1).

8.9 Reports of ORNL Dose Data Requested by Previous Employees

The Radiation Monitoring Section prepares and transmits, at the written, signed request of a previous employee, a summary statement of that employee's radiation monitoring data for the period of employment at ORNL.

The data for a non-employee may be directed to the employer by whom he was employed while at ORNL (the person may have been self-employed) or to the DOE. Two methods for reporting are currently in use:

a. If there were no significant internal exposures and if no permissible level was exceeded for external radiation, the form shown in Appendix 8.2 is used.

b. A specially prepared report, designating doses by calendar quarters, the periods of monitoring, and any other pertinent information would be transmitted for any person who was exposed in excess of levels which require special reporting to the DOE in compliance with Manual Chapter 0502.

8.10 Annual Report of the ORNL Industrial Safety and Applied Health Physics Division.

The Radiation Monitoring Section provides summary data related to internal exposures for this report.

8.11 Reports of Dose Data to the DOE

The Radiation Monitoring Section provides data for reports of internal radiation exposures to the DOE required by or requested by the DOE.

9. Standardization and Calibration

9.1 Whole Body Counter

The standardization and calibration of the Whole Body Counter are described in Reference 2.

9.2 Bioassays

9.2.1 Basic Standardization - Each bioassay procedure[1] has been standardized by analysis of a large number of standard samples to establish the separability, recovery and efficiency of the procedure.

9.2.2 Counting Equipment - The counting equipment is routinely calibrated with standard samples.

9.2.3 Routine Checks - The bioassay procedures are routinely checked with standard ("spiked") samples and blank samples.

10. References

1. L. C. Henley, Radiochemical Procedures, ORNL/TM-6372, May 1978.

2. C. D. Berger, R. E. Goans and R. T. Greene, The Whole Body Counting Facility at Oak Ridge National Laboratory, Systems and Procedure Review, ORNL/TM-7477, October 1980.

3. Report of Committee II on Permissible Dose for Internal Radiation, ICRP Publication 2 (1959).

4. "Deposition and Retention Models for Internal Dosimetry of the Human Respiratory Tract," Task Group on Lung Dynamics for Committee II of the ICRP, Health Physics 12, 173 (1966).

5. W. S. Snyder, "The Estimation of a Body Burden of Pu from Urinalysis Data," Proceedings of the Seventh Annual Meeting on Bioassay and Analytical Chemistry, ANL-6637 (1961).

6. Report of Committee IV on Evaluation of Radiation Doses to Body Tissues from Internal Contamination Due to Occupational Exposure, ICRP Publication 10, (1968).

7. E. D. Gupton, Methods and Procedures for External Radiation Dosimetry at ORNL, January 1, 1968, ORNL CF 68-1-73, et seq.

Number 3.3
Page 1 of 3 Pages
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PERSONNEL MONITORING

POLICY

It is the policy of the Oak Ridge National Laboratory that each person who has access to a radiation control zone be monitored for exposure to ionizing radiation while occupying the Laboratory premises.

LIMITATIONS

Regulations in this procedure may be suspended in accordance with Laboratory Emergency Procedures.

RESPONSIBILITIES

1. Health Physics and Safety
   (a) Prescribes personnel monitoring methods used in monitoring exposure to ionizing radiation, provides for the issuance and processing of personnel monitoring equipment, monitors personnel for radioactive contamination, and estimates the individual doses received.
   (b) Maintains a continuous audit program to determine and evaluate the accumulated radiation exposure of Laboratory personnel.
   (c) Informs supervision promptly when the radiation exposure of an individual exceeds maximum operating limits or when the running exposure rate is such as to suggest additional administrative controls.
2. Supervision
   (a) Ensures that personnel comply with the personnel monitoring procedures.
   (b) Advises Health Physics and Safety of exposure conditions in operating procedures that may require a re-evaluation of existing personnel monitoring requirements.
   (c) Promptly informs the Area Health Physics Representative of each occurrence where personnel exposure to external radiation or contamination is known or suspected to have exceeded an authorized planned exposure.

REGULATIONS

1. The radiation and contamination hazards in each work area shall be evaluated on a schedule considered adequate for keeping those in the work areas aware of their presence and appropriate personnel monitoring techniques shall be employed.

2. An immediate evaluation by Health Physics of the radiation exposure received by personnel should be made following any accident or occurrence in which abnormal or excessive exposure to radioactive materials is suspected.

3. The personnel monitoring techniques used for each radiation exposure condition shall:

   (a) be compatible with the work in progress permitting the control of planned necessary exposure on a single-job or daily accumulation basis,

   (b) give suitable warning when an exposure rate is such as to necessitate corrective measures or whenever there is a reasonable expectation that corrective measures may be needed,

   (c) provide sufficient information regarding the type and degree of personnel exposure sustained over a given period of time in order to permit the evaluation of accumulated exposure with respect to permissible dose limits, and

   (d) provide a record of personnel exposure, or lack of exposure, so as to authenticate the individual's Laboratory record of accumulated exposure.

4. Laboratory personnel shall be monitored for exposure to external radiation in accordance with Procedure No. 3.4 - Personnel Meters.

5. Laboratory personnel subjected to unconfined radioactive materials shall be monitored for exposure to internal and external contamination in accordance with Procedure No. 3.5 - Personnel Contamination Monitoring.

6. Personnel exposure data generated by Health Physics personnel monitoring units shall be recorded and reported in accordance with standard operating procedures.

7. The personnel monitoring exposure data shall be used to control and regulate planned exposures in accordance with methods and practices set forth in:

   (a) Procedure No. 3.1 - Personnel Radiation Exposure Limits.

   (b) Procedure No. 3.2 - Personnel Exposure Control.

8. Personnel monitoring data shall be made available to the Health Division for the evaluation of any personnel exposure that is known or suspected to be in excess

of a recommended limit so as to establish appropriate restrictions on future radiation work, aid in the evaluation of existing monitoring practices and requirements, and determine the course of any medical treatment or care in the case of severe overexposure.

APPENDIX 1.2

Number	3.5
Page	1 of 2
Issued	10/1/80
Supersedes Issue Dated	7/1/65

PERSONNEL CONTAMINATION MONITORING

POLICY

It is the policy of the Oak Ridge National Laboratory to require monitoring of personnel for radioactive contamination following work in a Contamination Zone or following a known exposure to unconfined radioactive materials.

LIMITATIONS

Regulations in this procedure may be suspended in accordance with Laboratory Emergency Procedures.

RESPONSIBILITIES

1. Health Physics
   (a) Conducts routine and special personnel monitoring surveys for radioactive contamination of personnel.
   (b) Provides bioassay and whole-body counting facilities sufficient to permit the evaluation of internal dose as a result of radioactive materials inadvertently taken into the body.

2. Supervision
   (a) Ensures that necessary contamination monitoring instruments are provided in local operating areas and that they are properly used in accordance with established procedures.
   (b) Coordinates the participation of individuals in prescribed internal exposure evaluations by bioassay or whole-body counting.

REGULATIONS

1. Laboratory personnel shall have their clothing and person monitored for possible radioactive contamination following (a) any work within a Contamination Zone or (b) any exposure to unconfined radioactive materials or, (c) whenever required by local operating procedures.

2. Persons whose work requires regular or occasional contact with radioactive materials shall be monitored routinely for internal contamination from radionuclides by the use of bioassay and/or whole-body counting techniques. The type of internal dose measurements performed and the frequency with which such measurements are made will depend upon the individual's job assignment and work schedule and the degree of exposure sustained.

3. Each Laboratory area where there is any likelihood that radioactive materials may be released to the working environment shall be provided with air monitoring and alarm facilities necessary to:

(a) give prompt warning of any unusual or excessive concentration or buildup of airborne radioactivity that would result in an exposure to personnel and
(b) provide data for the evaluation of any significant intake of radionuclides by inhalation.

4. Personnel and equipment leaving a Contamination Zone shall be monitored in accordance with posted monitoring procedures.

5. Requirements for personnel contamination checks and inspections shall be specified in the local operating procedures or posted regulations and shall be stated on each Radiation Work Permit issued.

6. Personnel working with, or exposed to, unconfined radioactive materials shall be monitored routinely for any excessive contamination on their person or articles of clothing.

7. Each lunchroom facility which permits occupancy of persons wearing contamination zone clothing shall be provided with appropriate self-service monitoring instruments and operating instructions shall be posted at the entrance to the facility; all personnel who are garbed in contamination zone clothing shall be required to check their hands, shoes, and outer clothing at this monitoring installation before entering the lunchroom.

8. All lunchrooms, canteens, and cafeteria facilities shall be monitored routinely for any indication of radioactive contamination; surveys of these areas shall be made following any radiation contamination incident that might result in the contamination of these areas.

9. Each individual whose person remains contaminated in excess of a permissible limit after reasonable decontamination efforts have been undertaken in the field with the assistance of a Health Physics representative should be referred to the Health Division, where further decontamination efforts will be performed under medical supervision.

10. Persons who have been subjected to conditions where there is a possibility that radioactive materials have been taken into the body should be referred to the Area Health Physics Representative, who will effect monitoring techniques as required.

APPENDIX 1.3

RADIATION PROTECTION STANDARDS FOR OCCUPATIONAL EXPOSURE

POLICY

It is the policy of the Oak Ridge National Laboratory to plan and conduct operations involving exposure of personnel to ionizing radiation in accordance with DOE standards for radiation protection and to require that departmental programming will be such as to result in planned exposures that will be below those standards as much as is practicable.

DEFINITIONS

1. External Exposure - Dose equivalent to body tissues from sources of ionizing radiation located outside the body.

2. Internal Exposure - Dose equivalent to tissues of the body from radioactive materials located within the body.

3. Rem (Roentgen equivalent man) - The unit of dose equivalent (H). Dose equivalent (in rem) = absorbed dose (in rads) x modifying factors. One sievert = 100 rem.

4. Rad - The unit of absorbed dose. One rad = 100 erg/g. For purposes of this Manual the rad is measured in tissue. One gray = 100 rad.

5. Modifying Factors - Dimensionless modifying factors related to linear energy transfer (Q), specific deposition of energy in an organ (N), etc., used to determine the dose equivalent.

6. CG - Concentration guide. An accepted upper limit for the concentration of a specified radionuclide in a material taken into the body below which continuous exposure to the material is not considered biologically harmful.

7. $(CG)_a$ - Concentration guide for air.

8. $(CG)_w$ - Concentration guide for water.

9. Critical Organ - That organ (or tissue) in which the dose equivalent would be most significant due to a combination of the organ radiosensitivity and selectivity and/or a particular dose pattern throughout the body.

10. Occupational Exposure - Occupational exposure of an organ or tissue consists of the total H delivered to that organ or tissue from external sources during working hours, and from internal sources whose presence in the body is a consequence of Laboratory employment. It shall not include any medical exposure or exposure to naturally occurring background radiation.

11. Maximum Permissible Dose Equivalent (MPH) - Limits on dose equivalent specified in DOE orders (based on recommendations of the NCRP and/or ICRP).

12. Dose Commitment - The dose equivalent received by specified organs during a period of one calendar year which was the result of uptake of a radionuclide by a person occupationally exposed.

13. Maximum Permissible Intake (MPI) - Limits on intake specified by DOE orders (based on information contained in NBS Handbook 69).

14. Recommended Operating Levels - Exposure levels calculated to result in long-term accumulations that will not exceed those specified as permissible in Table 1.

LIMITATIONS

This procedure applies only to planned occupational exposures.

REGULATIONS

1. The Maximum Permissible Dose Equivalent (MPH) and the Maximum Permissible Intake (MPI) limits specified in this procedure are limits for planned occupational exposures. Exposures at ORNL shall be maintained as far below these values as is reasonably achievable.

   (a) The MPH's for the various tissues and organs of the body are specified in Table 1.

TABLE 1. Dose-Limiting Recommendations for Occupational Exposure[1]

Type of Exposure	Condition	MPH (Dose equivalent or Dose commitment) (rem)
Whole body (gonads, head & trunk, lens of the eye, red bone marrow, and active blood forming organs also included)	Prospective (Planned) Annual Limit	5[2]
	Calendar Quarter	3
Skin (except hands & forearms), other organs, tissues[3,4] and organ systems (except bone).	Annual Limit	15
	Calendar Quarter	5
Hands or feet	Annual Limit	75
	Calendar Quarter	25
Forearms, bone	Annual Limit	30
	Calendar Quarter	10

[1] DOE Manual, Chapter 0524.

[2] In special cases with DOE approval, a worker may exceed 5 rem/yr provided his/her average exposure per year since age 18 will not exceed 5 rem.

[3] Exposure to women of reproductive capacity should be limited to 1.3 rem/qtr. Exposure of the fetus during any pregnancy should not exceed 0.5 rem.

[4] The presence of a chronic skeletal burden of a radionuclide of long effective half-life requires reduction of exposure to external sources of penetrating radiation as follows:

(i) if the estimated body burden is less than one-half of the maximum permissible, no consequential restriction of external radiation exposure need be applied;

(ii) if the estimated body burden is greater than one-half but less than the maximum permissible, the total body exposure to penetrating external radiation shall be limited to not more than 1.5 rem in any year; and if A years is the age of the individual when the body burden was first found to exceed one-half the maximum permissible, then the total accumulated dose from such future exposure beyond age A shall not exceed 1.5 (N-A) rem where N is the current age of the individual; if, however, at age B the body burden is found to have dropped to less than one-half the maximum permissible value, the accumulated dose from future external total body exposure beyond age B shall not exceed 5 (N-B) rem.

(iii) if the estimated body burden equals or exceeds the maximum permissible, no occupational exposure to penetrating external radiation is permissible.

(b) The MPI is based on the MPH values shown in Table 1 and is administered as follows:

(i) If there is no occupational external radiation exposure, the MPI for an individual during any calendar quarter shall be limited to the amount that would be taken into the body of standard man in 520 hours of exposure at the CG for a 40-hr week. This amounts to $6.5 \times 10^8 \times (CG)_a$ μCi/quarter by inhalation alone, and $7.2 \times 10^4 \times (CG)_w$ μCi/quarter by ingestion alone. The CG in each case is that for a 40-hr week.

(ii) If an individual is receiving occupational external radiation exposure, the above rule continues to apply with the limitation that (in calculating the MPI) the CG for a 40-hr week value referred to must be lowered as follows: if the dose that is permissible to the critical body organ during a specific calendar quarter is H rem and if external radiation is expected to deliver a dose of E rem to the organ during that quarter, then the CG based on the particular organ must be reduced by the factor $\frac{H-E}{H}$.

2. Recommended Operating Levels for Quarterly Exposures - In general, it is recommended that the planning of operations be such that the accumulated quarterly MPH or MPI will not exceed approximately 1/3 of the recommended quarterly limits. It is emphasized that, in planning, the Laboratory's policy of holding all personnel exposure as low as reasonably achievable be kept in mind.

3. Recommended Operating Levels for Weekly Exposure - The following recommendations shall be used as a guide in planning and conducting operations involving personnel radiation exposure. (Planned exposures in excess of these recommended levels shall be sanctioned only after careful consideration and in accordance with Procedure No. 3.2).

(a) External Exposure - The external exposure to an individual in any single week should not exceed:

(i) 100 mrem to the total body, head and trunk, lens of eyes, gonads, or blood-forming organs.

(ii) 300 mrem to the skin of the whole body.

(iii) 600 mrem to the forearms.

(iv) 1500 mrem to the hands.

(b) Internal Exposure - The intake of radioactive materials by an individual in any single week should not exceed 1/13 of the MPI per calendar quarter. (Note: This recommendation is intended to be used more for general planning purposes than as a practical

method for regulating internal exposures on a weekly basis. In contrast to external radiation exposures, it is very difficult to regulate or to determine the amount of intake of radioactive materials by an individual and the subsequent radiation dose to his body tissues. It is usually more practical to avoid internal exposures of significance by exercising prescribed contamination controls, employing appropriate material-handling techniques, and using adequate respiratory protection devices).

Number 3.2
Page 1 of 6 Pages
Issued 2/1/72
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PERSONNEL EXPOSURE CONTROL

POLICY

It is the policy of the Oak Ridge National Laboratory to keep personnel exposures at the lowest practical level and to ensure that no individual exceeds the recommended maximum dose limits.

DEFINITIONS

1. Personnel Exposure Control - Measures taken for the purpose of preventing or minimizing radiation exposure. Such measures include the control of access to radiation hazards, controlled dose rates, working time limits, and accumulated dose per time interval. Dose rates are controlled by shielding or containment, the use of maximum feasible working distance (assisted by remote handling equipment when appropriate), the minimization of surface and air contamination, and the use of personnel protection equipment.

2. Administrative Controls - Methods used for authorizing external exposure through supervisory line organization. Approvals are based on (a) exposure rates involved; (b) the individual's physical condition and accumulated dose status; and (c) specific operational conditions.

3. Health Physics Surveillance - The continuous or intermittent attendance of a Health Physics Representative at the site of a given work operation involving ionizing radiation. (The term "surveillance" is not to be confused with "radiation survey", which is defined in Procedure No. 2.1, this Manual.)

LIMITATIONS

1. Regulations in this procedure may be suspended in accordance with Laboratory Emergency Procedures.

2. Radiation exposures resulting from medical applications are exempt from the provisions of this procedure except as otherwise qualified by the Health Division.

RESPONSIBILITIES

1. Health Physics

   (a) Assists supervision in the development and application of effective methods for preventing radiation exposure, or in controlling necessary exposure at the Laboratory within specified recommended limits.

   (b) Keeps supervision currently informed regarding the radiation exposure status of personnel under their direction by means of daily, weekly, quarterly, or special reports.

2. Supervision

   (a) Informs all individuals who occupy areas under the supervisor's control of the nature of the ionizing radiation hazards present, or apt to be present, and effects the protective measures required.

   (b) Limits the exposure of personnel to the lowest practical level at or below the recommended limits.

3. Health Division

   Determines the physical eligibility of personnel for work with ionizing radiation at ORNL and recommends medical disqualification for such work when indicated.

4. Each Individual

   (a) Cooperates in preventing avoidable radiation exposure and minimizing those exposures that are necessary for completion of work assignments.

   (b) Uses personnel monitoring equipment as required for determination of exposures.

   (c) Reports to appropriate supervision knowledge of any incident or work condition in which he knows or suspects that a significant radiation exposure occurred, or may occur.

   (d) Informs his supervisor and the Director of the Health Division of prior or concurrent work with ionizing radiation and radioactive materials at installations other than the Laboratory.

   (e) Informs his supervisor and/or the Director of the Health Division of any known or suspected personal physical condition or any significant nonoccupational internal or external radiation exposure which might alter his current ORNL eligibility for further occupational exposure.

   (f) Cooperates in supplying samples of excreta, as required for dose determinations.

REGULATIONS

1. Only individuals qualified for radiation work shall be permitted to engage in ORNL activities involving radiation exposure above normal background. Grounds for disqualification for work involving radiation exposure include:

   (a) A known history of accumulated occupational radiation exposure or body burden of radionuclides in excess of recommended maximum limits.

   (b) A known history of accumulated non-occupational radiation exposure or body burden of radionuclides (e.g., diagnostic, therapeutic, or accidental) significantly in excess of the recommended maximum for occupational exposure.

   (c) Certain physical limitations specified by the ORNL Health Division.

   (d) Failure to comply with responsibilities, 4, above.

2. Existing and potential exposure areas shall be zoned in accordance with the Laboratory zoning procedure (see Procedure No. 2.7) and equipped with instruments and devices necessary to provide ample warning of any significant increase in radiation exposure potential.

3. In addition to the regularly issued film badge meter (see Procedure No. 3.4), all persons entering an area where there is a likelihood of a significant radiation exposure or contamination, shall be provided with special monitoring instruments, special clothing, protective equipment, instructions, and Health Physics surveillance appropriate for the existing exposure potential.

4. The radiation dose that may be sustained by an individual entering a zoned area shall be estimated, and each planned exposure of an individual exceeding 20 mrem/day shall be approved in advance by the immediate supervisor of that individual. The immediate supervisor is charged with knowing the current radiation exposure status of each individual whom he directly supervises.

5. Reference dose rates used in administering radiation exposures and exposure controls shall be determined on a current basis by appropriate radiation survey and operational inspection in accordance with radiation survey procedures (see Procedure No. 2.1).

6. Maximum working exposure-time limits shall be chosen on the basis of the type and magnitude of radiation hazard.

7. Planned exposures that are significantly above the recommended operating levels for weekly exposure require special consideration and justification.

(a) Any planned exposure of an individual in excess of the prorated weekly exposure limits (0.3 rem total body, 1.0 rem skin, 2.5 rem extremities) requires authorization of the employee's Division Director.

(b) Any planned operation which will subject an individual to an exposure greater than 1/3 of a recommended maximum quarterly limit in any one week requires the prior approval of the Laboratory Deputy Director.

8. A properly executed Radiation Work Permit shall be issued in advance of each work assignment for the day that involves a planned exposure greater than the average daily exposure permitted by the age proration formulas given in Table 1 of Procedure 3.1. These are 20 mrem whole body; 60 mrem skin; or 300 mrem extremities. Posted regulations properly approved may be used in lieu of a Radiation Work Permit for operating personnel when routine or repetitive operations are involved (see Procedure 3.6).

9. All planned exposures of personnel shall be undertaken only under conditions of accurate exposure determination, rigid exposure control, and detailed direction by supervision. Table 1 shall be used as a guide in planning and authorizing work that may involve external exposure to specified dose rates. Table 2 may be used as a guide in planning and authorizing work that may involve exposure to airborne radionuclides.

10. An employee whose radiation dose exceeds a recommended maximum limit shall be removed from further radiation exposure (emergencies excepted) until such time as his exposure status is within the recommended maximum limits.

Table 1. Guide for Planning and Authorizing External Exposure to Specified Dose Rates

I	II	III	IV	V	VI
Exposure Level Dose Rate to Whole Body* (rem/hr)	Direct Reading and/or Alarm-Type Monitoring Instruments Required	Health Physics Surveillance Required	Special Approvals Required		
			Area Division Director	Health Physics Division Director	Laboratory Deputy Director
0.003-5	X	X			
5-20	X	X	X		
20-50	X	X	X	X	
Over 50	X	X	X	X	X

*For individual organs, the equivalent multiple of the yearly dose rate indicated by the age proration formulas is to be used. See Procedure 3.1, Table 1.

Note: The above required approvals are to be noted on the Radiation Work Permit issued for the particular job assignment should doses > 20 mrem in any one day be expected. In the dose-rate range of from 0.003 to 5 rem/hr, and where an individual's exposure time ensures that he will receive less than 100 mrem accumulated dose in one week (or the equivalent for individual organs), the requirements indicated in Columns II and III may be replaced by other safeguards in written procedures approved by the appropriate authorities indicated in Columns IV to VI.

Table 2. Guide for Planning and Authorizing Exposure to Unidentified* Airborne Contaminants

Concentration Range		Immediate Action
Alpha (10^{-11} μCi/cc)	Beta-Gamma (10^{-9} μCi/cc)	
< 2	< 3	Masks not required unless airborne contamination is determined to be above $(MPC)_a$ for 40-hr week.
2 to 200	3 to 300	Full face mask required; otherwise, evacuate personnel from area.
> 200	> 300	Positive air supply required; otherwise, evacuate personnel from area. (Consider external exposure potential.)

*Where airborne contaminants are identified (see NBS Handbook 69 for MPC values), masks should be issued if the $(MPC)_a$ for a 40-hr exposure will be exceeded. A positive air supply should be provided if the concentration is more than 100 times the $(MPC)_a$ for a 40-hr week.

APPENDIX 1.5

GENERAL PROCEDURE FOR BIOASSAY SAMPLING, ANALYSIS, AND REPORTING

Responsibilities

1. ORNL divisions with the advice and recommendations of the Radiation and Safety Surveys staff are responsible for determining those employees for whom routine monitoring is required.

2. The Radiation and Safety Surveys staff is responsible for requesting all monitoring analyses of ORNL personnel.

3. The Radiation Monitoring Section is responsible for advising and recommending to the Radiation and Safety Surveys Section the types and frequency of monitoring analyses for cases of suspected or known exposure.

4. The employee is responsible for complying with sampling requests.

5. The Radiation Monitoring Section is responsible for providing sampling supplies and equipment and for performing all monitoring analyses.

Specimen Kits

1. Urine specimen kits are prepared by the Radioassays Group. Form UCN-2861A (Figure 704.1) is included in the kit.

2. The Shift and Area Surveys Group delivers and installs urine specimen kits in the dispensers which are located at the principal entry-exit portals of the Laboratory.

3. Feces specimen kits are prepared by the South Central Complex staff of the Radiation and Safety Surveys Section.

4. The Radiation and Safety Surveys staff installs feces specimen kits at the several feces sampling stations at the Laboratory.

Urine Sample Monitoring

1. A Radiation and Safety Surveys staff member of the ORNL area in which the employee works initiates a request for a urine sample.

   (a) Form UCN-2716 (Figure 704.2) is filled in (requester's portion) and forwarded to the Radiochemistry Group.

   (b) Form UCN-3712 (Figure 704.3) is filled in and given to the employee to be sampled.

   (c) The appropriate entry is made on form UCN-3855 (Figure 704.4).

2. The employee complies with the sampling request.*

   (a) He picks up a urine specimen kit from a dispenser station.

   (b) He collects a sample in accordance with instructions in the kit.

   (c) He fills in the information requested on form UCN-2861A.

   (d) He returns the kit to a dispenser station.

3. The Shift and Area Surveys Group collects the returned kits each day and delivers them to the Radiochemistry Group.

4. The Radioassays Group logs the sample and enters appropriate data on form(s) UCN-2716.

5. The Radioassays Group analyzes the sample in accordance with Radiochemical Procedures[1] and forwards form(s) UCN-2716 to the Dose Data Group.

6. The Dose Data Group makes any necessary calculations, records and reports.

7. The Dose Data Group initiates any necessary follow-up action.

Feces Sample Monitoring

1. A Radiation and Safety Survey staff member of the ORNL area in which the employee works initiates a request for a feces specimen.

   (a) Form UCN-2716 is filled in (requester's portion) and forwarded to the Radiochemistry Group.

   (b) The employee is verbally requested to submit a specimen.

   (c) The employee is verbally advised how to collect the specimen, where to obtain a specimen kit, and to notify the Radiation and Safety Surveys staff when the specimen kit is ready for pick-up for analysis.

2. The employee complies with the sampling request.

   (a) He picks up a feces specimen kit from a sampling station.

   (b) He collects a sample in accordance with instructions.

---

*If the employee does not comply with the initial request, iterated requests are made according to the need for the data.

[1]L. C. Henley, Radiochemical Procedures, ORNL/TM-6372, May 1978.

(c) He fills in the information on form UCN-5155 (Figure 704.5).

(d) He notifies the Radiation and Safety Surveys Section that the sample is ready for pick-up for analysis.

3. The Radiation and Safety Surveys Section picks up the specimen kit and delivers it to the Radiochemistry Group.

4. The Radioassays Group logs the sample and enters appropriate data on form(s) UCN-2716.

5. The Radioassays Group analyzes the sample in accordance with Radiochemical Procedures and forwards form(s) UCN-2716 to the Dose Data Group.

6. The Dose Data Group makes any necessary calculations, records and reports.

7. The Dose Data Group initiates any necessary follow-up action.

IS&AHP IP No. 704
Page 4 of 6 pages
Issued Sept. 28, 1970
Revised Jan. 1, 1981

FILL IN THE FOLLOWING INFORMATION (Please Print):

NAME
BADGE NO.
DIVISION
NAME OF YOUR HP REPRESENTATIVE

SAMPLE	DATE	TIME
START*		
END		

*Last voiding prior to use of Sample Kit.

(SEE OTHER SIDE)

INSTRUCTIONS FOR PREPARING A URINE SPECIMEN - II

This sampling kit includes bottles for collecting a urine sample. Your cooperation and care in collecting and submitting this sample is important, so that careful laboratory analysis of your specimen may be meaningful. Please do the following:

1. Keep the sample box and bottles as clean and free of radioactive contamination as possible.
2. Collect all the urine for 24 hours unless the bottles are filled in less time.
3. Tighten the bottle caps securely and replace the bottles in the box.
4. Fill in the information indicated on the reverse of this card and place this card in the box.
5. Return the kit to the sample collection point at the East or West Portal or where designated by your Health Physics representative.

UCN-2861A
(3 9-65)

(Over)

Figure 704.1

HEALTH PHYSICS BODY FLUIDS ANALYSIS REQUEST AND RECORD

LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	HP AREA NO.

REMARKS

TYPE OF SAMPLE
☐ URINE ☐ FECAL ☐ _____

TYPE ANALYSIS

SAMPLE PRIORITY	ANALYSIS REQUESTED
☐ 1. Incident	1. _____
☐ 2. Follow-up	2. _____
☐ 3. Work Area	3. _____
☐ 4. Background	4. _____
☐ 5. Other	5. _____

SAMPLE DATE

SAMPLE HOURS

d/m SAMPLE

SAMPLE	DATE	TIME
START		
END		

REQUEST DATE:

REQUEST: ☐ First ☐ Second ☐ Third

HP SURVEYOR

d/m/24 HOURS

UCN-2716 (3 9-79)

TO BE FILLED IN BY REQUESTER

Figure 704.2

NAME	BADGE NUMBER	DIV. OR DEPT.	DATE

BODY FLUIDS ANALYSIS REQUEST

For your Health Physics monitoring record, you are requested to collect and submit a urine sample for radiochemical analysis. Please obtain a sampling kit from one of the dispensers at the ORNL Portals, or contact your Health Physics area surveyor to obtain a kit. Take the kit home with you; collect a sample following the instructions enclosed in the kit, and return the kit to the portal or to your HP area surveyor.

HEALTH PHYSICS AREA SURVEYOR	TELEPHONE NO.

UCN-3712
(3 7-74)

Figure 704.3

IS&AHP IP No. 704
Page 6 of 6 pages
Issued Sept. 28, 1970
Revised Jan. 1, 1981

UCN-3858
(3 6-74)

BIO-ASSAY DATA

DATE REQUESTED	DATE SUBMITTED	SAMPLE ANALYSIS (d/m/24 hr. spec) URINE Gr.α	U	Sr	Ra	Pu				d/m SAMPLE FECAL Gr.α		SAMPLE FOR	REMARKS

NAME | BADGE NUMBER | DIVISION | CAT. | Pg

Figure 704.4

NAME _____
BADGE NO. _____
DATE _____
DIV. _____
WORK AREA _____

UCN-5155
(3 9-63)

Figure 704.5

APPENDIX 1.6

PRIORITIES FOR IVGS AND BIOASSAY ANALYSES

Priorities (as numbered):

1. Analyses requested as a result of an incident or unusual occurrence (refer to IS&AHP IP-No. 701).

2. Analyses requested as a follow-up to findings in previous analyses.

3. Analyses requested because employee works directly with radioactive materials or in an area where radioactive materials may be present. The frequency of analyses should be related to the likelihood of exposure and the half-life of the radioactive materials.

4. Analyses requested of persons who are not likely to have been exposed to radioactive materials in work at ORNL. Such analyses are for assessing background conditions at the Laboratory.

5. Analyses for purposes other than those of Priorities 1 through 4.

Responsibilities:

1. The Radiation and Safety Surveys Staff determines the need and originates requests for Priorities 1 and 3.

2. The Internal Dosimetry Group originates requests for Priorities 2, 4 and 5 and arranges with the Radiation and Safety Surveys Staff for requesting the analyses.

3. The Radiation and Safety Surveys Staff is responsible for transmitting all requests for analyses to Laboratory personnel.

APPENDIX 1.7

GENERAL PROCEDURE FOR REQUESTING AND REPORTING WHOLE BODY COUNTING (IVGS) RESULTS

Routine Analyses

1. Request for whole body counting shall be initiated by filling in card form UCN-8561 (Figure 705.1).

2. Request for whole body counting will be initiated by Radiation and Safety Surveys personnel according to priorities as specified in IS&AHP IP No. 702.

3. Prior to issuing form UCN-8561 to Laboratory personnel the Radiation and Safety Surveys representative will call the Whole Body Counter Facility, Bldg. 2008, telephone 4-6662, to arrange a date and time for the count.

4. Personnel at the Whole Body Counter will maintain an appointment schedule for selecting a time and date for the count to be made.

5. After confirming the date and time, the Radiation and Safety Surveys representative will fill in the information on the card form UCN-8561 and issue the card to the employee.

6. The Whole Body Counter staff and the Radiation and Safety Surveys representative will each notify the other as soon as it is known that a scheduled appointment cannot be kept.

Emergency Analysis

1. The Radiation and Safety Surveys representative will contact the whole body counting personnel directly by telephone (4-6662) when emergencies arise that require prompt attention. If it is feasible, the Radiation and Safety Surveys representative will fill in form UCN-8561 and have the employee take the card with him to the Whole Body Counter. If this is not practical, then the card may be filled in by Whole Body Counter personnel at the Whole Body Counter.

Reporting Procedure

1. Whole Body Counter personnel will immediately notify E. D. Gupton, or, in his absence, H. W. Dickson or R. L. Clark by telephone of any counting results which may imply as much as 25 percent of an MPOB.

2. Whole Body Counter personnel will enter the preliminary results of the count on the form UCN-8561 and promptly forward the form to the appropriate Health Physics Complex Office.

3. Whole Body Counter personnel will, when the information is available, fill in and forward UCN-8562, "Health Physics Whole Body Counter (IVGS) Analysis Data," to the Dose Data Group.

4. The Dose Data Group will prepare a quarterly report from data obtained from form UCN-8562 and file the form as a permanent record.

5. Two copies of the divisionally organized quarterly report will be sent to each Divisional HPR (one copy to be delivered by the HPR to the RCO) and one copy organized by HP Complex will be sent to the respective Radiation and Safety Surveys Complex Leader.

HEALTH PHYSICS IN VIVO COUNT REQUEST & PRELIMINARY REPORT

PRINT: LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	BLDG. NO.	H.P. AREA

YOU ARE SCHEDULED TO REPORT TO THE

WHOLE BODY COUNTER, BLDG. 2008

_____ AT _____
DATE TIME

REASON FOR COUNTING:

- ☐ INCIDENT
- ☐ FOLLOW-UP
- ☐ WORK AREA
- ☐ BACKGROUND
- ☐ OTHER

_____
REQUESTER

UCN-8561
(3 11-80)

PRELIMINARY RESULTS OF ANALYSIS

- ☐ NO OCCUPATIONAL DEPOSITION POSITIVELY DETERMINED
- ☐ LESS THAN 5% MPOB OF IDENTIFIABLE ACTIVITY
- ☐ LESS THAN 15% MPOB OF _____
- ☐ LESS THAN 25% MPOB OF _____
- ☐ LESS THAN 50% MPOB OF _____
- ☐ LESS THAN 100% MPOB OF _____
- ☐ GREATER THAN 100% MPOB OF _____
- ☐ RESULTS INCONCLUSIVE BECAUSE _____

_____
ANALYST

Figure 705.1

HEALTH PHYSICS WHOLE BODY COUNTER (IVGS) ANALYSIS DATA

LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	HP AREA NO.

DATE OF COUNT

REASON FOR ANALYSIS
1. ☐ INCIDENT
2. ☐ FOLLOW-UP
3. ☐ WORK AREA
4. ☐ BACKGROUND
5. ☐ OTHER

RESULTS OF ANALYSIS

- N ☐ INSIGNIFICANT
- 0 ☐ LESS THAN 15% MPOB*
- 2 ☐ LESS THAN 25% MPOB*
- 4 ☐ LESS THAN 50% MPOB*
- 6 ☐ LESS THAN 100% MPOB*
- 8 ☐ GREATER THAN 100% MPOB*
- S ☐ INDETERMINABLE

FOR ALL RESULTS > 10% MPOB

ISOTOPE	AMOUNT	% MP

TYPE - SERIAL NO.

TYPE _____

SERIAL NO. _____

UCN-8562
(3 11-80)

REMARKS

*Due to Occupational Exposure at ORNL

_____
ANALYST

Figure 705.2

9. Overdue SECOND REQUEST cases should be of serious concern and will be documented in the employee's record if the Radiation Monitoring Section is advised by Radiation and Safety Surveys staff.

HEALTH PHYSICS BODY FLUIDS ANALYSIS REQUEST AND RECORD

LAST NAME	INITIALS	EMPLOYEE NO.	DIVISION	HP AREA NO.

REMARKS

TYPE OF SAMPLE
☐ URINE ☐ FECAL ☐ _____

TYPE ANALYSIS

SAMPLE PRIORITY
☐ 1. Incident
☐ 2. Follow-up
☐ 3. Work Area
☐ 4. Background
☐ 5. Other

ANALYSIS REQUESTED
1. _____
2. _____
3. _____
4. _____
5. _____

SAMPLE DATE

SAMPLE HOURS

d/m SAMPLE

d/m/24 HOURS

SAMPLE	DATE	TIME
START		
END		

REQUEST DATE:

REQUEST: ☐ First ☐ Second ☐ Third

HP SURVEYOR

TO BE FILLED IN BY REQUESTER

UCN-2716 (3 9-79)

Figure 703.1

APPENDIX 1.8

PROCEDURE FOR BIOASSAY REQUEST CARDS, FORM UCN-2716

1. Requests for bioassay samples shall be initiated by filling out form UCN-2716 (Figure 703.1), hereinafter referred to as Form. Requests for bioassay samples assigned Priorities 1 and 3 will be made by Radiation and Safety Surveys personnel (Ref. IS&AHP IP No. 702). Forms for samples assigned Priorities 2, 4, and 5 will be initiated by the Internal Dosimetry Group.

2. Forms for Priorities 2, 4, and 5 will be forwarded by the initiating group to the Radiation and Safety Surveys Complex Leader who will effect the requesting of the sample.

3. The Form has spaces for entering "analysis requested" by the requestor. Only limited types and quantities of analyses may be done for a given sample.

   Routine analyses and the combinations which may be requested are:

   ^{3}H plus one of $\left\{ \begin{array}{l} Pu\ \alpha \\ {}^{241}Pu \end{array} \right.$ plus any combination of $\left\{ \begin{array}{l} TRE\ \beta \\ Trans\ Pu\ \alpha \\ Sr \\ {}^{32}P \\ U\ \alpha \end{array} \right.$

   L. C. Henley or E. D. Gupton should be consulted before other analyses or combinations of analyses are requested.

4. Radiation and Safety Surveys personnel will forward all Forms for which a sample is requested, when the sample is requested, to the Radiochemistry Laboratory (L. C. Henley).

5. Upon receipt of the sample, the Radiochemistry Laboratory will assign a process number for the sample and fill in those sections of the Form required for sample analysis and data evaluation; prepare additional Forms where more than one analysis is requested; log information on Bioassay Log Sheet; and perform analysis and record processing data.

6. When processing of sample is completed and data recorded, the Form will be forwarded to Dose Data Group for recording and reporting.

7. Forms for overdue samples will be removed from the "on request" file weekly and may be returned to the requester.

8. Radiation and Safety Surveys personnel should check their weekly bioassay IBM report for overdue samples from their respective areas and issue a second request for the samples. An updated Form should be initiated and SECOND REQUEST checked.