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Hanford Internal Dosimetry Program Manual

E. H. Carbaugh
M. J. Sula
D. E. Bihl
T. L. Aldridge

October 1989

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RLO 1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

This document describes the Hanford Internal Dosimetry Program, as it is administered by Pacific Northwest Laboratory (PNL) in support of the U.S. Department of Energy and its Hanford contractors. Program services include administrating the bioassay monitoring program, evaluating and documenting assessments of internal exposure and dose, ensuring that analytical laboratories conform to requirements, selecting and applying appropriate models and procedures for evaluating internal radionuclide deposition and the resulting dose, and technically guiding and supporting Hanford contractors in matters regarding internal dosimetry.

Specific chapters deal with the following subjects:

- practices of the program, including interpreting applicable DOE Orders, regulations, and guidance into criteria for assessment, documentation, and reporting of doses
- assessment of internal dose, including summary explanations of when and how assessments are performed
- recording and reporting of practices for internal dose
- selection of workers for bioassay monitoring and establishment of type and frequency of bioassay measurements
- capability and scheduling of bioassay monitoring services
- recommended dosimetry response to potential internal exposure incidents
- quality control and quality assurance provisions of the program.

In addition, appendixes describe the bioassay measurement screening and follow-up levels used by the program, illustrate the available on-line computerized data retrieval capability, briefly describe the analytical procedures used for measurements, and include copies of the bioassay sampling kit instructions.

This document was originally developed as a controlled manual with distribution limited to those Hanford site personnel who routinely use the program services. The uncontrolled version of the manual was prepared for distribution to those having an interest in the services offered by the program but who do not actually use those services. The manual should not be considered applicable to facilities or circumstances other than Hanford, and reflects the operational practices only as they existed as of July 1989. There is no plan or intent to update the uncontrolled copies as changes are made in the Hanford program.

GLOSSARY

analysis code:	a code for computerized scheduling of the type of analysis desired. For example, IPU denotes analysis for ^{238}Pu and $^{239+240}Pu$.
annual dose:	the dose received or assigned to a particular calendar year.
bioassay:	measurement of amount or concentration of material (usually radioactive material) in the body or in biological material excreted or removed from the body and analyzed for purposes of estimating the quantity of material in the body (according to draft American National Standards Institute [ANSI] Standard N13.30).(a)
can-not-out:	a term denoting that the worker took the sample kit inside his/her residence but did not put it out on collection day.
chest measurement:	direct measurement of radioactivity deposited in the chest region. Includes contributions from activity in the lung and skeleton.
committed dose equivalent:	the dose equivalent to an organ or tissue, or the effective dose equivalent, committed over a total 50-year period following an acute intake or onset of chronic intake of radioactivity.
contractual detection level:	a negotiated level of activity in a sample whose detection the Analytical Services Laboratory (Lab) must demonstrate at least 95% of the time. Minimum detectable amounts as defined by draft ANSI N13.30(a) are generally equal to or less than the contractual detection level.
dose assessment:	the evaluation and assignment of a specific dose associated with a specific intake. Documented by an evaluation report.
effective dose equivalent:	the sum of the products of the dose equivalent to organs and tissues of the body and the respective weighting factors as designated in DOE 5480.11 (1989). This dose is comparable to an equal dose received by total body exposure to gamma radiation.
evaluation report:	the formal documentation of an assessment of internal dose. The evaluation report is filed by Radiological Records in the worker's occupational radiation exposure file.

(a) American National Standards Institute (ANSI). 1987. Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30, New York, New York.

Exposure Evaluator:	the individual responsible for assessing and documenting internal dose.
Field Dosimetry:	the components within a contractor organization having internal exposure radiation protection responsibilities.
field monitoring:	monitoring performed at facilities, including air sampling, personal contamination surveys, etc.
follow-up level:	the minimum level of a bioassay measurement result at which a follow-up investigation is started. If the measurement is confirmed, a dose assessment is made.
head measurement:	direct bioassay measurement of radioactive content of the head. The measurement is used to estimate total skeleton content, and to correct a chest count to give an estimate of lung content.
insufficient volume:	a urine sample less than 500 ml that is scheduled for routine processing. This sample will not be analyzed, and another sample should be submitted.
internal dose:	the dose equivalent to an organ or tissue or to the effective whole body from radionuclides taken into the body. The period during which the dose is received is usually a calendar year or a 50-year period, although other time periods may be specified.
Internal Dosimetry:	the staff within the Pacific Northwest Laboratory's (PNL's) Occupational and Environmental Protection Section assigned to the Hanford Internal Dosimetry Program.
in vivo measurement:	direct measurement of radioactivity in the body.
kit:	a package containing bioassay sample containers. Usually one kit is used for each sample, but sometimes two kits are used to obtain one 24-hour total sample (work fraction and home fraction).
kit code:	a code designating the type of sample to be collected. (See Appendix B, Table B.4 for a comprehensive list of kit codes.)
lost in lab:	a sample that was lost during analysis. No results can be obtained.
lost kit:	a kit that was not retrievable by the Lab. A "can-not-out" becomes a lost kit if it is not retrieved in 5 days.
lung count:	direct bioassay measurement to determine the activity in the lung. The measurement is determined from the results of a chest count minus the activity that is contributed from the skeleton.

minimum detectable activity:	detectable amounts as defined by using statistics like those in the draft ANSI.[a] Generally equal to, or less than, the contractual detection level.
no sample:	a kit that was not used and remained outside the residence on collection day. The Lab notifies Internal Dosimetry or Field Dosimetry of a "no sample" within one day so that rescheduling may occur, if necessary.
organ dose equivalent:	the assessed dose equivalent to an organ or tissue of the body.
processing code:	the desired turnaround time for the analysis. A shorter turnaround time results in less sensitivity and/or higher cost. Four processing categories exist, but not all radionuclide analyses are available for each category.
Radiological Records:	the sitewide support program, operated by PNL, that maintains occupational radiation records for the Hanford Site.
reason code:	a computer code used to describe the reason a bioassay measurement is performed. (See Appendix B, Tables B.3 and B.9.)
reporting level:	the minimum level of a bioassay measurement result at which the measurement laboratory shall provide prompt verbal notification to Internal Dosimetry.
screening level:	minimum level of a bioassay measurement at which some further review or action is advantageous to determine if follow-up measurements are needed.
sequential analyses:	term that denotes more than one radiochemical analysis done on a single sample. For example, IPS is the analysis code for an IPU analysis and a ^{90}Sr analysis, on the same sample.
statement of work:	The technical and administrative specification of work to be performed under contract by the Analytical Services Laboratory.
whole body measurement:	direct bioassay measurement to determine the amount of high-energy gamma-emitting radionuclides in the total body.

(a) American National Standards Institute (ANSI). 1987. Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30, New York, New York.

ACRONYMS/ABBREVIATIONS

ANSI	American National Standards Institute
ALI	annual limit on intake
BCSR	Boeing Computer Services-Richland
CL	contractual detection level
DAC	derived air concentration
DAC-hours	time-integrated exposure to airborne contamination
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
DTPA	diethylenetriamine pentaacetic acid
EDF	Emergency Decontamination Facility
EE	Exposure Evaluator
EPA	U.S. Environmental Protection Agency
GPS	Good Practices Standard
HEHF	Hanford Environmental Health Foundation
HMS	Hanford Medical Scheduling
ICRP	International Commission on Radiological Protection
IDP	(Hanford) Internal Dosimetry Program
INTERTRAC	Internal Dose Tracking System
Lab	Analytical Services Laboratory
MDA	minimum detectable activity/amount
NAD	Nuclear Accident Dosimeter
NCRP	National Council on Radiation Protection and Measurements
NIST	National Institute of Standards and Technology
O&EP	Occupational and Environmental Protection (Section)
ORE	occupational radiation exposure
PADI	pocket alarming dose integrator

PNL	Pacific Northwest Laboratory
POC	Patrol Operations Center
QA	quality assurance
QC	quality control
REIRS	Radiation Exposure Information Reporting System
RPT	Radiation Protection Technologist
UDAC	Unified Dose Assessment Center
WBC	Whole Body Counter

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CHAPTER 1.0

INTRODUCTION

1.0 INTRODUCTION

The Hanford Internal Dosimetry Program (IDP) was initiated in late 1944. By 1946, a routine program had been established at Hanford to assess and document occupational doses to employees from intakes of radionuclides.

1.1 PROGRAM CHARTER

The current IDP is a sitewide service program operated by the Pacific Northwest Laboratory (PNL) for all Hanford U.S. Department of Energy (DOE) and DOE-contractor personnel. It is funded by the DOE-Richland Operations Office (DOE-RL), and is administered and staffed by the PNL Occupational and Environmental Protection (O&EP) Section. The Hanford Site Services Handbook (RL 1983) assigns by charter the following responsibilities to PNL:

- Assess and document occupational doses from intakes of radionuclides.
- Determine compliance with applicable internal dose standards.
- Administer the routine bioassay monitoring program required by site contractors.
- Provide technical guidance to contractors on internal dosimetry matters.
- Establish models for evaluating internal radionuclide deposition.

1.2 PROGRAM SCOPE

The scope of the IDP is limited to the support of Hanford contractor radiation protection efforts to the extent specified in the charter statement above. It is assumed that site contractors protect their workers from internal exposures to radioactivity and determine the extent to which the IDP is applied. This includes identifying needs for bioassay monitoring and determining when potential internal exposures have occurred.

Air sampling, contamination surveys, and other field monitoring techniques provide the primary means of identifying evidence of internal exposures at Hanford facilities. Routine bioassay monitoring is considered a secondary means of identifying internal exposures.

1.2 PROGRAM SCOPE (contd)

It is assumed that each contractor communicates to the workers the need for bioassay measurements and the need to address questions regarding measurements. The IDP staff discuss measurement results with workers on an individual basis if so requested by the contractor, and also deal with specific questions if contacted directly by workers. It is the intent of the IDP that the contractor dosimetry organization be the focal point for all communication with workers regarding dosimetry needs and concerns.

1.3 LIMITATIONS OF SERVICE

The IDP capabilities are limited by the degree to which contractors use the available services. The IDP provides consultation and advisory services to contractors for developing and establishing bioassay programs. However, it is assumed that the contractor bears the direct responsibility for determining that workers receive adequate and appropriate bioassay monitoring.

The IDP provides bioassay services that, if properly used, should be capable of identifying and evaluating an intake resulting in a first-year effective dose equivalent of 100 mrem. However, the capability for such sensitivity depends, in some cases, on early identification of potential intakes by the contractor using regular workplace monitoring and personal survey techniques. Because the routine bioassay monitoring program uses only periodic measurements, it does not necessarily provide adequate sensitivity to detect intakes resulting in first-year effective dose equivalents of 100 mrem.

1.4 HANFORD INTERNAL DOSIMETRY PROGRAM SERVICES

The Hanford IDP is administered as specified by the Hanford contractors and, for the benefit of all site employees, provides services to

- administer the routine bioassay monitoring program for internally deposited radionuclides
- investigate and document evaluations of potential internal exposures for exposure record files and contractor staff
- ensure that the Analytical Services Laboratory conforms to the requirements of the analytical services contract

1.4 HANFORD INTERNAL DOSIMETRY PROGRAM SERVICES (contd)

- select and apply appropriate models, procedures, and practices for evaluating internal radionuclide deposition and the resulting dose
- technically guide and support Hanford contractors in matters regarding internal dosimetry.

The IDP is committed to quality service that meets or exceeds DOE regulations and guidance, uses methods and practices recommended by appropriate national and international organizations, and actively explores needed improvements in technology and techniques.

1.5 PROGRAM RELATIONSHIPS

The IDP works closely with Hanford contractor dosimetry organizations to provide a comprehensive internal dosimetry service. However, the IDP has no direct responsibility to ensure protection of workers, to monitor or conduct surveillance of work environments, to operate facilities, or to assure worker cooperation with bioassay measurement requests. Such items are considered to be the responsibilities of the contractor.

The IDP also interfaces with other sitewide service programs operated by PNL, including Radiological Records, Whole Body Counting, External Dosimetry, Analytical Support Services, and the Emergency Preparedness Project.

1.6 MANUAL CONTENTS

This Hanford Internal Dosimetry Program Manual is one of three programmatic documents of the IDP. The other two programmatic documents are the Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1989) (hereafter referred to as the Technical Basis) and an internal manual documenting internal dosimetry procedures at Hanford. Chapter 9.0 discusses the purpose, scope, and interrelationship of these three documents.

This manual contains the following:

- the policies upon which the design and operation of the IOP are based (Chapter 2.0)

1.6 MANUAL CONTENTS (contd)

- a description of the internal exposure assessment methods and process and good practice recommendations for Hanford contractors to implement IDP policies in their radiation protection programs (Chapter 3.0)
- internal dose recording and reporting practices (Chapter 4.0)
- recommendations for participation in a bioassay monitoring program, including measurement types and frequencies (Chapter 5.0)
- a description of the available bioassay services and explanations of how to obtain them (Chapter 6.0)
- IDP response to potential internal exposure incidents (Chapter 7.0)
- the quality assurance and quality control features of the IOP (Chapter 8.0)
- a brief summary of the programmatic and technical assessment documents and use of Program Change Records to document any program changes (Chapter 9.0).

In addition, Appendix A lists screening and follow-up levels for routine bioassay measurements. Appendix B contains complementary figures of computer report screens and tables of data field codes. Appendix C describes the analytical procedures used by the Analytical Services Laboratory to analyze samples, and Appendix D contains copies of the instructions for each type of sample bioassay kit.

CHAPTER 2.0

PRACTICES OF THE HANFORD INTERNAL DOSIMETRY PROGRAM

2.0 PRACTICES OF THE HANFORD INTERNAL DOSIMETRY PROGRAM

It is IDP policy to comply with DOE Orders. Similarly, it is IDP practice to follow the guidance and good practice recommendations issued through the International Commission on Radiological Protection (ICRP), National Council on Radiation Protection and Measurements (NCRP), U.S. Environmental Protection Agency (EPA), DOE, and American National Standards Institute (ANSI) to the extent practical.

The following subsections describe the conduct of the internal dosimetry program and provide for interpretation of applicable regulations and guidance for application at Hanford.

2.1 ASSESSMENT AND DOCUMENTATION OF INTERNAL DOSE

This section contains criteria for assessment, documentation, and revision of internal doses at Hanford.

2.1.1 Criteria for Assessing Internal Oose

Assessment of potential internal exposure is conducted for

- any potential occupational intake reported to Internal Dosimetry by site radiation protection organizations
- any bioassay measurement that indicates a potential occupational internal exposure, not previously evaluated, resulting in an annual internal effective dose equivalent greater than 10 mrem
- any "new hire" or "beginning work" bioassay measurement that indicates any detectable intake not previously evaluated
- any employee, hired by DOE-RL or a DOE contractor, who has incurred an occupational internal exposure.

The initial assessment generally should include confirmatory bioassay measurements. To the extent practicable, confirmatory bioassay measurements should consist of the following:

- a minimum of one bioassay measurement following a workplace indication of an intake, or
- a minimum of two bioassay measurements following a bioassay indication of an intake.

2.1.1 Criteria for Assessing Internal Dose (contd)

A potential intake is considered to be confirmed if

- follow-up bioassay measurements show detectable levels of internal radioactivity not associated with background or previously identified intakes, or if
- follow-up bioassay measurements were not performed according to the criteria for confirmatory bioassay measurements (listed above) and there is no overriding evidence that an occupational intake did not occur.

2.1.2 Dose Assessment Practices

Where appropriate bioassay data are available, they constitute the primary basis for assessment of internal dose. Workplace monitoring data (such as air samples) or other means may be used to assess dose in cases where appropriate bioassay data are not available.

If the available evidence suggests that the annual effective dose equivalent from an intake does not exceed 100 mrem, generalized (default) models and assumptions may be used, where specific information is not readily available, to assess the dose. These general assumptions are as follows:

- The intake is assumed to occur by inhalation.
- The intake is acute.
- If the actual intake date(s) is unknown, the intake occurs at the midpoint of the potential exposure period for acute intakes or throughout the potential exposure period for chronic intakes.
- For monitored workers, the potential exposure period extends back one monitoring period unless known to be otherwise.
- The radionuclides that were observed in bioassay measurements or were otherwise known to be present are included in the assessment.
- The physiological characteristics of Reference Man (ICRP 1974) are assumed.
- The biokinetic models and parameters described in the Technical Basis are used for radionuclides included in the document; otherwise models and parameters endorsed or prescribed by the NCRP or ICRP are used.

2.1.2 Dose Assessment Practices (contd)

At projected annual effective dose equivalents above 100 mrem, actions are taken as follows:

- Bioassay and exposure characterization data are obtained to enable adjustments to be made to the default assumptions and models, as appropriate.
- All radionuclides potentially involved in the exposure are considered, including those not specifically identified in the initial bioassay measurements but expected to be present.

At projected annual effective dose equivalents above 1500 mrem, consideration is given to individual-specific physiological characteristics.

Dose equivalents are recorded as calculated for each assessment, with the following special provisions:

- Quantified doses of less than 10 mrem are rounded to the nearest whole number, and doses of 10 mrem or greater may be rounded to two significant figures.
- Organ dose equivalents are recorded for any organ contributing more than 10% to an annual effective dose equivalent exceeding 100 mrem/yr or for any organ receiving more than 1 rem/yr.
- If a committed effective dose equivalent for an intake is less than 100 mrem, then the entire committed effective dose equivalent is assigned to the year of intake. Once recorded, committed doses are not reassigned to actual calendar years for purposes of dose control.

2.1.3 Documentation of Dose Assessments

Assessments of occupational internal exposures are documented.

The documentation includes or references the methods, assumptions, and data used to make the assessment and provides a summary of the assessed dose equivalents.

A copy of the documented assessment is provided to Radiological Records for placement in the individual worker's occupational radiation exposure (ORE) file.

For each assessment, a letter, summarizing the conclusion of the assessment and updating the worker's current internal exposure status, is sent to the worker's radiation dosimetry organization.

2.1.3 Documentation of Dose Assessments (contd)

Assessments are documented within 3 months of obtaining all the necessary data. A preliminary assessment is issued by February 1 for all internal exposure cases originating the preceding year for which final assessments have not been completed. These preliminary assessments include the estimated internal dose equivalent received during the prior calendar year and the projected internal dose equivalent for the current calendar year.

Chronic internal exposures are assessed within 4 months of termination of the chronic exposure and on a calendar-year basis for continuing exposures.

2.1.4 Revisions and Updates

Assessments for active workers are revised when information demonstrates a change in the currently assessed annual internal effective dose equivalent of 10% of either the DOE standard or the previously assigned dose, whichever is higher.

When the revision involves a specific exposure case, the contractor dosimetry representative is notified, in advance, of the need to issue a revised assessment.

When the revision results from general changes in dosimetry techniques, assumptions, or regulations, and a number of exposure cases are affected, then Internal Dosimetry presents a discussion of the impacts of the change to the Hanford Dosimetry Advisory Committee.

Internal dose assessments for specific intakes by active workers are reviewed and updated every 5 years as long as the worker's annual effective dose equivalent from the intake is greater than 1 rem.

2.2 REPORTS OF INTERNAL DOSE

Internal Dosimetry provides reports of internal dose to contractor dosimetry organizations and to Radiological Records as described in the following subsections.

2.2.1 Reports Provided to Contractor Dosimetry Organizations

Final exposure evaluation reports and annual summary reports are provided to contractor dosimetry organizations as follows:

2.2.1 Reports Provided to Contractor Dosimetry Organizations (contd)

- Final report of evaluated internal exposure--Final reports are provided upon completion of internal exposure evaluations. Preliminary reports (verbal or written) are provided upon request. The reports contain the projected 50-year committed and the assigned first and maximum calendar-year effective dose equivalent for the assessed exposure.

- Summary of annual, committed, and cumulative (through age 75) internal dose equivalents--A summary report of doses for all assessed internal exposures to active workers is provided by December 15 of each year.

2.2.2 Reports Provided to Radiological Records

The following four reports on annual effective dose equivalent are provided to Radiological Records:

- Annual effective dose equivalent, all intakes--Reports of annual effective dose equivalents are prepared for active workers and visitors during the prior calendar year by February 1 of each year. (The reports are used to prepare annual dose reports for workers.)

- Annual effective dose equivalent, each evaluated intake--Reports of the annual effective dose equivalent received by active workers and visitors during the prior calendar year are provided by February 15 of each year and include separate doses for each evaluated internal exposure. (This information is used to prepare reports required by DOE 5484.1 [1981].)

- Annual effective dose equivalent, terminating workers--Reports of annual effective dose equivalent from internally deposited radionuclides are provided for terminating workers within 90 days of their termination.

- Annual effective dose equivalent, next calendar year--Reports of the annual effective dose equivalent for the subsequent calendar year from internally deposited radionuclides are provided by December 15 for all evaluated internal exposures.

(Radiological Records provides this information to contractors via the ORE system for use in occupational exposure management.)

2.3 BIOASSAY MONITORING

Internal Dosimetry provides, to the extent that Hanford Site contractors and DOE-RL will support and that technical capabilities will allow, a bioassay monitoring program capable of detecting an intake potentially resulting in an annual effective internal dose equivalent of 100 mrem.

The bioassay monitoring program is developed in consideration of facility-specific radionuclide mixtures and characteristics.

Bioassay capabilities are optimized considering sensitivity requirements and cost.

2.4 PROGRAM DOCUMENTATION

The practices and general recommendations of the IDP are documented in this controlled distribution manual. Copies of the manual and updates to the manual are maintained in the Hanford Radiation Protection Historical Files. The manual is updated within 12 months of any changes in practice or recommendations.

Temporary or interim practices and recommendations are documented in a letter, with a copy maintained in the Hanford Radiation Protection Historical Files.

The following are also documented or referenced in the Hanford Radiation Protection Historical Files:

- operating procedures
- technical bases
- biokinetic models
- computer codes.

CHAPTER 3.0

ASSESSMENT OF INTERNAL DOSE

3.0 ASSESSMENT OF INTERNAL DOSE

The internal dose assessment process involves collecting and analyzing information concerning a potential internal exposure and developing a conclusion regarding the magnitude of the exposure in terms that can be related to radiation protection standards. In a broad sense, the dose assessment process consists of three parts:

- identification of a potential exposure
- collection of exposure information
- evaluation and documentation of dose equivalent.

The accomplishment of a successful internal exposure assessment effort at Hanford relies on both the contractor dosimetry organization (Field Dosimetry) and IDP support. Field Dosimetry has the primary responsibility for identifying potential internal exposures for assessment. Internal Dosimetry supports this effort by providing guidelines and recommendations for establishing routine bioassay monitoring programs and for identifying situations that warrant assessment of internal exposure (see Chapters 5.0, 6.0, and 7.0). The performance of bioassay measurements and the collection of other data and information used in the assessment require the combined efforts and cooperation of Field Dosimetry and Internal Dosimetry.

The evaluation of the data, the assessment of internal dose, and the documentation of the assessment are primarily the responsibility of Internal Dosimetry, as discussed in this chapter.

3.1 GENERAL DESCRIPTION OF AN INTERNAL EXPOSURE ASSESSMENT

Determining when and what kind of an assessment of internal exposure is necessary and how the assessment is conducted for various exposure situations are key to the assessment process.

3.1.1 Criteria for Performing an Assessment

Program practice statements in Chapter 2.0 establish the criteria for determining when an internal exposure assessment is needed and provide the general guidance used in performing the assessment.

3.1.2 Types of Assessments

Assessments of potential internal exposures generally fall into one of three categories:

3.1.2 Types of Assessments (contd)

- preliminary evaluation
- final evaluation
- re-evaluation.

Preliminary Evaluation

A preliminary evaluation may be performed before completing the follow-up investigation. Its purpose is to provide a prompt or interim assessment of the potential seriousness of an intake prior to obtaining the data required for a final evaluation. Because the preliminary evaluation is performed before completing the investigation, the assessment of the magnitude of exposure is based on relatively conservative assumptions. Thus, preliminary evaluations tend to result in a higher assessed dose than do final evaluations.

In cases where the significance of the potential exposure is obviously small, the conclusions of the preliminary evaluation are reported verbally. For cases with greater significance, Field Dosimetry may request a written preliminary evaluation. The written preliminary evaluation is usually issued within a week of the request. A preliminary evaluation will also be issued within 3 months of the identified need for dose assessment, if a final evaluation cannot be issued within that time.

Final Evoluation

A final evaluation represents the conclusion of the internal dose assessment process based on the follow-up investigation. As stated in Section 2.1.3, a report on the final evaluation is issued within 3 months of the receipt of the necessary data. Generally, the time period between identifying an intake and issuing a final internal dose evaluation report ranges from 1 month, for simple cases, to 1 year for complex cases where long-term bioassay data are needed. Final evaluations may be revised by issuing a re-evaluation report if additional evidence is obtained affecting the conclusion of the previous final evaluation.

Re-evoluation

A re-evaluation is an updated final evaluation report. The criteria for determining when a re-evaluation should be performed are provided in Section 2.1.4.

3.1.3 General Approach

Assessments of internal dose are conducted by investigating the nature of the exposure and by analyzing bioassay measurement results and other pertinent data. Bioassay measurement data provide information on the deposition and retention of radionuclides in the involved individual(s) and, therefore, provide the best basis for assessing internal dose. However, in cases where bioassay data are not available, an internal dose assessment can be

3.1.3 General Approach (contd)

made using other available information, such as air sample data, source terms, contamination surveys, and other relevant sources.

3.1.4 Exposure Assessment Situations

Various situations necessitate an assessment of internal dose. Table 3.1 lists possible situations for which an assessment may be needed and the criteria used to determine if an assessment is needed.

TABLE 3.1. Dose Assessment Situations

Situation	Criteria for Initiating an Internal Dose Assessment
Field Dosimetry identifies a potential internal exposure incident.	Field measurement data meet contractor criteria for potential exposure. Recommendations for these criteria are provided in Chapter 7.0.
Specially-requested (nonroutine) bioassay measurement shows detectable activity.	Measurement result indicates internally deposited radionuclides.
Routine bioassay measurement shows activity.	Measurement result exceeds the routine bioassay monitoring program follow-up level.
Bioassay result for a worker with a known internal deposition shows an unanticipated increase.	Recent and previous known bioassay measurements are compared and it is determined that the recent result exceeds normally expected fluctuations.
Bioassay data collected subsequent to an evaluated intake suggest that the assigned dose may be incorrect.	Evidence suggests that the assigned dose may be in error by 10% of an annual dose limit or 10% of the previously assigned dose, whichever is greater.
Field Dosimetry requests a special internal dose assessment.	Request by Field Dosimetry.
Prior work history or beginning work bioassay measurement for a newly hired employee indicates a previously incurred occupational exposure.	Bioassay or other information indicates internally deposited radioactivity at the time of employment.

3.2 PERFORMING THE ASSESSMENT

When one of the situations in Table 3.1 occurs and the dose assessment criteria are met, an assessment of internal exposure is performed. The assessment process includes investigation, documentation, and reporting of conclusions. Figure 3.1 depicts the steps that comprise the complete assessment process.

3.2.1 Investigation

The investigation phase of the exposure assessment process involves the performance of follow-up bioassay measurements and the collection of other pertinent data.

Follow-up bioassay measurements have three purposes:

1. identifying (confirming) that an intake occurred
2. establishing the material's distribution in and clearance from organs in the body
3. assessing dose equivalent.

Recommendations for follow-up bioassay measurements are made by Internal Dosimetry on a case-by-case basis consistent with stated practices in Chapter 2.0 and other guidance provided in Chapters 6.0 and 7.0, and with the concurrence of Field Dosimetry. The type and extent of the follow-up measurements depend on the significance and complexity of the exposure case.

Follow-up measurements for assessing dose are based on the need to establish the magnitude of the internal deposition and its clearance rate from the body. Generally, the frequency for performing follow-up bioassay measurements can be decreased with time post-intake, until, for long-retained nuclides, the follow-up measurements can be continued on an annual monitoring frequency. It is recommended that follow-up bioassay measurements continue until the measurement results are consistently less than detectable or below the follow-up level established for routine bioassay monitoring.

Other information of primary importance to the assessment that should be obtained during the follow-up investigation is listed in Table 3.2.

The investigation determines that either an intake did or did not occur. If the conclusion is that an intake did occur, the magnitude of the resulting exposure in terms of annual and committed dose equivalent is determined.

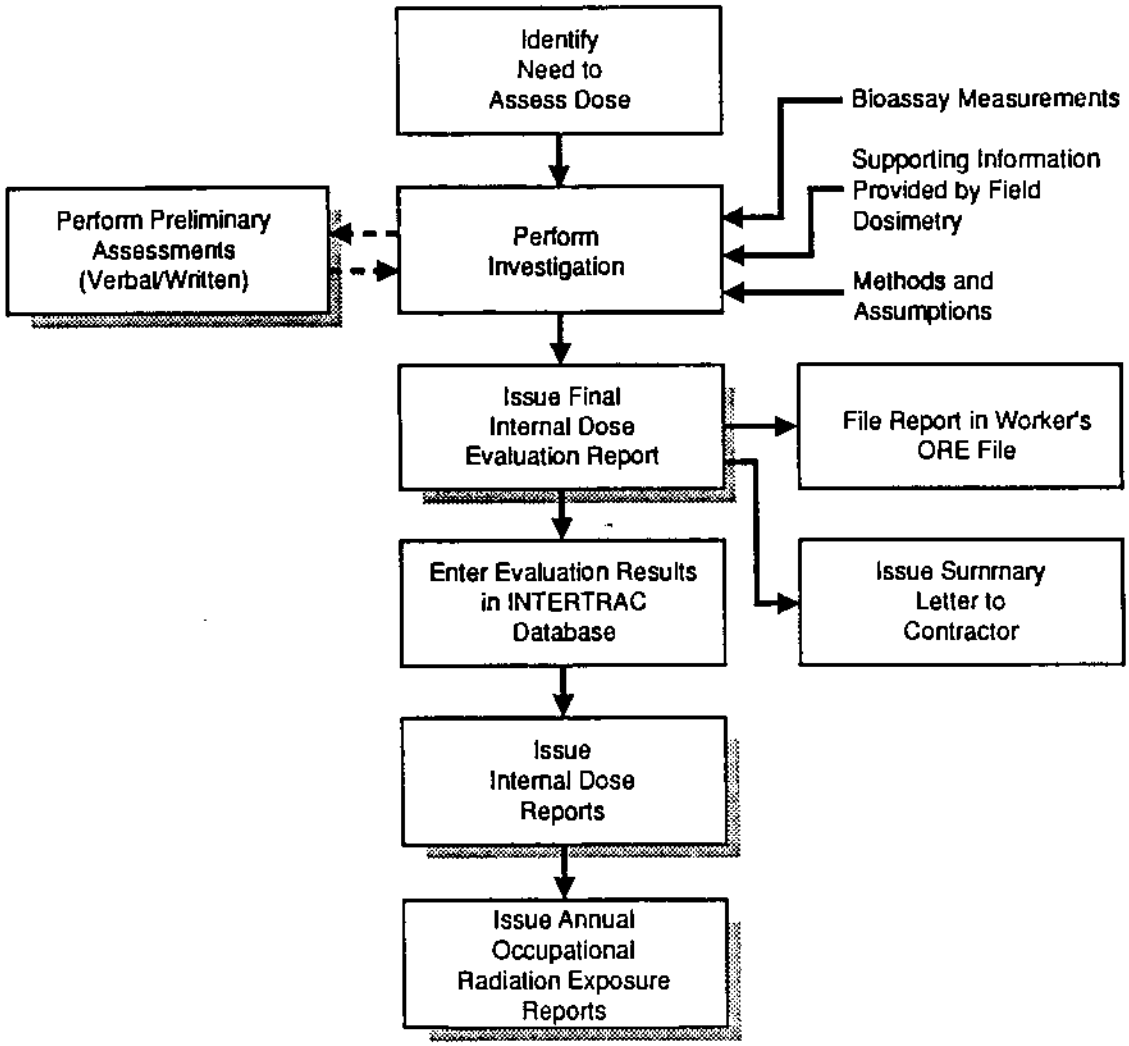

FIGURE 3.1. Internal Dose Assessment Process Flow Chart

3.2.2 Documentation

Internal Dose Evaluation Report

Occupational internal exposures to radionuclides are assessed and formally documented via the Internal Dose Evaluation Report. The Internal Dose Evaluation Report provides the methods, assumptions, data, and conclusions of the assessment. All subsequent detailed or summary accounts of internal dose from a particular exposure event are derived from the Internal Dose Evaluation Report.

Internal Dose Evaluation Reports are prepared by Internal Dosimetry using methods and assumptions described in this manual, in the Technical Basis, and in other resources as appropriate. Before any report is issued, it is reviewed internally by a peer.

TABLE 3.2. Information Supporting the Internal Dose Assessment

General Information	Location where exposure occurred
	Description of the exposure event, including time, suspected mode of intake, duration of intake, and other individuals involved
	Personnel contamination survey results and decontamination actions
	Radionuclide(s) involved, including relative abundance in mixtures
	Physical and chemical characteristics of contamination and host matrix
Inhalation Intake Information	Airborne radionuclide concentrations
	Respiratory protection used
	Observed facial, nasal, and/or hand contamination
	Breathing habits (mouth/nose breather)
Absorption/Wound Information	Location of wound(s)
	Cause and description of wound
	Wound contamination survey results
	Characteristics of contamination in and around the wound site
	Medical and health physics actions
Materials for Potential Analysis	Analysis of the following materials can also provide useful information, and it is recommended that, to the extent practical, these materials be identified and retained for a period of 1 month: • air sample media (filters, canisters) • contamination smear survey pads • nasal swab and irrigation fluid • respirator filters • wound debris (blood, tissue, foreign matter)

3.2.2 Documentation (contd)

Exhibit 3.1 shows the evaluation report form that is used to document internal dose evaluations. This form is used to identify the assessment, organize the content of the report, summarize the conclusions, and show who prepared and reviewed the report. When an assessment is complex, special attachments, containing the details of the assessment, are attached to the evaluation report form.

Each internal dose evaluation is identified by a unique identification number. Prior to 1987, numbers were assigned sequentially. Beginning on January 1, 1987, the numbering system was revised to include a five-digit event number followed by a two-digit person designator and a one-digit evaluation revision designator. The first two digits of the event number represent the calendar year during which the evaluation is originally initiated, and the last three digits are assigned sequentially to each event during that year. The sequence character after the two-digit individual worker number indicates that the evaluation report is either the original ("A") or a revision ("B,C,D---"). For example, the evaluation number, "87005-02A," identifies the evaluation as the original version issued for individual number 2 who was involved in the fifth potential internal exposure event of 1987.

Evaluation numbers are assigned by the Internal Dosimetry clerk upon notification that an assessment will be performed.

The following information is provided in the evaluation report:

- evaluation number
- worker's name, payroll number, and social security number
- date or period of exposure, actual or assumed
- area and building where exposure occurred, if known
- summary of exposure scenario, if known
- mode(s) of intake, actual or assumed
- radionuclides addressed by the assessment
- summary of data used in the assessment
- description of assessment methods and assumptions

3.2.2 Documentation (contd)

- calendar-year and committed effective dose equivalents
- calendar-year dose to organs meeting the criteria in Section 2.1.2
- references, as required
- author's name and signature and date prepared
- peer reviewer's signature.

3.2.3 Reporting

Summary Letter

A letter summarizing the conclusions of the evaluation (preliminary or final) is sent to the designated dosimetry office of the involved worker's employer, and a copy of the summary letter along with the evaluation report, is sent to Radiological Records for inclusion in the worker's ORE file.

The summary letter contains the following information:

- worker's name and payroll number
- date or period of the exposure
- area and building where the exposure occurred
- assigned effective dose equivalent for the year of intake
- maximum annual effective dose equivalent and the assigned year
- projected committed effective dose equivalent
- recommendations for further follow-up sampling.

3.3 DOSE ASSESSMENT METHODS

Program practices, discussed in Chapter 2.0, provide general statements regarding the operation of the IDP. Technical considerations for the internal dose assessment process are covered in the Technical Basis. The methods and approaches used for investigating, assessing, and reporting internal dose assessments are summarized in the following subsections. They are "default" methods used unless available information points to a more appropriate

method or assumption. If a method and technique other than those discussed here are used, they are documented in the evaluation report.

3.3.1 General Approach

Internal exposures are preferably assessed based on bioassay measurement results. However, if bioassay data are unobtainable, the assessment is performed using whatever information is available.

Direct (in vivo) measurements of internal burdens and retention patterns are preferred to indirect (excreta) methods that require the use of excretion functions and biokinetic models.

Assumptions used in the dose assessment process should be conservative but realistic. Assumptions should not be made when actual data or information are available.

When the actual intake time or period is not known, it is necessary to attempt to identify the probable intake date(s). This may be done by considering available evidence, such as air monitoring results, contamination surveys, operating periods, previous bioassay measurement results, and any other pertinent information. After narrowing the intake time to a probable time period, it is assumed that an acute intake occurred at the midpoint of that period. If the evidence suggests that a chronic exposure is more reasonable, it is assumed that the chronic exposure occurred uniformly throughout the duration of the probable exposure period.

If the mode of intake is not known, it is assumed that the intake was by inhalation.

3.3.2 Evaluating Lung Dose for Inhalation Exposures

Potential lung doses from inhalation exposures must be considered even if direct in vivo measurements do not identify the nuclide in the lung. In such cases, assessments of the lung burden and dose should be performed using alternative techniques such as excreta measurements, air samples, or other available information; but the assessed activity in the lung should not exceed the reported minimum detectable activity (MDA) level of the chest measurement.

3.3.3 Solubility and Particle Size Assumptions

Input terms for biokinetic models should be based on field data and on bioassay measurements that are specific to the exposure event being evaluated. If model input requires information that cannot be reasonably obtained, then appropriate conservative assumptions should be used. For particle size input to the respiratory tract biokinetic model, the default particle size input is 1.0 μm AMAD (activity median aerodynamic diameter), assuming that the particles are lognormally distributed with a geometric standard deviation of 2.7 μm. For transportability class input to the model, the transportability characteristics should be determined based on the known or probable chemical and physical makeup of the material. The evaluation should include appropriate discussion of the rationale for choosing these parameters.

3.3.4 Radionuclides Included in the Assessment

The internal dose assessment should consider all radionuclides identified by in vivo or field measurements, as well as additional radionuclides that are reported by Field Dosimetry as being present or that are known to be present from previous experience. If field measurements indicate gross radioactivity levels only (gross β, gross α), then appropriate radionuclide representations of these levels should be used based on a conservative evaluation of radionuclides potentially present. Reference radionuclide mixtures developed in the Technical Basis can be considered applicable in this situation.

3.3.5 Assessment of Exposures of Localized Tissue

For radionuclide depositions in localized tissues, such as in regional lymph nodes or at wound sites, the quantity of the radionuclide deposited in the tissue and its projected half-life are assessed and documented. This assessment becomes part of an individual's ORE record, but is not used for determining compliance with either stochastic or nonstochastic annual dose equivalent limits in DOE 5480.11 (1989). This approach is analogous to the approach required by DOE 5480.11 (1989) for irradiation of limited areas of the skin. Additional discussion is provided in Appendix B of the Technical Basis.

3.3.6 Biokinetic Models

Biokinetic models for specific applications are discussed in the Technical Basis. The standardized models summarized below are used for initial evaluation of internal exposure and are applied to final evaluations unless a more appropriate model is determined to apply to the specific exposure situation.

3.3.6 Biokinetic Models (contd)

Respiratory Tract Model — The general model for the respiratory tract presented in ICRP 30 (1979) is used for evaluation of retention and elimination of inhaled particulates by the respiratory system.

Gastrointestinal Tract Model — The model for the gastrointestinal (GI) tract presented in ICRP 30 (1979) is used to evaluate retention and absorption of materials by the stomach and small and large intestines.

Systemic Retention Models — The systemic retention models used are those described in ICRP 30 (1979), except for the updated recommendations on uptake fractions and retention for transuranic radionuclides contained in ICRP 48 (ICRP 1986). Retention models are most useful when organ uptake and retention cannot be determined using in vivo measurements.

Systemic Excretion Models — The systemic excretion functions in Table 3.3 are applied to excreta data unless a more appropriate model applies to a specific situation. The models are discussed further in the Technical Basis.

TABLE 3.3. Excretion Functions

Element	Systemic Excretion Model
Plutonium	Jones function (Jones 1985)
Strontium	Alkaline earth model, as implemented by the GENMOD computer code (Johnson and Myers 1981)
Uranium	ICRP 30 (1979) retention model
Tritium	ICRP 30 (1979) retention model

3.3.7 Computer Programs Used for Dose Calculations

The computer program codes listed in Table 3.4 are consistent with the retention and/or excretion models discussed previously and are used in the assessment process unless another approach is determined to be more appropriate for the specific situation. Each of the computer programs is documented in the Hanford Radiation Protection Historical Files.

TABLE 3.4. Computer Programs Used for Dose Calculations

Computer Program Code Name	Purpose
GENMOD	A general purpose retention, excretion, and dose-calculation program that is compatible with ICRP 30 (1979) and ICRP 48 (1986)
PUCALC	A set of programs for estimating systemic uptake of plutonium from urine data
PLUDO GENDOS	Adaptations of GENMOD for calculating calendar-year dose equivalents from plutonium intakes

3.3.8 Simplified Dose Assessments

The simplified dose assessment procedure is a standardized approach for assessing internal doses. The procedure is generally employed for calculations used in prospective program design, initial retrospective assessments when available bioassay and other data regarding the exposure are minimal, and final assessments for which the dose equivalent is relatively low. Generally, the simplified dose assessment procedure is used for final assessment of intakes resulting in annual effective dose equivalents of less than 100 mrem.

The simplified dose assessment procedure employs the standardized excretion and retention functions and assumptions discussed previously in this section and other specific assumptions and methods described in the Technical Basis.

If the assessed dose, using the simplified dose assessment procedure, exceeds the 100-mrem/yr effective dose equivalent, then models, methods, and assumptions are reviewed to determine their applicability.

3.4 GOOD PRACTICE RECOMMENDATIONS FOR FIELD DOSIMETRY

Monitoring and assessing internal occupational exposures at Hanford are accomplished through the mutual effort and cooperation of the Hanford Internal Dosimetry Program and Field Dosimetry. These activities are complementary, that is, both the contractor and Internal Dosimetry responsibilities must be fulfilled. The recommendations provided below are suggested by Internal Dosimetry as

3.4 GOOD PRACTICE RECOMMENDATIONS FOR FIELD DOSIMETRY (contd)

general guidance for Field Dosimetry administration of monitoring programs. In addition to this general guidance, Internal Dosimetry provides specific guidance and technical support as needed.

3.4.1 Identifying Routine Bioassay Monitoring Needs

The following good practice recommendations cover activities that are required for a complete internal dosimetry program:

- Identify the routine bioassay monitoring needs of individuals and arrange for a routine bioassay monitoring program that is responsive to these needs. The bioassay monitoring program should be radionuclide-specific; that is, established by radionuclide and exposure scenario, rather than by measurement type. General guidance on bioassay monitoring program needs is provided in Chapter 5.0 of this manual. Internal Dosimetry can recommend measurement types to ensure the inclusion of radionuclides of concern.

- Apprise Internal Dosimetry of the radiological conditions in facilities. Include identification and physical and chemical characteristics of the radionuclides and the potential internal exposure situations that exist.

- Contact Internal Dosimetry as needed for specific guidance and support in the setup and operation of the routine bioassay monitoring program.

- In cooperation with Internal Dosimetry, identify the radionuclides for which bioassay monitoring is not performed or is not adequate, and assure that appropriate monitoring of these radionuclides (using other techniques) is provided. This could apply, for example, to short-lived radionuclides that cannot be reliably detected through routine bioassay monitoring.

3.4.2 Identifying Potential Internal Exposures

Identify potential internal exposure events and report these promptly to Internal Dosimetry. Assessments of internal dose are more accurate and can be performed with less expense if the intake time is known, if follow-up samples are collected shortly after intake, and if field data are available regarding the nature and characteristics of the exposure.

3.4.3 Managing Internal Exposures

Good practice in managing internal exposures includes adhering to the following recommendations:

- Avoid potential internal exposures to workers until baseline bioassay measurements (e.g., beginning employment) have been performed and prior exposure history has been reviewed.
- Consider the impact of internal exposures on allowable external exposure for workers with internal doses.
- Consider a work restriction if the annual dose from internal exposure exceeds 50% of the standards.
- Consider a temporary work restriction to avoid exposure to like radionuclides if such exposures could adversely affect an ongoing investigation of a potential internal exposure.
- Provide long-term follow-up bioassay measurements for workers with current internal depositions. This tracks the retention of the radionuclide and establishes a baseline from which to evaluate possible future exposures.
- Inform the worker of the status of the follow-up investigation and dose assessment.

Exhibit 3.1

Internal Dose Evaluation Report Form

Battelle Pacific Northwest Laboratories	STRICTLY PRIVATE EVALUATION OF POTENTIAL INTERNAL EXPOSURE		
Name	Payroll No.	Soc. Sec. No.	Potential Intake No.
Potential Intake Scenario:		Date of Potential Intake:	
Dose Evaluation Summary:			
Attachments:		Evaluated by: Reviewed by:	

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CHAPTER 4.0

RECORDING AND REPORTING INTERNAL DOSES

4.0 RECORDING AND REPORTING INTERNAL DOSES

Reports of occupational dose equivalent are required as specified in DOE 5480.11 (1989) and DOE 5484.1 (1981). The occupational dose equivalent is composed of the dose equivalent received from external sources of radiation and internally deposited radionuclides. This section provides information on the recording and reporting of the internal dose component as performed by the IDP. Assessed internal doses are provided to Radiological Records for compilation and preparation of occupational dose reports.

4.1 INTERNAL DOSE RECORDS

The official record of internal dose is the Internal Dose Evaluation Report. Section 3.2.2 describes the contents of the Internal Dose Evaluation Report. An Internal Dose Evaluation Report is issued for each assessed internal exposure. Completed reports are maintained by Radiological Records in ORE files. Summary dose information is maintained in the ORE database.

4.2 INTERNAL DOSE DATABASE

Dose information from Internal Dose Evaluation Reports is maintained by Internal Dosimetry in the computer database INTERTRAC (for Internal Dose Tracking System). INTERTRAC contains annual and committed organ and effective dose equivalent information from the Internal Dose Evaluation Report for each assessed intake, and this information is used to generate dose summaries for tracking and reporting occupational doses to individuals. Reports that can be generated using INTERTRAC include the following:

- annual organ and effective dose equivalents for each evaluated intake
- annual organ and effective dose equivalents from all evaluated intakes
- cumulative organ and effective dose equivalents through a specified year or for a specified number of years
- committed organ and effective dose equivalents for each evaluated intake and for all evaluated intakes.

4.2 INTERNAL DOSE DATABASE (contd)

Additional information on the INTERTRAC system is provided in "The Hanford Internal Dose Accounting and Reporting System - INTERTRAC (Version 1.0)."(a)

Prior to the beginning of a new calendar year, the annual effective dose equivalent from all internal exposures assessed to date is provided to Radiological Records for input into an interactive file on the ORE database. Thus, the current year effective dose equivalent is accessible to contractors. Updates to this file are made as new or revised evaluations are issued.

4.3 REPORTS OF INTERNAL DOSE

Letters of assessed internal dose are issued to contractor dosimetry representatives upon completion of the Internal Dose Evaluation Report as discussed in Chapter 3.0. Summary reports of employee internal dose equivalents are distributed to contractor dosimetry representatives annually. Updates to these reports are provided throughout the year, based on new or revised internal dose assessments, or to include reactivated workers with internal doses from past intakes. The current calendar-year effective dose equivalent can be accessed on the ORE system (see Appendix B, Figure B.6).

Annual occupational dose reports (report cards), reports of occupational dose for terminating employees, and reports to the DOE Radiation Exposure Information Reporting System (REIRS) are provided by the Hanford Radiological Records group. Special requests for internal dosimetry information may be made to the IDP.

Several groups of Hanford workers are considered to be chronically exposed to radionuclides during the course of their work. These groups include those individuals working with tritium and uranium of low or depleted enrichment. Bioassay samples for these workers are collected throughout the year. A final internal dose assessment is issued after yearend; however, throughout the year, the routine bioassay measurements are reviewed and the contractor is advised if there is an indication that the annual effective dose equivalent from chronic exposures could exceed 100 mrem.

(a) Sula, M. J., K. K. Johnson, and R. A. May II. 1989. "The Hanford Internal Dose Accounting and Reporting System - INTERTRAC (Version 1.0)." Internal Report dated February 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

4.4 REQUESTS FOR INTERNAL DOSIMETRY RECORDS

Occupational radiation exposure records are controlled according to the requirements and provisions of the Privacy Act (1974) and ANSI N13.6-1966 (ANSI 1966), Practice for Occupational Radiation Exposure Records Systems. Access to the records is permitted as follows:

- Current employees may contact their company's radiation protection representative, who will arrange with Radiological Records to obtain the requested records.
- Individuals may request their records by contacting Radiological Records either in person or by mail. Verbal requests are not accepted.
- Employers requesting records of current or former Hanford workers should contact Radiological Records.
- Requests by the U.S. Transuranium Registry should be made by contacting Radiological Records.
- If none of the above apply or are practical, contact the DOE Privacy Act Officer, who will prepare the proper paperwork and submit the request to Radiological Records.

In the above cases, the following are required before records are released:

- An individual appearing in person must provide a driver's license or other photographic identification and sign a release form that will be provided by Radiological Records. This signed release is entered into the individual's ORE record.
- An individual requesting records by mail must provide in a notarized written request his/her name, social security number and/or payroll number, and signature. This written request must define exactly which records are needed and the address to which they should be sent. Verbal requests are not honored.
- Employer and U.S. Transuranium Registry requests must be accompanied by a signed radiation exposure release-of-information form.

CHAPTER 5.0

BIOASSAY MONITORING

5.0 BIOASSAY MONITORING

This chapter discusses who should be included in a routine bioassay monitoring program, what measurements should be performed, and at what frequency.

5.1 CONDITIONS FOR MONITORING WORKERS

DOE 5480.11 Requirement

Participation in an internal dose evaluation and routine bioassay monitoring program is required by Section 9.g.(2) of DOE 5480.11 (1989), which states:

> "Internal Radiation. Internal dose evaluation programs (including routine bioassay programs) shall be adequate to demonstrate compliance with the radiation protection standards in paragraph 9b. Such programs are required for radiation workers exposed to surface or airborne radioactive contamination where the worker could receive 0.1 rem (0.001 sievert) annual effective dose equivalent from all intakes of all radionuclides from occupational sources, or if any organ or tissue dose equivalent could exceed 5 rem (0.05 sievert) annual dose equivalent."

Although DOE 5480.11 requires only that dose evaluation and routine bioassay programs be adequate to demonstrate compliance with the annual dose equivalent standards, it is the practice of the IDP, as stated in Section 2.3, to provide bioassay monitoring capability to detect an intake potentially resulting in an annual effective dose equivalent of 100 mrem.

The achievement of an annual effective dose equivalent capability of 100 mrem for bioassay monitoring eliminates the possibility that any single organ or tissue might exceed 5 rem in a calendar year without being detected via bioassay monitoring. This is because a 100-mrem program capability, divided by the smallest weighting factor (0.03) leads to an organ or tissue dose equivalent of 3.3 rem, which is well below the 5-rem criterion.

The requirement in DOE 5480.11 further calls for monitoring in consideration of the potential total dose from all intakes, rather than monitoring on a "per nuclide" basis. Thus, monitoring may be appropriate for workers exposed to multiple nuclides, even though any single nuclide may be only a small fraction of the criterion for an effective dose equivalent of 100 mrem/yr.

5.1 CONDITIONS FOR MONITORING WORKERS (contd)

General Recommendation Based on Committed Dose

The IDP recommends placing workers on a routine bioassay monitoring program if the 50-year committed effective dose equivalent from a single intake or multiple intakes in a single calendar year may exceed 100 mrem for all radionuclides.

The 50-year committed effective dose equivalent is recommended for establishing bioassay monitoring requirements. Its use provides some conservatism relative to the annual dose equivalent limit specified by DOE 5480.11 (1989), particularly with regard to tenaciously retained nuclides. The committed dose equivalent also allows for the convenience of correlating bioassay requirements to derived air concentrations (DACs), annual limits on intake (ALIs), and time-integrated exposure to airborne contamination (DAC-hours), which are widely used in the workplace for exposure control.

For bioassay program planning purposes, a 100-mrem committed effective dose equivalent may be considered to correspond to chronic exposure for 1 year to 2% of a DAC, an acute or chronic intake equal to 2% of an ALI, and a time-integrated exposure to airborne contamination of 40 DAC-hours. Technically, this is not completely accurate, because if the DAC or ALI is based on the nonstochastic limit for a particular organ or tissue, the corresponding committed effective dose equivalent will be less than 100 mrem. Because of this conservatism, the use of established DAC and ALI values is an acceptable practical approach.

The DAC, ALI, and DAC-hour concepts and the nature of the work and the exposures may be used to determine who should be included in a bioassay monitoring program. The following subsections provide guidance for their application for bioassay monitoring.

5.1.1 Derived Air Concentration

Long-Term Chronic Exposures

A worker should be placed on a routine bioassay program if chronic exposure to airborne radioactivity could exceed an average of 2% of the DAC. For exposures to multiple nuclides, the contribution from each significant nuclide should be considered. The DACs referred to in this manual are those contained in Attachment 1 to DOE 5480.11 (1989). The DACs for selected Hanford radionuclide mixtures are given in Table 5.1.

TABLE 5.1. Derived Air Concentrations and Annual Limits on Intake for Common Radionuclide Mixtures

Radionuclide Mixture[a]	Inhalation Class	DAC (μCi/ml)	ALI (μCi)
Uranium (natural, depleted and recycled)	D - chronic	3.E-8[c]	75 mg[b]
	D - acute	NA[d]	14 mg[b]
Uranium (natural and depleted)	W	2.E-10	7.E-1
	Y	2.E-11	5.E-2
Uranium (recycled)	W	2.E-10	6.E-1
	Y	2.E-11	4.E-2
Plutonium (6% Mixture)[e]	W	2.E-12	5.E-3
	Y	5.E-12	1.E-2
Plutonium (12% Mixture)[e]	W	2.E-12	5.E-3
	Y	4.E-12	1.E-2

(a) Isotopic ratios are given by Sula, Carbaugh, and Bihl (1989).
(b) The class D chronic inhalation and acute inhalation values are based on the chemical toxicity discussion by Sula, Carbaugh, and Bihl (1989).
(c) Units are mg/ml.
(d) Not applicable.
(e) Expressed as total alpha activity.

5.1.1 Derived Air Concentration (contd)

Short-Term Chronic Exposures

Workers exposed to short-term chronic exposures should participate in a routine bioassay monitoring program for each radionuclide to which he/she is exposed when the average air concentration exceeds that determined by the following formula:

$$\text{Air Concentration Implying Bioassay Monitoring} = \frac{0.02 * DAC}{f_w} \qquad (5.1)$$

where DAC is the derived air concentration listed in DOE 5480.11 (1989), and fw is the occupancy factor determined by

$$f_w = \frac{\text{number of hours per year in airborne area}}{\text{2000 working hours per year}} \qquad (5.2)$$

If a worker is exposed to more than one radionuclide, the result of Equation (5.1) should be divided by the number of significant radionuclides.

5.1.1 Derived Air Concentration (contd)

Short-Term Chronic Exposures (contd)

In general, Hanford experience has shown that no more than four radionuclides or mixtures contribute significantly to internal dose in any one situation.

5.1.2 Annual Limit on Intake

The ALI is a useful concept for bioassay planning purposes when acute intakes are considered or exposure may be limited to readily identified quantities or sources. A routine bioassay program should be considered if an acute or chronic intake of activity corresponding to 2% of the ALI might be possible. Although ALIs are not listed in DOE 5480.11 (1989) or its attachments, they can be derived by multiplying the DOE 5480.11 DAC (units of μCi/ml) by 2.4E+9 (giving the ALI in units of microcuries). The ALIs for selected Hanford radionuclide mixtures are given in Table 5.1.

NOTE: Specific reference is made to DOE 5480.11 DACs as the basis for ALI calculation. It should not be assumed that ALIs calculated based on DOE 5480.11 (1989) are identical to the ALIs contained in ICRP 30 (1977).

Even if not chronically exposed to airborne radioactivity, certain workers risk incurring an intake because of an unplanned breakdown of a protection barrier. Potential conditions may be identified by the amount of material handled in a process, the physical form of the material, and the type of containment, or by the determination that the workers frequently need respiratory protection.

One approach to the consideration of source magnitude and containment is to use potential intake factors related to material form and containment. The potential intake factors in Table 5.2 should be considered for general guidance only. Actual facility experience should be used when possible.

For example, a worker should be included in a routine bioassay monitoring program if the activity of an unencapsulated radionuclide that is frequently handled, processed, or worked with in any way equals or exceeds the activity calculated by the following formula:

$$\text{Activity of Material Implying Bioassay Monitoring} = \frac{0.02 * \text{ALI}}{\text{potential intake fraction}} \qquad (5.3)$$

TABLE 5.2. Potential Intake Fractions[a] as a Function of Containment Type and Physical Form

Form	Containment		
	Glovebox	Open-Faced Hood	Open Area
Tritium[b]	1.6E-4	1.6E-3	1.6E-2
Powders	1E-5	1E-4	1E-3
Volatile liquids, elevated temperatures, iodines	1E-6	1E-5	1E-4
Normal liquids	1E-7	1E-6	1E-5
Grinding, sawing, polishing, etc., on solids	1E-8	1E-7	1E-6

(a) Extrapolated from data and discussion in Watson and Fisher (1987; pp. 15-19) and from Brodsky (1980). The purpose of these potential intake fractions is to determine the need for participation in a bioassay program. The fractions should not be used to estimate actual expected releases under average conditions.
(b) Data from U.S. Nuclear Regulatory Commission Regulatory Guide 8.32 (1988).

5.1.2 Annual Limit on Intake (contd)

where ALI is the annual limit on intake. Potential intake fractions are listed in Table 5.2 as a function of the type of containment and physical form. The information in Table 5.2 should be considered for general guidance only. Actual facility experience should be used when possible.

If a worker is exposed to more than one radionuclide, the result of Equation (5.3) should be weighted, based on the number of significant nuclides.

5.1.3 DAC-hours

For specific job assignments, it is useful to consider the concept of DAC-hours in planning bioassay requirements. A worker potentially exposed to an accumulation of 40 DAC-hours in a year for all radionuclides should participate in a routine bioassay program.

5.1.4 Nature of Work

Special consideration for routine bioassay programs should be given to the following:

- Knowledge of or prior experience with the work performed or the facility involved.
- Workers who frequently wear respirators in airborne radioactivity areas.
- Workers who routinely work with transuranics in hoods or glove boxes.
- Workers who are subjected to a wide range of potential internal exposure conditions.

5.1.5 Long-Term Follow-Up of a Prior Deposition

A worker who has been assessed as having a long-term internal deposition of radioactivity may be recommended by Internal Dosimetry for a specialized follow-up bioassay monitoring program to verify the accuracy of the assessment and identify any potential need for revision.

This provision results from the need to update long-term body burdens and associated doses from well-retained radionuclides, and it applies regardless of present work assignment or origin of the occupational exposure.

Better understanding of the biokinetic behavior of retained material and improved estimates of dose can be obtained from long-term follow-up bioassay measurements. For example, a small, very long-term component of material in the lung may be masked for several years by short-term components until the short-term components are removed. However, the long-term component will add significantly to dose in outyears as well as to the 50-year dose commitment.

Long-term follow-up monitoring is most likely to be associated with depositions of plutonium and americium, although other nuclides may also warrant it.

5.1.6 Beginning and Ending Work Bioassay

Beginning and ending work samples or measurements should be obtained for a worker whose work assignments will require or have required routine bioassay monitoring (NCRP 1987; ANSI 1978). Such samples should provide a better estimate of the time and nature of an intake, prevent the improper assignment of a prior intake to the

5.1.6 Beginning and Ending Work Bioassay (contd)

present task, and provide accurate feedback on the effectiveness of radiation protection measures for specific work assignments.

Beginning and ending work measurements may be a suitable alternative to the routine bioassay monitoring associated with work assignments of limited duration. Consult with Internal Dosimetry to determine whether this option is appropriate.

5.1.7 Offsite Exposure

Bioassay programs designed for monitoring internal exposures to materials and situations at Hanford may not necessarily be adequate for monitoring internal exposures to materials or facilities that may occur offsite. Internal Dosimetry should be contacted to determine the appropriate bioassay if offsite internal exposure is a possibility.

5.1.8 Visitors

The same criteria used for determining the need for bioassay monitoring of workers should be used for determining the bioassay monitoring requirements for visitors. Consideration may be given to the nature of the visit, facility entered, proximity to sources, duration of visit, and extent of work performed while a visitor. Application of the DAC-hour criteria or equations 5.1 and 5.3 may be helpful.

5.1.9 Pregnant Women and Minors

The DOE 5480.11 Radiation Protection Standards for pregnant women and minors are substantially more restrictive than those for occupational workers. Routine bioassay monitoring programs may not have the sensitivity required to verify compliance with the more restrictive standards. Internal Dosimetry should be consulted on a specific case basis as the need arises.

5.2 SELECTION OF NUCLIDES FOR BIOASSAY

Any radionuclide or mixture of radionuclides that may contribute more than 25% to the 100-mrem committed effective dose equivalent criterion should be included in the bioassay monitoring program. Radionuclides do not require specific bioassay monitoring if they are adequately monitored by indicator nuclides for a reference mixture.

5.2 SELECTION OF NUCLIDES FOR BIOASSAY (contd)

In some cases it is possible to use indicator radionuclides for established mixtures to optimize the number of bioassay measurements performed. For example, mixtures containing equal parts of ^{137}Cs and ^{90}Sr may be sufficiently monitored by using whole body measurements of ^{137}Cs as an indicator of exposure.

Once a worker is placed on a routine program, that program should be reviewed on a regular basis to assure that potentially significant nuclides are adequately addressed.

As a rule of thumb, it may be considered that workers are not likely to be exposed to more than four reference mixtures of radionuclides.

5.3 BIOASSAY MEASUREMENT FREQUENCY

The frequency of bioassay measurements is dictated by two objectives. The first is to monitor the accumulation of radioactive material in the body from low-level chronic intakes. The second is to assure that significant acute depositions are detected so that appropriate corrections can be instituted in the working conditions (NCRP 1987).

In general, significant acute intakes are discovered by first-line monitoring methods (e.g., air monitoring, and clothing and body surveys) and are investigated according to the protocol discussed in Chapter 7.0. Nevertheless, a properly chosen bioassay frequency is important both to account for undetected, acute intakes and to monitor the effectiveness of first-line monitoring methods.

The choice of frequency depends on the following:

- purpose of the measurement, i.e., to monitor for accumulation from chronic intakes, potential acute intakes undetected by first-line monitoring methods, or acute intakes that occur simultaneously with a chronic background
- the need to meet the objective given in Section 2.3 (i.e., an annual effective dose equivalent of 100 mrem)
- MDAs for various radionuclides and bioassay measurements
- likelihood and ratios of combinations of radionuclides associated with an intake for a particular facility or task.

Longest Interval Between Bioassays

Routine bioassay measurement frequencies longer than annual are not recommended (NCRP 1987; ANSI 1978). Routine bioassay measurement periods longer than five effective half-lives are also generally not recommended.

5.3.1 Typical Bioassay Frequencies

Table 5.3 lists typical measurement frequencies and monitoring methods for pure radionuclides. Unless otherwise noted, the frequencies are based on detecting an acute intake occurring on the day after the last sample or measurement that could result in a first-year effective dose equivalent of 100 mrem. Also, unless noted, it is assumed that chronic intake is negligible. Trying to detect a potential acute intake above a chronic background requires greater sampling frequencies.

5.3.2 Frequencies for Multiple Nuclides

Many facilities and tasks deal with more than one radionuclide at a time. In such cases, the measurement frequencies in Table 5.3 may not be appropriate. Characterizing the source of potential intakes and consulting with Internal Dosimetry is advised to establish the best bioassay monitoring program for the situation. Table 5.4 lists bioassay programs for some typical Hanford radionuclide combinations.

5.3.3 Uranium Bioassay

Monitoring for uranium poses special problems for the following reasons:

- Uranium presents both chemical and radiological toxicity risks, the relative importance of which depends on its transportability from the lung.
- Uranium usually exists in mixed transportability classes.
- Small recent intakes easily mask larger older intakes because nearly 50% of the uranium going to blood is cleared immediately through the urine.
- An intake of class Y material potentially resulting in a committed effective dose equivalent of 100 mrem generally cannot be detected by normal routine bioassay monitoring practices. Monitoring of the workplace to document the working environment and to provide immediate indication of an intake is essential.

TABLE 5.3. Potentially Undetected Effective Dose Equivalent for Bioassay Measurements of Single Radionuclides(a)

Radionuclide	Inhalation Class	Bioassay Method and Detection Level	Frequency	Potentially Undetected Dose, mrem	
				First Year	50-Year Committed
^{3}H	D	Urine, 10 dpm/ml	Monthly (b)	1	1
			Quarterly(c)	25	25
^{54}Mn	D	Whole body count, 3 nCi	Annual	60	60
	W	Whole body count, 3 nCi	Annual(b)	20	20
^{59}Fe	D	Whole body count, 6 nCi	Annual	70	70
	W	Whole body count, 6 nCi	Semiannual(b)	15	15
			Annual	150	150
^{60}Co	W	Whole body count, 3 nCi	Annual(b)	8	9
	Y	Whole body count, 3 nCi	Annual(b)	3	7
^{90}Sr	D	Urine, 2 dpm/day	Annual(b)	1	5
^{125}I	D	Thyroid count, 0.004 nCi	Semiannual(b)	<1	<1
			Annual(c)	<1	<1
^{129}I	D	Thyroid count, 0.004 nCi	Annual(b)	<1	<1
^{131}I	D	Whole body count, 4.5 nCi	Monthly	140	140
	D	Thyroid count, 0.03 nCi	Monthly	1	1
^{137}Cs	D	Whole body count, 3 nCi	Annual(b)	2	12
^{154}Eu	W	Whole body count, 4.5 nCi	Annual(b)	2	10
	Y	Whole body count, 4.5 nCi	Annual(b)	5	20
U natural(d)	D	Urine, 1 μg/day	14 days(b,e)	<1	<1
			Monthly(b,e)	<1	1
			Quarterly(b,e)	4	14
	D	Chest count	----------Not Recommended----------		
	W	Urine, 0.2 μg/day	Semiannual	7	8
			Annual	70	80
	W	Chest count, 1.8 nCi ^{234}Th	Monthly	360	400
			Quarterly	670	740
	Y	Urine, 0.2 μg/day	Monthly	70	340
			Quarterly	130	600
			Semiannual	130	600
			Annual	130	600
	Y	Chest count, 1.8 nCi ^{234}Th	Quarterly	610	2900
			Semiannual	660	3200
			Annual	850	4100
^{238}Pu, ^{239}Pu	I(g)	Urine, 0.02 dpm/day	Annual(b)	30	820
	W	Urine, 0.02 dpm/day	Annual(b)	40	830
	Y	Urine, 0.02 dpm/day	Annual(h)	340	3500

TABLE 5.3. (contd)

Radionuclide	Inhalation Class	Bioassay Method and Detection Level	Frequency	Potentially Undetected Dose, mrem	
				First Year	50-Year Committed
^{241}Am	I	Urine, 0.02 dpm/day	Annual[b]	30	950
	W	Urine, 0.02 dpm/day	Annual[b]	380	850
	Y	Chest count, 0.18 nCi	Annual[b]	360	9600

(a) Based on data in Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1988).
(b) Recommended frequency.
(c) Detectable but >5 x half-life.
(d) For depleted uranium, multiply doses by 0.5. For recycled uranium, multiply doses by 1.5 (class D), 1.4 (class W), and 1.3 (class Y).
(e) Based on chemical toxicity.
(f) Generally, both urine sampling and chest counting are necessary for proper monitoring of class W and Y uranium, especially if chronic intakes are possible. Frequent urine sampling is used to establish the time of an acute intake or the beginning of chronic intakes. Less frequent chest counting is used to quantify the lung deposition. This applies to depleted-through-1.25%-enriched uranium, but the detectable effective dose equivalents will vary slightly from those listed for natural uranium.
(g) Injection - represents readily-transportable material or an intake straight to the blood.
(h) Semiannual or quarterly sampling frequency does not improve the ability to detect.

5.3.3 Uranium Bioassay (contd)

- Low-level chronic intakes are common, so the bioassay program must monitor for long-term buildup as well as for potentially significant acute intakes.
- Individual and temporal variability in the environmental background of uranium complicates interpretation of urinalysis results.

Consequently, the proper bioassay monitoring program for uranium workers is best determined on a case-by-case basis in consultation with Internal Dosimetry.

5.3.4 Plutonium - Class Y

An intake of class Y (or worse, i.e., less transportable) plutonium with a ^{239}Pu:^{241}Am ratio greater than about 1:1 cannot practically be detected at a potential annual effective dose equivalent of 100 mrem by routine bioassay monitoring. Prompt detection of an intake at the workplace is essential.

5.3.5 Special Forms of Nuclides

Special forms of radionuclides (e.g., tritium or ^{14}C-labeled materials) can behave much differently than the normal compounds for which routine bioassay programs are designed. Case-specific bioassay monitoring programs for situations such as these should be established through consultation with Internal Dosimetry.

TABLE 5.4. Example Bioassay Programs for Some Typical Radionuclide Combinations

Case Description	Program Description
Reactor corrosion products. These typically include ^{60}Co, ^{58}Co, ^{54}Mn, ^{59}Fe, and ^{134}Cs, but ^{60}Co predominates in activity and dose impact.	Annual whole body counts. If ^{60}Co is detected, germanium counting is done to quantify the other corrosion products.
Aged fission products. ^{137}Cs and ^{90}Sr predominate. A 1:1 ratio is assumed if the site-specific ratio is not known.	Annual whole body counts. If ^{137}Cs is above the screening level, ^{90}Sr urine samples are scheduled.
Europiums at N Reactor. ^{154}Eu and ^{155}Eu are assumed to have a 2:1 ratio at intake.	Annual whole body counts.
Readily-transportable uranium. Considered a chemical toxicity risk only. Both chronic and potential acute intakes are considered.	Biweekly or monthly urine samples obtained after 2-day absence from the workplace.
Depleted-to-slightly-enriched uranium metal and various oxides resulting in a mixture of class D class Y material. Chemical and radiological risks and chronic and potential acute intakes are considered.	No program at present is adequate to detect 100 mrem. A combination of frequent urine samples and less frequent chest counts is used. Urinalysis results above the screening level trigger special chest counts.
Class W plutonium mixtures containing ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and possibly ^{241}Am in various amounts.	Annual plutonium urine samples and annual chest counts. Chest counts monitor for possible chronic buildup or for small class Y components.
Class Y plutonium mixtures.	No program at present is adequate to detect 100 mrem. Annual plutonium urine samples and annual chest counts are used. Chest counts quantify lung burden when ^{241}Am grows in or if the intake is of aged 12% plutonium.(b)

(a) NA = not applicable.
(b) 12% by weight ^{240}Pu at several years after americium separation.

CHAPTER 6.0

BIOASSAY SERVICES

6.0 BIOASSAY SERVICES

After a bioassay monitoring need has been identified and the appropriate types of measurements have been determined, the measurements then need to be scheduled and performed. This chapter covers normal bioassay services provided through the IDP, i.e., the available bioassay services, the scheduling of bioassay samples, and the generation, reporting, and follow-up of data. Special services not included here can be scheduled by contacting Internal Dosimetry.

Frequently used telephone numbers and mail stops for bioassay services are:

- Internal Dosimetry Dffice, 376-7245, A3-60
- Whole Body Counter Facility, 376-6102, 81-60
- Radiological Records, 376-6342, 376-8203, A3-60
- United States Testing Company, Inc., Richland, 375-3131, H2-51

6.1 INDIRECT BIOASSAY MEASUREMENT SERVICES

The indirect bioassay analyses are performed by the Analytical Services Laboratory (Lab). Terms applicable to Lab services are provided in the Glossary. The Lab is responsible for

- providing sample kits, including kit delivery and pickup at designated locations (usually worker residences) within a 75-mile radius of Richland. (Field Dosimetry is responsible for kit delivery and pickup outside of this range.) Delivery and pickup of routine and priority samples are usually available on business days only.
- attempting a second pickup of a "can not out" sample on a day specified by Field Dosimetry, within 5 days after the originally scheduled pickup.
- analyzing urine and fecal samples in four processing categories: routine, priority, expedite, and emergency.
- analyzing miscellaneous samples, such as blood, body tissue, cloth, air filters, etc., by rapid or priority processing. Some chemical analyses, such as that for creatinine, are also available.

6.1 INDIRECT BIOASSAY MEASUREMENT SERVICES (contd)

Provisions have been made for obtaining bioassay samples from workers outside the 75-mile service area through the use of mail and private carrier. Internal Dosimetry should be contacted if this method of bioassay sampling is to be done.

The sample type and collection method are identified by the sample kit code. Nine kit codes are available. They are explained in Appendix B, Table B.4, and kit instructions are provided in Appendix D.

The analytical and reporting requirements for the four processing categories as of FY 1989 are detailed in Tables 6.1 through 6.6. Changes in these requirements occur from year to year. Therefore, Internal Dosimetry should be contacted when the most accurate information is needed.

Note that the detection levels listed are "contractual." Actual detection levels, as determined by statistics like those in draft ANSI N13.3D,(a) are generally equal to or lower than the contractual detection levels (CLs).

6.2 IN VIVO MEASUREMENT SERVICES

Routine in vivo measurements are performed by PNL's O&EP Section at the 747-A Building. In vivo measurement services are summarized below and details are provided in the Whole Body Counting Manual (Palmer et al. 1987). The type of measurement performed depends on the radionuclide(s) being looked for and, for some radionuclides, the expected location of the radionuclide(s) in the body.

6.2.1 Whole Body Counts

Most gamma-emitting radionuclides can be easily detected by a standard whole body count. This measurement is normally scheduled as a periodic routine measurement or when an employee is newly hired, terminated, or beginning or ending a special project. No appointment is necessary for a whole body count. Annually scheduled in vivo examinations normally occur on the same day as the worker's annual physical.

The whole body measurement may consist of one or more counts using different equipment. Generally, a screening

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(a) American National Standards Institute (ANSI). 1987. Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30, New York, New York.

TABLE 6.1. Analytical and Reporting Requirements for Routine Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level(a) (dpm/sample) Urine	Fecal	Determination Time (business days following sample receipt)	Reporting Time Oral	Written(b)
Pu(α) iso. (IPU)	^{238}Pu, $^{239,240}Pu$	0.02	0.2	20		
^{241}Am (AM241)	^{241}Am	0.02		20		
Cm(α) iso. (ICM)	^{241}Cm, $^{243,244}Cm$, + Others(c)	0.02		20	By close of business on day of determination if > reporting level(f)	Within 5 business days
Tritium (H3)	^{3}H	10 dpm/ml		5		
^{90}Sr (SR90)	^{90}Sr	2		30		
^{147}Pm (PM147)	^{147}Pm	4		20		
^{144}Ce (CE144)	^{144}Ce	15		20		
Eu iso. (IEU)	^{152}Eu, ^{154}Eu, ^{155}Eu	2		20		
^{99}Tc (TC99)	^{99}Tc	20		20		
Gamma spectroscopy (ISPEC)	^{40}K, ^{137}Cs, + Others(d)	See Table 6.5		20		
Gamma spectroscopy (LEPD)	^{241}Am	5		20		
U natural (U)	Elemental U	0.03 μg/sample		20		
U natural (QUS)	Elemental U	0.5 μg/sample		4		
Sequential Analyses:						
Pu(α) iso., ^{90}Sr (IPS)	Same as for individual analyses above	Same as for individual analyses above		35		
Pu(α) iso., ^{241}Am (IPA)				25		
Pu(α) iso., U natural (IUPU)				25		
Actinide(α) iso. (ITPAC)(e)				25		
^{90}Sr, ^{144}Ce, ^{147}Pm (ISCP)				35		

(a) Minimum volume for valid samples of urine is 500 ml for kit code 1 (except for ^{99}Tc for which the maximum aliquot size is 200 ml) and 20 ml for all other sample types.
(b) Time allowed following determination of samples for receipt of written results by Internal Dosimetry.
(c) Report ^{243}Cm, ^{245}Cm, ^{246}Cm, and ^{248}Cm if the measured activity exceeds the contractual detection level.
(d) Report all radionuclides observed to be present at levels exceeding the appropriate contractual detection level (CL) in Table 6.5 and any other radionuclides determined to be present. If ordered by the Battelle Technical Administrator, report results for radionuclides listed in Table 6.5 specified with the order, regardless of measured level of activity.
(e) Pu(α) isotopic, ^{241}Am, and Cm(α) isotopic.
(f) Reporting levels: 0.01 dpm/sample for ^{238}Pu and $^{239+240}Pu$ and CL for all other listed constituents.

TABLE 6.2. Analytical and Reporting Requirements for Priority Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level(a) (dpa/sample) Urine	Fecal	Determination Time (business days following sample receipt)	Reporting Time: Oral	Reporting Time: Written(b)
Pu(α) iso. (IPU)	^{238}Pu, ^{239,240}Pu	0.02	0.2	8		
Cm(α) iso. (ICM)	^{242}Cm, ^{243,244}Cm, + Others(c)	0.02	0.6	8		
U(α) iso. (IU)	^{233}U, ^{234,235}U, ^{238}U	0.02	0.3	8		
Ra(α) iso. (IRA)	^{224}Ra, ^{226}Ra	0.3	1.5	8		
^{228}Ra (RA228)	^{228}Ra	0.3	1.5	8		
Th(α) iso. (ITH)	^{228}Th, ^{230}Th, ^{232}Th	0.1	1.5	8	By close of	
^{237}Np (NP237)	^{237}Np	0.02	1	8	business on	
^{241}Am (AM241)	^{241}Am	0.02	0.1	8	day of	
U natural (U)	Elemental U	0.03 μg/sample		8	determination	
U natural (QUS)	Elemental U	0.5 μg/sample		4		
Tritium (H3)	^{3}H	10 dpa/ml	--	3		Within 5
^{14}C (C14)	^{14}C	10 dpa/ml	200	3		business
Sr total (SR)	89+90Sr	2	10	7		days
^{90}Sr (SR90)	^{90}Sr	0.2	45,10	15(e)		
^{106}Ru (RU106)	^{106}Ru	10	25	8		
^{144}Ce (CE144)	^{144}Ce	25	25	8		
^{147}Pm (PM147)	^{147}Pm	4	220	8		
Eu iso. (IEU)	^{152}Eu, ^{154}Eu, ^{155}Eu	2	15	8		
^{210}Pb (PM210)	^{210}Pb	2	20	8		
^{241}Pu (PU241)	^{241}Pu	2	7	9		
Gamma spectroscopy (ISPEC)	^{40}K, ^{137}Cs, + Others(d)	See Table 6.5		3		
Gamma spectroscopy (LEPD)	^{241}Am	5	5	8		
^{99}Tc (TC99)	^{99}Tc	20	200	8		
Sequential Analyses:						
Pu(α) iso., Sr total (IPSR)				9	By close	Within 9
Pu(α) iso., ^{90}Sr (IPS)	Same as for individual	Same as for individual		9(f)	of business	business
Pu(α) iso., ^{241}Am (IPA)	analyses	analyses		9	on day of	days
Pu(α), iso., ^{241}Am, Sr tot (IPDA)				9(f)	determination	
^{90}Sr, ^{144}Ce, ^{147}Pm (ISCP)				9(g)		
Pu(α) iso., ^{241}Pu, ^{241}Am (IPUBA)				9(g)		
Pu(α) iso., U nat (IUPU)				9(h)		

(a) Minimum sample size is 20 ml for urine and 30 grams for feces. Maximum aliquot size for ^{99}Tc is 200 ml. The contractual detection level (CL) is stated in terms of disintegrations per minute per 50 grams for fecal samples in excess of 50 grams.
(b) Time allowed following determination of samples for receipt of written results by Internal Dosimetry.
(c) In addition, report ^{248}Cm, ^{245}Cm, ^{246}Cm, and ^{248}Cm if the measured activity exceeds the CL.
(d) Report all radionuclides observed to be present at levels exceeding the appropriate CL in Table 6.5 and any other radionuclides determined to be present. If ordered by the Battelle Technical Administrator, report results of radionuclides listed in Table 6.5 specified with the order, regardless of measured level of activity.
(e) Strontium-90 to be determined within 15 business days. Total strontium to be determined within 7 business days and reported orally upon determination.
(f) Strontium-90 to be determined within 16 business days. Total strontium to be determined within 9 business days and reported orally upon determination.
(g) ^{241}Pu to be determined within 16 business days.
(h) U natural to be determined within 12 business days.

TABLE 6.3. Analytical and Reporting Requirements for Expedite Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level(a) (dpm/sample) Urine	Fecal	Reporting Time Oral	Written(b)
Pu(α) iso. (IPU)	^{238}Pu, $^{239,240}Pu$	0.08	3		
Cm(α) iso. (ICM)	^{242}Cm, $^{243,244}Cm$, + Others(c)	1.2	70		
U(α) iso. (IU)	^{233}U, ^{234}U, ^{235}U, ^{238}U	.12	4		
Th(α) iso. (ITH)	^{228}Th, ^{230}Th, ^{232}Th	.08	1	By 9:00 a.m.	Within 6
Ra(α) iso. (IRA)	^{224}Ra, ^{226}Ra	0.9	3	on 2nd business	business
^{241}Am (AM241)	^{241}Am	0.08	6	day following	days
^{210}Po (PO210)	^{210}Po	0.1	10	sample receipt	
^{237}Np (NP237)	^{237}Np	0.12	3		
U natural (U)	Elemental U	0.5 μg/sample	5 μg/sample		
Tritium (H3)	^{3}H	100 dpm/ml	--		
^{14}C (C14)	^{14}C	20 dpm/ml	2000		
^{147}Pm (PM147)	^{147}Pm	6	2000		
^{210}Pb (PB210)	^{210}Pb	4	100		
Eu iso. (IEU)	^{152}Eu, ^{154}Eu, ^{155}Eu	6	180		
^{241}Pu (PU241)	^{241}Pu	3	70		
Sr total (SR)	$^{89,90}Sr$	10	150		
^{144}Ce (CE144)	^{144}Ce	10	50		
^{99}Tc (TC99)	^{99}Tc	30	2000		
Gamma spectroscopy (ISPEC)	^{40}K, ^{137}Cs, + Others(d)	--------See Table 6.5-------			
Gamma spectroscopy (LEPD)	^{241}Am	6	6		
Sequential Analyses:					
Pu(α) iso., ^{241}Am (IPA)					
Sr tot, ^{144}Ce, ^{147}Pm (ISCP)					
Pu(α) iso., Sr tot (IPSR)	----------As for individual analyses----------				
Pu(α) iso., Sr tot, ^{241}Pu (IPSA)	----------As for individual analyses----------				
Pu(α) iso., ^{241}Pu (IPUB)	----------As for individual analyses----------				
Pu(α) iso., ^{241}Pu, ^{241}Am (IPUBA)		(e)	(e)		
Pu(α) iso., U nat (IUPU)		(e)	(e)		

(a) Detection level in terms of disintegrations per minute per 300 ml for urine samples in excess of 300 ml. Detection limit is in terms of disintegrations per minute per 50 grams for feces samples in excess of 50 grams.
(b) Time allowed following oral report for delivery of written results to Internal Dosimetry.
(c) Report ^{243}Cm, ^{244}Cm, ^{245}Cm, and ^{248}Cm if their measured activity exceeds the contractual detection limit (CL).
(d) Report all radionuclides observed to be present at levels exceeding the appropriate CL listed in Table 6.5 and all other radionuclides observed. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table 6.5 specified in the processing instructions, regardless of the activity measured.
(e) Additional 2 business days for reporting ^{241}Pu results.

TABLE 6.4. Analytical and Reporting Requirements for Emergency Processing of Samples

Analysis (Code)	Constituents Reported	Contractual Detection Level[a] (dps/sample) Urine	Feces	Reporting Requirements (hours following sample receipt) Oral Urine/Feces	Written[b]
Pu(α) iso. (IPU)	^{238}Pu, ^{239}Pu, ^{240}Pu	0.5	9	5/8	
Cm(α) iso. (ICM)	^{242}Cm, ^{243}Cm, ^{244}Cm, + Others[c]	10	240	6/8	
U(α) iso. (IU)	^{233}U, ^{234}U, ^{235}U, ^{238}U	1	12	5/8	
Th(α) iso. (ITH)	^{228}Th, ^{230}Th, ^{232}Th	0.5	2	5/8	Within
Ra(α) iso. (IRA)	^{224}Ra, ^{226}Ra	2.0	10	6/8	24 hours
^{241}Am (AM241)	^{241}Am	1	20	5/8	and data
^{210}Po (PO210)	^{210}Po	0.8	340	4/8	circuit
^{237}Np (NP237)	^{237}Np	1	10	5/8	input
U natural (U)	Elemental U	7 μg/sample	8 μg/sample	1/8	within 5 business
Tritium (H3)	^{3}H	500 dps/ml	--	1/-	days
^{14}C (C14)	^{14}C	100 dps/ml	10,000	1/8	
^{147}Pm (PM147)	^{147}Pm	8	8,000	6/8	
^{210}Pb (PB210)	^{210}Pb	20	340	4/8	
Eu iso. (IEU)	^{152}Eu, ^{154}Eu, ^{155}Eu	140	600	3/8	
^{241}Pu (PU241)	^{241}Pu	20	450	4/8	
Sr total (SR)	$^{89,90}Sr$	90	450	4/8	
^{144}Ce (CE144)	^{144}Ce	75	145	3/3	
Gamma spectroscopy (ISPEC)	^{40}K, ^{137}Cs, + Others[d]	-------See Table 6.6------		3/3	
Gamma spectroscopy (LEPD)	^{241}Am	20	20	3/3	
^{99}Tc (TC99)	^{99}Tc	80	8,000	6/8	
Sequential Analyses:					
Pu(α) iso., ^{241}Am (IPA)				5/8	
Sr tot, ^{144}Ce, ^{147}Pm (ISCP)	----------As for individual analyses----------			5/8	
Pu(α) iso., Sr tot (IPSR)	----------As for individual analyses----------			5/8	
Pu(α) iso., Sr tot, ^{241}Pu (IPSA)	----------As for individual analyses----------			5/8	

(a) Detection level in terms of disintegrations per minute per 300 ml for urine samples in excess of 300 ml. Detection limit is in terms of disintegrations per minute per 50 grams for feces samples in excess of 50 grams.
(b) Time allowed following oral report for delivery of written results to Internal Dosimetry.
(c) Report ^{243}Cm, ^{244}Cm, ^{245}Cm, ^{246}Cm, and ^{248}Cm if their measured activity exceeds the contractual detection limit (CL).
(d) Report all radionuclides observed to be present at levels exceeding the appropriate CL listed in Table 6.5 and all other radionuclides observed. If ordered by the Battelle Technical Administrator, report results for radionuclides in Table 6.6 specified in the processing instructions, regardless of the activity measured.

TABLE 6.5. Contractual Detection Levels for Routine, Priority, and Expedite Processed Gamma Spectroscopy Analyses(a)

Isotope	CL for Urine (dpm/sample)	CL for Feces (dpm/sample)
^{60}Co	15	15
^{59}Fe	15	15
^{54}Mn	10	10
^{106}Ru	60	75
^{141}Ce	15	20
^{144}Ce	40	50
^{134}Cs	10	10
^{137}Cs	15	15
^{95}Zr	15	20
^{140}Ba	35	35
^{131}I	10	20
^{24}Na	15	15
^{22}Na	15	15
^{65}Zn	20	20
^{239}Np	25	30
^{241}Am	70	65

(a) The Lab shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and contractual detection levels (CLs) listed should be interpreted as minimum capability; the Lab shall detect and quantify all other gamma-emitters present at a nominal detection level of 20 dpm for each unspecified nuclide with gamma energy > 100 keV. Internal Dosimetry may relax the CLs for individual nuclides in mixtures if requested and justified by the Lab.

(b) The CLs are in units of dpm/l for samples $\geq$ 1 l.

TABLE 6.6. Contractual Detection Levels for Emergency Processing of Gamma Spectroscopy Analyses[a]

Isotope	CL for Urine (dpm/sample)	CL for Feces (dpm/sample)
^{60}Co	35	35
^{59}Fe	35	55
^{54}Mn	20	35
^{106}Ru	115	220
^{141}Ce	20	35
^{144}Ce	75	145
^{134}Cs	20	30
^{137}Cs	20	35
^{95}Zr	30	50
^{140}Ba	60	115
^{131}I	15	25
^{24}Na	25	25
^{22}Na	25	25
^{65}Zn	40	65
^{239}Np	40	70
^{241}Am	100	180

(a) The Lab shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and contractual detection levels (CLs) listed should be interpreted as minimum capability; the Lab shall detect and quantify other unspecified gamma-emitters present. Internal Dosimetry may relax the CLs for individual nuclides in mixtures if requested and justified by the Lab.
(b) The CLs are in units of dpm/100 ml for samples > 100 ml.

6.2.1 Whole Body Counts (contd)

count will be performed on the preview counter, which is a standup counter that uses five NaI detectors. If the preview counter indicates the presence of an occupationally related radionuclide or if there are interferences that limit the usefulness of NaI spectrometry, the sled counter is also used. The sled counter, which uses two germanium detectors, can better resolve and quantify radionuclides, especially in the presence of interfering radionuclides, such as radon progeny.

The whole body count produces results under two different assumptions for the distribution of the activity in the body: 1) evenly distributed throughout the body, and 2) in the lung only. Table 6.7 lists the detection capabilities for radionuclides routinely quantified by the preview counter for the two distribution assumptions. The sled counter provides sensitivity equal to or better than the preview counter for all listed radionuclides.

6.2.2 Chest Counts

Chest counting is also performed when there is concern about the presence in the lung of radionuclides that emit photons with energies of less than 200 keV. A chest count must be scheduled in advance with the Whole Body Counter (WBC) staff. When possible, annual chest counts are scheduled to coincide with a worker's whole body measurement and physical examination. There are two types of chest counts: a normal count (code C) and an extra-sensitive count (code C2). They differ only in the time of the count. Detection capabilities for chest counts are listed in Table 6.8 under "lung."

If activity is detected in a chest count, a measurement of chest wall thickness and a head count may also be needed to make appropriate corrections to the chest count data. These measurements may be performed on the same day or rescheduled for a later date.

6.2.3 Special Counts

Other counts performed by special request include liver counts (for low-energy photons), head counts (to determine skeletal content for low-energy photons), thyroid counts (for radioiodines), wound counts, and selected lymph node counts. These counts are normally performed as part of special investigations or as long-term follow-up of known depositions. These counts are arranged through Internal Dosimetry.

Table 6.8 lists the detection capabilities for radionuclides emitting low-energy photons, which are analyzed

TABLE 6.7. Accuracy and Sensitivity for Whole Body Counts in the Preview Counter[a]

$$MDA^{(b)} = \frac{4.65\sigma}{KT} + \frac{3}{KT}$$

Radionuclide	Gamma Ray Energy, MeV	Counting Time (sec)	Organ[c]	95% Confidence MDA Statistical Error (nCi)	1σ Precision[d] (%)	1σ Estimate Body Shape and Size Error (%)[e]
^{137}Cs-^{137}Ba	0.662 MeV	200	WB	3	5	±10
			L	2.4	5	±10
^{51}Cr	0.32 MeV	200	WB	22	5	±15
			L	18	5	±15
^{60}Co	1.17 and 1.33 MeV	200	WB	3	5	±10
			L	2.4	5	±10
^{131}I	0.36 MeV	200	WB	6	5	±15
			L	4.5(f)	5	±20
^{59}Fe	1.10 and 1.29 MeV	200	WB	6	5	±10
			L	4.5	5	±10
^{54}Mn	0.84 MeV	200	WB	3	5	±10
			L	2.4	5	±10
^{106}Ru-^{106}Rh	0.51 MeV	200	WB	12	5	±10
			L	9	5	±10
^{40}K	1.46 MeV	200	WB	15	5	±10
^{110}Ag	0.658 MeV	200	WB	3	5	±10
			L	2.4	5	±10
^{22}Na	1.28 MeV	200	WB	1.5	5	±10
^{24}Na	1.37 and 2.75 MeV	200	WB	0.7	5	±10
^{232}Th	Using ^{208}Tl 2.61 MeV	200	WB	2	5	±10
			L	1.5	5	±10
^{65}Zn	1.12 MeV	200	WB	4.5	5	±10
			L	3.4	5	±10
^{95}Zr-^{95}Nb	0.724 and 0.756	200	WB	3	5	±10
			L	2.4	5	±10
^{125}Sb	176 keV	200	WB	6	5	
			L	4.5	5	
^{154}Eu	1.274	200	WB	4.5(g)	5	±10
			L	3.4	5	±10
^{144}Ce-^{144}Pr	2.18	200	WB	100(g)	5	±10
			L	75	5	±10
^{140}La	1.596	200	WB	2	5	±10
			L	1.5	5	±10

(a) Reproduced from Palmer et al. (1987)
(b) See Equation 7.1 in the Whole Body Counting Manual (Palmer et al. 1987).
(c) WB = whole body; L = lung.
(d) Precision values are for cases where the count rate is high enough that the count rate error is insignificant compared with the precision error.
(e) Activity in the gastrointestinal tract can give counting rates that vary ±5%, depending on the location within the tract.
(f) Lower MDA can be obtained by other methods (see Table 7.3 in the Whole Body Counting Manual [Palmer et al. 1987]).
(g) Much lower MDA is obtained using six germanium planar detector systems (see Table 7.1 in the Whole Body Counting Manual [Palmer et al. 1987]).

TABLE 6.8. Accuracy and Sensitivity for In Vivo Measurements of Common Radionuclides Using Various Numbers of Germanium Planar Detectors(a)

Low-Energy Photon Emitters

$MDA^{(b)} = \frac{B\sigma}{KT}$

Radionuclide	Photon Energy	Time (sec)	Organ	Number of Detectors	95% Confidence MDA or Statistical Error (nCi)	1σ Precision(c) (%)	1σ Estimate of Body Shape and Size Error (%)
^{239}Pu	59.6-keV ^{241}Am tag	2000	Lung	6	1.6	10	20
	with 15:1, ^{239}Pu:	2000	Liver	3	1.4	7	20
	^{241}Am ratio(d)	3000	Bone	2	3.5	10	20
^{239}Pu	59.6-keV ^{241}Am tag	2000	Lung	6	0.6	10	20
	with 5:1, ^{239}Pu:	2000	Liver	3	0.5	7	20
	^{241}Am ratio	3000	Bone	2	1.2	10	20
^{239}Pu	17.0- and 20.4-keV	2000	Lung	6	50	20	40
	x rays from pure	2000	Liver	3	100	20	40
	^{239}Pu, 3 cm CWT(e)	3000	Bone	2	50	10	30
		600	Wound	1	0.06	10	20
^{238}Pu	17.0- and 20.4-keV	2000	Lung	6	20	20	40
	x rays from ^{238}Pu	2000	Liver	3	40	20	40
	3 cm CWT	3000	Bone	2	20	10	20
^{241}Am	59.5 keV	2000	Lung	6	0.12	10	20
		2000	Liver	3	0.10	7	20
		3000	Bone	2	0.36	10	15
		600	Wound	1	0.10	10	15
^{238}U	93 keV from ^{234}Th	2000	Lung	6	0.12 (3.5 mg)	10	20
^{235}U	183.7 keV	2000	Lung	6	0.08 (0.036 mg)	10	20
^{232}Th	239 keV from ^{212}Pb	2000	Lung	6	0.36	8	15
^{144}Ce	134 keV	2000	Lung	6	0.40	8	15
^{154}Eu	123 keV	2000	Lung	6	0.05	8	15
		3000	Bone	2	0.14	7	15
^{155}Eu	86.5 keV	2000	Lung	6	0.12	10	20
		3000	Bone	2	0.24	7	20
^{210}Pb	46.5 keV	2000	Bone	3	2.0	8	15
^{125}I	27 keV	2000	Thyroid	2	0.0025	10	15

(a) Reproduced from Palmer et al. (1987).
(b) See Equation 7.2 in Palmer et al. (1987).
(c) Precision values are for cases where the count rate is high enough that the counting rate error is insignificant compared with the precision error.
(d) This assumed ratio does not mean that this is a commonly found ratio nor does it mean that the ratio of ^{239}Pu to ^{241}Am remains constant as it transfers from lung or wound to liver and bone.
(e) CWT = chest wall thickness.

6.2.3 Special Counts (contd)

using germanium detectors, assuming normal count times. Slightly lower MDAs can be achieved if longer count times can be arranged.

6.3 SCHEDULING AND RECORD KEEPING

This section discusses scheduling of bioassay measurements, reporting of routine results to Field Dosimetry, and record keeping. Follow-up of detected activity is discussed in Section 6.4. Assessment of confirmed intakes is covered in Chapter 3.0, and response to incidents is covered in Chapter 7.0.

6.3.1 Contacting the Worker

All contacts with the worker concerning the scheduling and results of bioassay measurements are conducted by Field Dosimetry. (During a response to an incident, both Field Dosimetry and Internal Dosimetry usually work directly with the worker.) Internal Dosimetry also consults with a worker at other times at the request of Field Dosimetry.

6.3.2 Scheduling Indirect Bioassay Measurements

Summary

The PNL O&EP Section coordinates all bioassay measurement requests to the Lab, either through Internal Dosimetry or through Radiological Records using the ORE database.

The details of scheduling depend on the reason the sample is needed. Currently used sample reason codes are described in Table 6.9, and scheduling details categorized by reason type are discussed below. Table B.3 in Appendix B provides explanations of both current and historical sample reason codes.

Beginning Work, Ending Work, New Hire, Termination

To schedule a worker for a beginning or ending work, new hire, or termination sample, Field Dosimetry must complete two steps:

1. Field Dosimetry submits an Employee and Dosimetry Changes form (Exhibit 6.1) to Radiological Records to delete the old routine schedule (if there is one) and to establish the new routine schedule. This information is entered into the ORE database, and the form is kept in the worker's ORE file. (An Employee and Dosimetry Changes form is not needed for beginning and ending work samples for planned offsite exposures.)

TABLE 6.9. Reason Codes for Indirect Bioassay Measurement

Reason for Measurement	Code	Description of Reason
Routine	R	Sample is collected on a predetermined periodic schedule for routine surveillance. Routine processing time is normally used.
New hire	H	Sample is collected before worker begins employment or enters a radiation zone. Either routine or priority processing time is used.
Beginning work	B	Sample is collected before a worker begins a specific type of radiation zone work or before an offsite trip where potential internal exposure could occur. Routine processing time is normally used.
Ending work	E	Sample is collected after a worker completes a specific type of radiation zone work or after return from a trip where potential offsite internal exposure could have occurred. Routine processing time is normally used.
Contractor request	F	Sample is requested by Field Dosimetry for reasons other than an indication of a potential occupational exposure.
Incident	I	Sample is requested after a potential occupational internal exposure.
Exposure evaluator (EE) request	X	Sample is requested by an EE for special purposes not covered by other reason codes.
Termination	T	Sample is collected when a worker terminates employment. No entry into radiation zones should occur after sample is collected. Priority processing time is normally used.
Recount	C	Original measurement is recounted to confirm the detected activity.
Investigate high routine	V	Sample is collected after the report of an unexpectedly high result. Usually priority or expedite processing time is used.
Follow-up	U	Sample is collected for long-term follow-up after an evaluation. Usually routine processing time is used.
Research/Quality Control	Q	Sample is collected for research or quality control.
Visitor	Z	Sample is collected from a visitor to Hanford.

6.3.2 Scheduling Indirect Bioassay Measurements (contd)

Beginning Work, Ending Work, New Hire, Termination (contd)

2. The sample request is either called in by Field Dosimetry to the Internal Dosimetry clerk or sent in on a Field Dosimetry Bioassay Request Sheet form (see Exhibit 6.2).

Routine

The Employee and Dosimetry Changes form (Exhibit 6.1) initiates the request for a routine bioassay measurement schedule. It should be completed and sent to Radiological Records at the time the new hire or beginning work sample request is made. Information from the form is put on the ORE database and sent to Field Dosimetry for review about 1 month before the scheduled sample time. The reviewed list is then sent to the Lab I week before the scheduled sample month, and this pattern is repeated routinely until another Employee and Dosimetry Changes form is received.

If the routine sample is not collected for some reason, or is of insufficient volume, or is "lost in lab," the Lab notifies Field Dosimetry directly. Field Dosimetry reschedules the sample request through the Internal Dosimetry clerk, either by telephone or by using the Field Dosimetry Bioassay Request Sheet form (Exhibit 6.2). Internal Dosimetry has the request information entered into the ORE database.

Contractor Request

Contractor-requested measurements are made by Field Dosimetry to the exposure evaluator (EE), usually by telephone.

Incident, Exposure Evaluator (EE) *Request, Investigate High Routine, Follow-Up*

Incident measurement requests, EE-requested measurements, requests for investigation of high routine measurements, and follow-up measurements are requested by an EE after consultation with Field Dosimetry. During incident response, the EE often gives sample kits directly to the worker. Incident codes and investigate-high-routine codes are used while data are being collected for an assessment. After a preliminary or final assessment has been made, samples collected for further surveillance of the intake are referred to as follow-up samples.

6.3.3 Reporting Results from Indirect Measurements

Valid Results

A result from a routinely processed sample is verbally reported to Internal Dosimetry if it exceeds the reporting level. For most indirect analyses, the reporting level is equal to the contractual detection level (CL). The reporting level for plutonium in urine is 0.01 dpm per sample. Reporting requirements for indirect bioassay measurements are listed in Tables 6.1 through 6.4 under "Reporting Time--Oral." A result from a priority-,

6.3.3 Reporting Results from Indirect Measurements (contd)

Valid Results (contd)

expedite-, or emergency-processed sample is reported verbally regardless of the level of the result. All sample results are transferred electronically from the Lab to the ORE database at least once a week.

Invalid or No Results

There are a number of reasons why a sample may not be obtained or a result not be provided. When such circumstances occur, the Lab notifies Field Dosimetry or Internal Dosimetry to take appropriate follow-up action. These circumstances and appropriate actions are discussed below.

Lost in Lab (LL)

An LL indicates that a valid sample was provided by the worker; however, due to analytical problems, a valid analytical result could not be obtained. Examples of these problems include spillage, cross-contamination, analytical procedure errors, inadequate yield, or out-of-specification quality control samples. For LL results, the Lab verbally notifies Internal Dosimetry and writes a nonconforming data report that is placed in the worker's ORE file. Generally, a worker whose result is lost in the Lab should be rescheduled for the lost analysis.

Insufficient Volume Sample (IS)

If a urine sample does not meet the minimum volume requirement specified for the sample type (see Tables 6.1 through 6.4), then the sample is not analyzed and IS is noted in the ORE database results column. A worker who provides an insufficient volume sample should be contacted to ensure that the sample kit instructions will be followed, and then the sample and analysis should be rescheduled.

Lost Kit (LC)

If the Lab delivered a sample kit, but was unsuccessful in retrieving the kit, then one of three codes may be assigned to the ORE database results field. The LC means that the Lab was unable to obtain a sample for analysis.

Can-not-out (CNO)

If the kit was not out at the time of the scheduled pickup, a CNO is assigned. The Lab will advise Field Dosimetry of the attempted pickup and will make one more attempt to pick it up. Samples not retrieved within 5 days of the scheduled pickup are assigned a "lost kit" designation and should be rescheduled.

No Sample (NS)

The NS means that a sample kit was delivered to the designated residence; however, it was not used and remained outside at the residence on the scheduled pickup date. The Lab notifies Field Dosimetry or Internal Dosimetry of no samples. The worker should be contacted before rescheduling pickup.

6.3.4 Scheduling In Vivo Bioassay Measurements

Summary

All in vivo bioassay measurement requests are arranged by the O&EP Section, either by Internal Dosimetry or by the WBC staff.

The details of scheduling depend on the reason the measurement is needed. Currently used measurement reason codes are discussed in Table 6.10 and scheduling details, categorized by reason type, are discussed below. Appendix B, Table B.9 provides explanations for both current and historical measurement reason codes.

Beginning Work, Ending Work, New Hire, Termination

To schedule a worker for a beginning work, ending work, new hire, or termination in vivo measurement, Field Dosimetry follows a two-step scheduling process similar to the scheduling of indirect bioassay samples:

1. Field Dosimetry submits an Employee and Oosimetry Changes form (Exhibit 6.1) to Radiological Records to delete the old routine schedule (if there is one) and to establish the new routine. This information is entered into the ORE database, and the form is kept in the worker's permanent file. (An Employee and Dosimetry Changes form is not needed for beginning and ending work samples for planned, offsite exposures.)

2. Field Dosimetry schedules the measurement directly with the WBC staff.

Routine

The Employee and Dosimetry Changes form (Exhibit 6.1) initiates the request to put a worker on a routine in vivo measurement at the time of the new hire or beginning work measurement. This information is entered into the ORE database and is used by the WBC staff and Field Oosimetry as needed.

Routine Whole Body Count

For a whole body measurement no other scheduling is necessary. Field Oosimetry is responsible for having the worker show up at the 747-A Building on the scheduled day. When possible, a routine whole body measurement is coordinated with the annual medical physical examination. Boeing Computer Services-Richland (BCSR) maintains the schedules for annual physical examinations for Hanford workers. Once a month, the Hanford Environmental Health Foundation (HEHF) has BCSR send a schedule to Field Dosimetry, identifying which workers are due for their physical examinations. Field Dosimetry arranges the date of the physical exam and whole body count with the worker and enters the date on the Hanford Medical Scheduling (HMS) database. That information is also transferred to the ORE database, from which the WBC staff print out the list, as needed.

TABLE 6.10. Reason Codes For In Vivo Bioassay Counting

Reason for Measurement	Code	Description of Reason
Routine	1	Measurement is performed on a predetermined, periodic schedule for routine surveillance.
New hire	2	Measurement is performed before worker begins employment or enters a radiation zone.
Termination	3	Measurement is performed when a worker terminates employment. No entry into radiation zones should occur after measurement is performed.
Unusual exposure (incident)	4	Measurement is requested after an incident of potential occupational internal exposure.
Evaluator exposure (EE) request	5	Measurement is requested by an EE for special purposes not covered by other reason codes.
Contractor request	6	Measurement is requested by Field Dosimetry for reasons other than an indication of potential occupational internal exposure.
Recount	7	Count is performed to verify an original measurements.
Follow-up	8	Measurement is performed 1) as a follow-up to any unexpected activity, or 2) for a long-term follow-up to an incident.
Beginning work	9	Measurement is performed before a worker begins a specific type of radiation zone work or before a trip offsite where potential internal exposure could occur.
Ending work	10	Measurement is performed after a worker completes a specific type of radiation zone work or after the worker returns from a trip where potential off-site internal exposure could have occurred.
Visitor	11	Measurement is performed on a visitor to Hanford.
Contract work	12	Measurement is performed by special contract work to the PNL WBC Facility.
Research project	13	Measurement is performed specifically for a research project.
Investigate high routine	16	Measurement is performed after the report of an unexpectedly high result.

6.3.4 Scheduling In Vivo Bioassay Measurements (contd)

Routine Chest Count — If a routine chest measurement is needed, Field Dosimetry schedules the measurement by telephoning the WBC staff.

Incident — Field Dosimetry notifies Internal Dosimetry of any incident involving possible internal exposures. Bioassay measurements needed because of the incident are arranged by Internal Dosimetry with the concurrence of Field Dosimetry (details are provided in Chapter 7.0). All incident-related measurements taken prior to issuing a dose assessment are also called incident measurements and are arranged through Internal Dosimetry.

Investigate High Routine — Either Internal Dosimetry or the WBC staff arrange for the investigate-high-routine measurement(s) after consultation with Field Dosimetry. All measurements taken to investigate the high routine result are so coded until a preliminary or final assessment is issued.

Contractor Request — Field Dosimetry initiates contractor requests through Internal Dosimetry. Internal Dosimetry provides advice on the types of measurements needed and arranges the counts with the WBC staff.

Follow-up — Internal Dosimetry may recommend a specialized long-term follow-up schedule as a result of a worker's intake. Field Dosimetry can have the schedule placed on the ORE database using an Employee and Dosimetry Changes form and make arrangements with the WBC staff in the same manner as for routine measurements. Also, Internal Dosimetry reviews the monthly list of workers scheduled for in vivo measurements and may issue a request for follow-up measurements to Field Dosimetry at that time.

Exposure Evaluator (EE) — Internal Dosimetry consults with Field Dosimetry concerning EE-requested measurements.

Visitor — Field Dosimetry schedules visitor counts by directly contacting the WBC staff by telephone. Internal Dosimetry assists if so requested.

6.3.5 Reporting Results of In Vivo Measurements

Valid Results — An in vivo measurement result is verbally reported to Internal Dosimetry if it exceeds the reporting level. The reporting levels for routinely scheduled in vivo measurements have been set equal to the screening levels of Appendix A. In addition, results from incident, evaluator-requested, and contractor-requested measurements are reported verbally to Internal Dosimetry, regardless of the level of the results. Internal Dosimetry, in turn, relays the results to Field Dosimetry with

6.3.5 Reporting Results of In Vivo Measurements (contd)

recommendations for follow-up, if necessary. All results are officially transmitted weekly to the ORE database.

No Results

Invalid results or no results may be obtained for an in vivo measurement for a variety of reasons, such as radon daughter interference, equipment problems, or interference from medically administered radioactivity. A comprehensive list of no-result codes is given in Appendix B, Table B.16.

6.3.6 Reporting "No Shows"

The fact that a worker does not show up for an in vivo measurement is noted in the "no show" file of the ORE database. It is the responsibility of Field Dosimetry to notify the worker. The worker can make up a whole body measurement on another day without scheduling an appointment; however, Field Dosimetry must reschedule a chest count or special count with the WBC staff.

6.4 FOLLOW-UP MEASUREMENTS AND REPORTS

Follow-up measurements and their associated documentation are handled as described in the following subsections.

6.4.1 Indirect Bioassay Measurements

The need for follow-up indirect bioassay measurements depends on the initial measurement result and its relationship to the screening levels of Appendix A.

< Screening Level

If the indirect bioassay measurement result is below the screening levels of Appendix A, no follow-up is performed by Internal Dosimetry and a computer-generated letter is sent to Field Dosimetry (see Exhibit 6.3).

≥ Screening Level

If the result is above the screening levels of Appendix A, different actions are taken, depending on the reason for the sample, according to the practices discussed in Chapter 2.0. If the reason code is for a new hire, beginning work, incident, or contractor-requested measurement, any result above the reporting level is investigated. If the reason code is for a routine, ending work, or termination measurement, then the result is compared with 1) the expected result because of prior assessed intakes, if applicable, and 2) a level that would possibly indicate an intake resulting in an annual effective dose equivalent greater than 10 mrem (see Appendix A, Table A.1). If the result is greater than expected or implies that an intake greater than the 10-mrem dose criterion has occurred, then the result is

6.4.1 Indirect Bioassay Measurements (contd)

investigated. Otherwise, the letter shown in Exhibit 6.3 is sent to Field Dosimetry and no follow-up is performed by Internal Dosimetry.

QUS

An exception to the above practice exists for results from individuals working with soluble uranium, where the principal hazard is chemical toxicity. The analysis code for these samples is QUS, and two action levels exist for QUS results: 1) a screening level, and 2) a follow-up level (see Appendix A, Table A.2). If a screening level is exceeded, Field Dosimetry is notified but no other action is taken by Internal Dosimetry. If a follow-up level is exceeded, the result is investigated.

Recounts

If a routine- or priority-processed plutonium urinalysis result is at or above 0.01 dpm but less than 0.02 dpm, generally the first step in an investigation is to order two recounts of the sample. This step reduces random false positive results that ensue from counting statistics alone. If both recounts are less than 0.01 dpm, then the letter shown in Exhibit 6.3 is sent to Field Dosimetry. If the recount is also at or above 0.01 dpm, then Field Dosimetry is notified, a formal assessment is performed, and eventually a letter summarizing the results of the assessment is sent to Field Dosimetry. Details about the assessment of internal dose are discussed in Chapter 3.0.

Recounts may be ordered under other circumstances at the discretion of the EE.

6.4.2 In Vivo Measurements

The need for follow-up in vivo measurements depends on the measurement result and its relation to the screening levels listed in Appendix A. For in vivo measurements, the reporting levels are equal to the screening levels.

Preliminary Report

The worker receives a preliminary report on the results of in vivo measurements at the end of each visit to the WBC Facility (see Exhibit 6.4). The preliminary report places the results of the measurements into one of three categories: 1) less than the screening level, 2) not immediately available, e.g., final calculations by computer are delayed or calculation/evaluation by hand is required, and 3) equal to or exceeding the screening level.

6.4.2 In Vivo Measurements (contd)

Final Report < Screening Level

When a result is finalized, and if the result is below the screening level and is not associated with an incident, no follow-up is performed by Internal Dosimetry. If the information in the preliminary report needs no change, then no further correspondence is necessary. If the final result differs from the preliminary report, then the letter shown in Exhibit 6.5 is sent to Field Dosimetry.

Final Report ≥ Screening Level

If the result is above the screening level, different actions are taken depending on the reason for the measurement, according to the practices discussed in Chapter 2.0. If the reason code is for a new hire, beginning work, or contractor-requested measurement, any result above the screening level is investigated. If the reason code is for a routine, ending work, or termination measurement, the result is compared with 1) the expected result because of prior assessed intakes, if applicable, and 2) a level that would possibly indicate an intake resulting in an annual effective dose equivalent greater than 10 mrem (see Appendix A, Table A.1). If the result is greater than expected or implies that an intake greater than the 10-mrem dose criterion has occurred, then the result is investigated. Otherwise, the letter shown in Exhibit 6.5 is sent to Field Dosimetry and no follow-up is performed by Internal Dosimetry.

6.5 OCCUPATIONAL RADIATION EXPOSURE DATABASE

The results of all bioassay measurements are permanently retained in the ORE database. Field Dosimetry, Internal Dosimetry, WBC, and Lab staff all have access to only those parts of the ORE database that are essential to their task responsibilities. Examples of the actual computer screen data and code descriptions of some files available in the ORE database are given in Appendix B.

Exhibit 6.1

Employee and Dosimetry Changes Form

Employer	Date	RADIATION PROTECTION RECORDS EMPLOYEE AND DOSIMETRY CHANGES

Name (Last) (First) (Middle Initial)	Social Security No.	Payroll Or Ident. No.	Org. Code

☐ Change Work Address To: _____ (Building) _____ (Area)

☐ Change Of Suffix From: _____ To _____ Effective Date _____

☐ Change Home Address To: _____ (See Instructions)
Street City State Zip Code

☐ Change Name From: _____
Last Name First Middle Initial

☐ Change Employee Status:
☐ End of Employment Effective Date _____
☐ Deceased Effective Date _____

EXTERNAL DOSIMETRY REQUIREMENT Effective Date Of Change _____

☐ Assign Basic TL Dosimeter (Annual)		
☐ Assign Multi-Purpose TL Dosimeter	☐ Monthly Exchange	☐ Quarterly Exchange
☐ No Dosimeter Required		
☐ Change From Basic TLD To Multi-Purpose TLD	☐ Monthly Exchange	☐ Quarterly Exchange
☐ Change From Multi-Purpose TLD To Basic TLD (Annual)		
☐ Change Multi-Purpose Frequency To	☐ Monthly Exchange	☐ Quarterly Exchange
☐ Discontinue Dosimeter Issue		

INTERNAL DOSIMETRY REQUIREMENTS

Bioassay:	☐ Radionuclide _____	☐ Radionuclide _____	☐ Radionuclide _____
	____ ☐ Monthly	____ ☐ Monthly	____ ☐ Monthly
	____ ☐ Quarterly	____ ☐ Quarterly	____ ☐ Quarterly
	____ ☐ Semi-Annually	____ ☐ Semi-Annually	____ ☐ Semi-Annually
	____ ☐ Bi-Annually	____ ☐ Bi-Annually	____ ☐ Bi-Annually
	____ ☐ Annually	____ ☐ Annually	____ ☐ Annually
	____ ☐ 5 Year	____ ☐ 5 Year	____ ☐ 5 Year
	____ ☐ Other Freq.	____ ☐ Other Freq.	____ ☐ Other Freq.
	____ ☐ Discontinue Bioassay	____ ☐ Discontinue Bioassay	____ ☐ Discontinue Bioassay

In-Vivo: ☐ Routine In-vivo Counting Required (See Reverse for List) Type(s): _____ Frequency _____
☐ Discontinue In-vivo: _____
_____ Concurrence—Rad. Protection

Remarks

_____ (Supervisor's Signature) _____ (Title) _____ (Phone Number)

INSTRUCTIONS:
1. If employee being scheduled for bioassay sampling has P.O. Box or RFD address, attach map or sketch, showing location of home, to this form to aid in delivering sample equipment.
2. Contact your radiation protection organization to determine internal and external dosimetry requirements.
3. Send all copies of this form to contractor radiation protection organization.

DISTRIBUTION: White —Personnel Dosimetry Services, PNL
Yellow —Contractor Radiation Protection Organization
Pink —Originator

54-3000-485 (A-1-82)

Exhibit 6.2

Field Dosimetry Bioassay Request Form

BIOASSAY REQUEST SHEET

Name	PR#	*R	+N	Address	City	**SS &	Sample Date

FROM _____

COMPANY_____

DATE_____

* R ROUTINE
H NEW HIRE
B BEGINNING WORK
E ENDING WORK
T TERMINATION

** FOR NEW HIRES ONLY

+ NUCLIDE

Exhibit 6.3

Sample Form - Bioassay Urine Sample Results

STRICTLY PRIVATE

(Addressed to individual worker)

BIOASSAY URINE SAMPLE RESULTS

Analysis of your recent bioassay urine sample submitted by you on (date) is normal and indicates no unusual intake of radioactive material.

Bioassay urinalyses are just one of several monitoring techniques used at Hanford to determine if an intake of radioactive material has occurred in excess of the dose limits established by the Department of Energy and the Hanford Internal Dosimetry Program.

The details of this bioassay sample analysis are included with all your personal radiation dosimetry records and are available for your inspection upon request. If you wish to review these, or other records in your file, please contact (Field Dosimetry Representative) Telephone no - to arrange for an appointment.

Exhibit 6.4

Sample Letter - Preliminary Analysis of In Vivo Examination

NAME_____ PAYROLL_____ DATE_____

Preliminary analysis of your in vivo examinations(s) indicates:

__ Your in vivo measurements are completed, and the results do not exceed the criteria for follow-up.

__ Analysis of the examination data is not immediately available. The results of this examination will be provided to your company's radiation protection organization when available.

__ Your measurement exceeded a screening level.* A further review of the examination will be performed and your radiation protection organization will be notified of the results. Follow-up measurements may be required.

* The screening level is used to determine if there is a need for further evaluation of possible internal radioactivity.

Please note: This report is based on a preliminary evaluation of your measurement by computer and is subject to change based upon additional review. If there is a change from the above-reported results, Internal Dosimetry will notify your company's radiation protection organization.

If you have any questions concerning your in vivo examination, please contact the following representative of your company's radiation protection organization:

Company Name Phone

Exhibit 6.5

Sample Letter - In Vivo Measurements Results

STRICTLY PRIVATE

DATE PR#

NAME ORG CODE

WHOLE BODY COUNTER EXAMINATION REPORT

Analysis of your recent in vivo examination on _____ has been completed. Results do not exceed the criteria for follow-up measurements. The results of this examination do not change previous assessments of internal dose or current bioassay measurement schedules.

Records of this and your other bioassay examinations are maintained in your personal exposure history file. Contact your company's radiation protection or radiation dosimetry office on _____ if you have any questions regarding your occupational radiation exposure status.

This statement was prepared by Hanford Internal Dosimetry.

CHAPTER 7.0

INTERNAL EXPOSURE INCIDENT RESPONSE

7.0 INTERNAL EXPOSURE INCIDENT RESPONSE

This chapter provides guidance for recommended dosimetry response to potential internal exposure incidents. The roles of contractor, Internal Dosimetry (the EE), and other support groups in obtaining dosimetry data and in performing early assessments of internal exposure are addressed. In addition, some of the EE tasks described are performed under the auspices of the IDP but are not directly related to internal dosimetry.

For the purposes of this chapter, an internal exposure incident is defined as any circumstance involving loss of containment or administrative control that may result in a worker incurring an intake requiring an internal dose assessment. Section 2.1.1 requires that a dose assessment be performed for any potential occupational internal exposure.

7.1 INCIDENT RESPONSE OBJECTIVES OF THE HANFORD INTERNAL DOSIMETRY PROGRAM

In responding to an internal exposure incident, the IDP's principal objective is to perform initial and follow-up assessments of the seriousness of the exposure. Such assessments support the contractors' reporting and investigating requirements, and address the medical considerations regarding the effectiveness of dose-reduction therapy. In addition to the role in responding to internal exposure incidents, the IDP EE provides notification services for other types of incidents at Hanford.

7.2 INCIDENT RESPONSE SERVICES PROVIDED BY THE HANFORD INTERNAL DOSIMETRY PROGRAM

The IDP provides incident response by means of its EE function. The EE is a sitewide 24-hr/day contact for dosimetry and notification assistance.

The following internal exposure assessment services are available through the EE:

- consultation regarding the need for and priority of special bioassay measurements
- arrangements for bioassay measurements and samples
- identification of supplemental measurements and samples to aid in the performance of internal exposure evaluations (e.g., measurement of air filters, smears, etc.)

7.2 INCIDENT RESPONSE SERVICES PROVIDED BY THE HANFORD INTERNAL DOSIMETRY PROGRAM (contd)

- arrangement with PNL Radiation Protection for Radiation Protection Technologist (RPT) support for the WBC Facility and Emergency Decontamination Facility (EDF)
- initial assessment of the potential severity of intakes based on early data
- discussion with workers about the results of specific measurements (done in conjunction with Field Dosimetry)
- arrangement for appropriate follow-up bioassay measurements.

The following services, not related to internal dosimetry, are also available through the EE:

- dosimetry assistance for unusual external exposure situations
- activation of the Unified Dose Assessment Center (UDAC)
- activation of PNL Hanford environmental monitoring teams
- activation of the DOE Region 8 Radiological Assistance Team
- request for assistance from PNL Radiation Protection for monitoring potentially contaminated Hanford patients who report to Kadlec Medical Center, HEHF first aid stations, the EDF, or the WBC Facility.

7.3 DETERMINATION OF THE NEED FOR INTERNAL DOSIMETRY SUPPORT

Internal Dosimetry should be contacted whenever an intake of radioactivity is suspected, or when the dosimetric significance of an observation or event is in doubt.

The following are examples of circumstances that could warrant contacting Internal Dosimetry:

- suspected intake of radioactive material with the potential for an annual effective dose equivalent of 100 mrem
- extended or extensive personal skin contamination

7.3 DETERMINATION OF THE NEED FOR INTERNAL DOSIMETRY SUPPORT (contd)

- loss of containment or exposure control, such as failure of a ventilation system or respiratory protection, resulting in exposure to high concentrations of radioactivity in the air
- spread of contamination that results in levels of radionuclides at or exceeding levels given in Table 7.1.
- unplanned releases of radioactive material to the environment

Recommendations are provided below for two levels of Internal Dosimetry support for potential internal exposure situations.

It is also recommended that Internal Dosimetry be included on distribution for radiation occurrence reports.

Notify HEHF

Internal Dosimetry recommends that HEHF Occupational Medicine be promptly alerted to potential internal exposures when the criteria of Table 7.2 are exceeded. The primary purpose of this notification is to alert HEHF to the possibility that dose reduction therapy may be warranted. At the request of the contractor, the EE makes this notification.

7.3.1 Notifications for Prompt Internal Exposure Evaluation and Dose Reduction Therapy

Notify Exposure Evaluator (EE)

The EE should be notified immediately when prompt actions may be required to evaluate internal exposure. The criteria recommended for immediate notification and request for EE support are shown in Table 7.1. These criteria are based primarily on Hanford experience, and may be taken as conservative indicators that annual effective dose equivalents may exceed 10 to 100 mrem.

The EE should be notified the same day that intakes or potential intakes occur or are identified to assure that adequate provision is made to obtain bioassay measurements for dose assessment.

When the criteria of Table 7.1 are not met, it is unlikely that therapeutic actions would be taken based on early bioassay measurements. Bioassay measurements are still needed for dose assessment purposes. In some cases

TABLE 7.1. Contamination Levels for Internal Dosimetry Notification, dpm

Indicator	Alpha Emitters	^{90}Sr	Mixed Fission or Activation Products
Nasal or mouth smears	50	1,000	5,000
Facial contamination			
Spotty, loose	500	10,000	50,000
General, loose	200	4,000	20,000
Skin breaks	Any skin breaks while handling alpha-emitters	Any detectable activity around a skin break; or undetectable activity but with potential for intake based on other information (e.g., blood smear).	
Head, neck contamination			
Spotty, loose	5,000	100,000	250,000
General, loose	2,000	40,000	100,000
Contamination inside respirator	Oetectable activity inside respirator after use.		
Hands, forearms, clothing(a)			
Spotty, loose	10,000	200,000	500,000
General, loose	5,000	100,000	250,000
Airborne contamination	Acute exposure equivalent to 40 OAC-hours after incorporating respiratory protection factor.(b)		

(a) Clothing contamination levels apply to exposure without respiratory protection, such as contamination levels on inner coveralls while undressing.
(b) DAC-hours = time-integrated exposure to airborne contamination.

TABLE 7.2. Contamination Levels for Notification of the Hanford Environmental Health Foundation, dpm

Indicator	Alpha Emitters	^{90}Sr	Mixed Fission or Activation Products
Nasal or mouth smears	>5,000	>100,000	--
Facial contamination	>25,000	>500,000	--
Skin breaks	>1,000	>20,000	--

7.3.1 Notifications for Prompt Internal Exposure Evaluation and Dose Reduction Therapy (contd)

Notify Exposure Evaluater (EE) (contd)

the measurements may not need to be immediate (i.e., same day), and may be scheduled on a priority basis a few days after the potential intake. Under these circumstances, the EE may suggest a delayed measurement protocol in consideration of convenience and cost.

7.3.2 Information to Provide When Notifying the Exposure Evaluator

Exhibit 7.1 provides a summary check list of information that may be useful to the EE for dosimetry evaluation purposes. The EE Office maintains a telephone log for each separate incident notification, using a form similar to the one shown in Exhibit 7.2.

7.4 CONTACTING THE EXPOSURE EVALUATOR

Contacting the on-call EE may be done using several methods described in the following subsections. During normal working hours, it should be possible to contact the EE within a few minutes by one phone call. After-hours procedures have been established with the intent that the maximum response time for obtaining EE support should not exceed 40 minutes.

7.4.1 Preferred Method

Call 376-2222

The preferred method of contacting the EE is to call the EE Office phone number (376-2222). During working hours, the Internal Dosimetry clerk usually answers the phone. After working hours, the phone is forwarded to the on-call EE's residence. If no answer is obtained, wait 5 minutes and try again. Make at least two attempts, waiting at least 5 minutes between each call. If contact cannot be made by this method, use one of the alternate methods described below.

7.4.2 Alternate Methods

Patrol Operations Center or PNL-Single Point Contact

Call one of the following and ask them to contact the EE:

Patrol Operations Center: 373-3800
PNL Single Point Contact: 375-2400

Both the Hanford Patrol Operations Center (POC) and the PNL Single Point Contact have emergency procedures for contacting the EE, including radio pager, two-way radio, and alternate contacts.

7.4.2 Alternate Methods (contd)

Radio Pager 85-618 — The on-call EE carries a pager that can be activated from a Hanford Site telephone (prefix 373, 376) by calling 85-618. This method is particularly useful after hours if the EE is not at home to answer 376-2222. Pager messages should be simple, brief, and to the point; for example, "Exposure Evaluator, call John Jones at 6-6543." Messages should be repeated. Expect some delay in response in order to allow the EE to reach a telephone. If no response is received within 15 minutes, contact the Hanford Patrol or the PNL Single Point Contact and request an alternate EE.

Two-Way Portable Radio (P-66) — The two-way portable radio can be used at the discretion of the EE to contact the POC, primarily if the EE plans to be away from a phone. The EE would be advised of the need to contact the POC by the radio pager (85-618) and could respond by radio to the POC. Under most circumstances, however, this is not a reliable way to contact the EE; it is simply a convenience for EE-to-POC communications.

7.5 EXPOSURE EVALUATOR RESPONSE TO INCIDENTS

This section briefly describes the general EE response to an internal exposure incident.

7.5.1 Receiving Incident Notification

Upon notification of an incident, the EE initiates an incident telephone log (similar to Exhibit 7.2). Based on the information provided by the contractor and the specifically requested services, the EE makes appropriate emergency notifications, arranges for appropriate bioassay measurements, and identifies additional information that might assist in assessing the significance of the exposure.

The EE Office does not normally report incidents to DOE or HEHF. The decision to report to DOE or HEHF is the responsibility of the contractor, unless other arrangements have been made with the EE Office. However, if the probability of exposure is considered serious enough to warrant therapy, HEHF may be informally advised by the EE Office.

The previous statements should not be construed as restricting the EE Office in any way from responding to requests from DOE or HEHF regarding the dosimetry associated with an incident.

7.5.1 Receiving Incident Notification (contd)

The initial priority of the EE is to obtain the identification of the workers and the circumstances surrounding the exposure, determine the appropriate type of bioassay measurements, arrange for the measurements, and make a preliminary assessment of the potential effectiveness of therapeutic measures.

7.5.2 Scheduling and Performing Bioassay Measurements

A variety of bioassay measurements may be requested. Some of the typical reasons for requesting certain bioassay measurements are described in Table 7.3.

The EE arranges to obtain suitable bioassay measurements. The EE establishes priorities for measurement types and, if necessary, for individuals needing measurements.

In addition to direct in vivo counts that can be performed within a few hours of the incident, rapid processing of excreta samples can provide an analytical result within a few hours of sample delivery to the Lab. With rapid sample processing, analytical sensitivity is sacrificed for quick turn-around time. The purpose of rapid processing is to obtain immediate results to assess the potential need for, or effectiveness of, dose reduction therapy. The EE should determine if trading analytical sensitivity for quick results is appropriate for dosimetry. Circumstances may also warrant rapid processing to provide the contractor with preliminary information.

Based on initial measurements, the EE determines the need for follow-up bioassay measurements and advises Field Dosimetry of the needed measurements. In some cases, it may be appropriate for the EE to arrange follow-up measurements directly with the worker at the time of the initial measurements. As information becomes available, the EE advises the contractor and discusses results with workers, if requested. The intent of the EE function is to work through Field Dosimetry for all but the most pressing worker communications.

The EE determines measurement protocols for incidents. Although the circumstances will vary for each incident, the protocols of Table 7.4 provide general guidance on measurements that may be required to assess internal exposure following an incident.

TABLE 7.3. Typical Incident Response Bioassay Measurements and Their Purposes

Measurement	Purpose
Whole body counts and lung counts	Measure activity present in a person at a specific post-intake time. Multiple measurements are used to establish the specific retention pattern in the person.
Head counts	Estimate skeleton burden of bone-seeking radionuclides. This estimate is used to confirm skeleton deposition and to convert chest count results to lung content by correcting for interference from skeleton activity.
Organ counts or wound count	Measure activity present in a specific organ or tissue at a specific post-intake time. Used to estimate the retention pattern of the individual.
Urine samples (simulated 12 hr) (simulated 24 hr) (total)	Estimate excretion rate of radionuclides not readily detectable by direct in vivo counting. Internal deposition of such nuclides is estimated based on standard models. Multiple samples may be required to determine the individual excretion patterns and appropriate excretion model.
Urine samples (single voiding or "spot")	Provide initial order-of-magnitude estimate of exposure based on excretion model. This measurement is also suitable for routine and nonroutine tritium dosimetry.
Fecal samples	Confirm intake. Provide isotope identification and ratio information. Estimate dose based on early clearance (may require multiple samples). Differentiate soluble from insoluble materials.

TABLE 7.4. Example Protocols for Incident Bioassay Measurements

Time Post Intake	Relative Contamination Level(a)								
	Alpha-Emitters			^{90}Sr			Mixed Fission and Activation Products		
	1-5	5-20	>20	1-5	5-20	>20	1-5	5-20	>20
Same Day									
In vivo counts	X	X	X	X	X	X	X	X	X
Spot urine		X	X			X			
Total urine									
Overnight urine	X	X	X	X	X	X			X
Feces		X	X						
Next Day									
In vivo counts		X	X		X	X		X	X
Total urine			X						
Simulated 24-hr urine	X	X		X	X	X		X	X
Feces	X	X	X						X
First Week									
In vivo counts			X				X	X	X
Additional urine	X	X	X	X	X	X			X
3-5 feces	X	X	X			X			X
Follow-Up									
In vivo counts			X					X	X
Additional urine	X	X	X		X	X			X
Additional feces			X						
Special Measurements									
Isotopic smear	X	X	X		X	X		X	X
Particle size			X			X			
Solubility			X						

(a) Expressed as a multiple of the criteria in Table 7.1.

7.5.3 Dose Assessment Capability

The dose assessment and reporting practices are described in Chapters 3.0 and 4.0 of this manual. Summary statements are provided here because they are related to incident response.

Dose Sensitivity

The IDP has the capability to assess an annual effective dose equivalent of 100 mrem for all radionuclides of concern at Hanford. In some cases the ability to do so is contingent upon obtaining appropriate bioassay measurements (fecal samples, urine samples, in vivo measurements) within the first 5 to 10 days post-exposure. For most nuclides, if early data are obtained within the

7.5.3 Dose Assessment Capability (contd)

Dose Sensitivity (contd)

first few days following exposure, the dose assessment capability is 10 mrem or less. The Technical Basis provides more in-depth discussion of the capability of bioassay measurements with regard to dose assessment sensitivity.

Preliminary Dose Assessment

An initial assessment of the magnitude of a potential internal exposure or dose is made as soon as the data permit. Because the circumstances of each internal exposure are different, initial estimates may be inaccurate. In general, when bioassay measurements confirm an intake, follow-up measurements are required to estimate an internal dose accurately. Early estimates of an exposure should be considered as order-of-magnitude estimates only.

Initial assessments are normally communicated directly to Field Dosimetry without a formal evaluation and transmittal letter. A preliminary dose assessment letter is provided, if requested by the contractor.

Final Dose Assessment

Final dose assessments are issued when sufficient data have been obtained to confidently estimate the annual and committed doses required to be reported to DOE. These dose assessments become part of the permanent ORE files.

7.6 GUIDANCE FOR EXPOSURE EVALUATOR RESPONSE TO INCIDENTS

This section provides general guidance for EE responses to some anticipated situations. It is not intended to be an all-encompassing statement of EE response, nor is it intended to replace other contractor and EE policies, procedures, or requirements.

7.6.1 Managing Externally Contaminated Uninjured Workers

The incident contractor is responsible for the management of externally contaminated uninjured workers. Normally, workers should be decontaminated before being released from the facility. If external contamination is detected on workers at the WBC Facility, the EE, RPT, contractor, and WBC staff must determine the course of action. The WBC Facility is not used as a decontamination center, and workers with removable contamination should not be counted until such contamination has been removed.

Clothing or personal items discovered to be contaminated in surveys made at the WBC Facility or EDF are bagged and dispositioned according to the contractor instructions. Normally, the contractor radiation protection organization deals with these items.

7.6.2 Managing Externally Contaminated Injured Workers

The primary responsibility for management of all injured workers, whether contaminated or not, lies with HEHF. When dealing with contaminated workers, the EE supports HEHF by providing advice in matters of dosimetry for the patients and attending staff. The decontamination of an injured worker is HEHF's responsibility, although the EE or RPT may be requested to assist in the decontamination efforts. HEHF also determines the priority of medical treatment versus decontamination.

The EDF is the facility designated to receive contaminated injured workers who do not have life-threatening medical conditions. It is HEHF's responsibility to decide whether to treat a worker at the EDF or to send the worker to a hospital.

When notified of EDF activation, the EE arranges for PNL Radiation Protection support at the EDF. In addition, an EE is dispatched to the EDF to participate as part of the treatment team. A second EE may also be sent to assist. In addition to patient dosimetry evaluation, the EE also provides initial radiation protection coverage for the team until RPT support arrives. The overall responsibility for all EDF-related activities lies with the lead HEHF physician.

If decontamination efforts fail to completely remove personal contamination, it may be appropriate to release a worker with residual skin contamination. This decision must be made by the contractor representative. Under such circumstances, the worker should be advised of appropriate techniques to limit the potential spread of contamination after his/her release. Such techniques might include the use of shower caps, gloves, bandage, etc., to provide a barrier against contamination spread. In addition, it is suggested that the worker be advised when spread of contamination would not be a significant concern upon his/her release. In some cases, home surveys may be appropriate and are the responsibility of the event contractor and the worker's employer.

7.6.3 Taking Therapeutic Measures to Reduce Internal Dose

Therapeutic measures to reduce dose are the responsibility of HEHF Occupational Medicine. These methods may include the use of various drugs (e.g., diethylenetriamine pentaacetic acid [DTPA], potassium iodide, alginates, diuretics, etc.) and surgical techniques (minor tissue excision, wound debridement). The EE advises HEHF of the potential effectiveness of various

7.6.3 Taking Therapeutic Measures to Reduce Internal Dose (contd)

treatment alternatives to reduce dose, and informs HEHF of the potential internal dose to patients as subsequent bioassay data become available.

7.6.4 Releasing Workers Following an Incident

The initial bioassay measurements that are necessary following an incident should be performed before the worker is released. The personal comfort of a worker is considered if extensive hold-over following a workday has already occurred or if discomfort occurs because of injury or extensive counting times. Actual measurements for the initial worker assessment should not normally require more than about 2 hours at the WBC Facility. If more than one worker is involved in an incident, this time could be extended, or workers may be requested to return for additional counts at a later time.

When workers involved in an incident are initially counted or treated, a contractor representative should be present. This representative bears the responsibility for release of the worker and for dealing with the worker's questions about overtime compensation, when to return, and other pertinent questions. The EE addresses, to the extent that the available data allow, questions about the worker's potential internal dose and arranges for necessary excreta samples.

7.6.5 Assisting in External Radiation Exposure Situations

If the contractor requests special assistance regarding an external radiation exposure incident or concern, the EE arranges for the Hanford External Dosimetry Program to provide this assistance.

7.6.6 Requesting Region 8 Radiological Assistance Program Teams

Upon request by DOE, the EE activates Region 8 Radiological Assistance Program teams according to the Emergency Preparedness Project protocol.

7.6.7 Requesting Activation of the Unified Dose Assessment Center

If requested by DOE or appropriate contractor personnel, the EE activates or caucuses UDAC according to the Emergency Preparedness Project protocol.

7.6.8 Requesting Offsite Assistance

If the EE receives a request for offsite assistance from a non-Hanford source, the EE attempts to determine the nature of the requested assistance and to direct the inquiry to the appropriate authority. Specific requests for Hanford services are directed to DOE-RL. Examples of such requests include support to be provided by Region 8 Radiological Assistance Program teams in the event of transportation accidents or support in dealing with a potentially contaminated patient at a local hospital.

EXHIBIT 7.1

Check List for Incident Data

GENERAL INFORMATION

- Description of incident--one or two sentences and date and time of incident
- Location of incident (area, building, room)
- Personnel involved (name, payroll number, job title, and address for each person).

INTERNAL EXPOSURE-RELATED INFORMATION

- Retain any object causing contamination for possible investigation
- Radionuclides
- Form of material (wet/dry, chemical form, soluble/insoluble)
- Mode of intake
- Respiratory protection (type, evidence of leakage)
- Nasal, mouth, or blood smear results (dpm)
- Facial contamination level (dpm)
- Other skin contamination (dpm)
- Clothing contamination (dpm)
- Area contamination (dpm)
- Airborne activity concentration (μCi/cc)
- Correlation of contamination levels to potential exposure of worker.

EXTERNAL EXPOSURE-RELATED INFORMATION

- Radionuclides (or type and energy of emission)
- Source activity
- Source geometry
- Estimated dose rate (type of instrument and distance)
- Pencil dosimeter reading or pocket alarming dose integrator (PADI) dose
- Duration of exposure
- Worker position relative to source
- Shielding around worker
- Shielding around source
- Anticipated delivery of dosimeters for processing.

CRITICALITY EXPOSURE-RELATED INFORMATION

- How detected?
- Number of workers exposed?
- Quick sort performed? Results of gut readings?
- Readings on worker personal effects
  - Item, reading
  - Instrument used, efficiency and background
  - Elapsed time between criticality and reading
- Orientation and distance of worker to critical assembly
- Any immediate symptoms? (describe)
- Fissile material
- Shielding material and thickness
- Current status of area; any chance for recurrence?
- Environmental release?
- Have nuclear accident dosimeters (NADs or "candles") been collected?
- Have worker dosimeters been collected?

EXHIBIT 7.2

Incident Telephone Log

PACIFIC NORTHWEST LABORATORY
RICHLAND, WASHINGTON

RADIATION INCIDENT - TELEPHONE REPORT

Date of Report _____ Unusual Radiation Exposure Report No. _____

Time of Report _____ Contractor Incident No. _____

Report by _____

Contractor _____

Employee	PR#/Code - SS#	Job Title/Craft	Address
1.			
2.			
3.			
4.			
5.			

Incident Date _____ Time _____ Bldg. _____ Area

Incident Description: _____

RADIATION MONITORING RESULTS

INTERNAL

Emitter Isotope _____
Mode of Intake _____
Chemical Form _____
Wet or Dry _____
Skin Contam. _____
_____
Nasal Smears _____
Right _____
Left _____
Floor Contam. _____
Airborne Contam. _____

EXTERNAL

Source Emitter _____
Type of Radiation _____
Pencil _____
Dose Rate _____
Time _____
Distance _____
Location _____
Orientation _____
Shielding _____

EXHIBIT 7.2 (contd)

ACTION TAKEN BY: _____

Internal	Scheduled Date/Time	Results	Date/Time of Results
___ Chest Count			
___ WBC			
___ Other Count			
___ Spot Urine Sample			
___ Particle Size (Analysis)			
___ DTPA Administered			
External			
___ Dosimeter Special Processing			

Verbal Notification

Contractor Representative _____ By: _____

Time _____ Results _____

_____

_____

_____

Exposure Evaluator Comments _____

_____

_____

_____

Miscellaneous _____

_____

_____

_____

_____

Exposure Evaluator _____ Date _____

CHAPTER 8.0

QUALITY ASSURANCE

8.0 QUALITY ASSURANCE

The IOP has been designated as an Impact Level III Project in accordance with the internal manual on quality assurance (QA). By this designation, the program must comply with the Good Practices Standard (GPS), detailed in the QA Manual, and is committed to meeting the mandatory good practices.

The QA and quality control (QC) features of the program are briefly summarized in the following sections.

8.1 QUALITY ASSURANCE AND QUALITY CONTROL FOR BIOASSAY ANALYSES

Quality assurance and QC for sample analysis are assured by the Analytical Services Laboratory's QA and QC programs, Internal Dosimetry's Lab-audit program, and the WBC program.

8.1.1 Analytical Services Laboratory

The Analytical Services Laboratory (Lab) measures essentially all indirect bioassay samples and is required by contract to maintain rigorous, extensive, well-documented QA and QC programs.

The Lab is required to maintain a QA manual that outlines responsibilities and also provides requirements for data control, document control, maintenance/test equipment calibration and checks, procedures, training, corrective action in the event of noncompliance, and traceability to standardizing bodies such as the National Institute of Standards and Technology (NIST).

The QC program involves analyzing blanks and spiked samples with each batch of real samples, constant reviewing of data, and publishing quarterly and annual QC reports. Approximately 10 to 15% of all samples processed are blanks and spikes.

The QC samples are used to demonstrate compliance with requirements specified in the contract between the Lab and PNL. The requirements in the contract are at least as restrictive, and in some areas more restrictive, than the recommendations in the draft ANSI N13.30[a] on

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(a) American National Standards Institute (ANSI). 1987. Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30, New York, New York.

8.1.1 Analytical Services Laboratory (contd)

performance criteria for radiobioassay. These requirements determine detection levels (MDAs) for each radionuclide and matrix, as well as the allowable bias and required precision of the results. The Lab must demonstrate that actual MDAs are no greater than the levels specified in the contract and that bias and precision are within specified limits.

All routine analyses (i.e., not research and procedure development work) must be done according to written and approved procedures.

All technicians must be trained and certified in each procedure before they can routinely perform the applicable analysis.

8.1.2 Internal Dosimetry Audit of the Lab's Quality Control Program

Internal Dosimetry conducts an independent audit program as a check on the validity of the Lab's QC results. The program consists of a combination of blank and spiked samples, which may be submitted for analysis as known audit samples (open audits), masked for analysis as authentic worker samples (blind audits), or split with another laboratory for simultaneous analytical intercomparison (split samples). The results of the audit samples are used to determine Lab performance relative to the CLs in essentially the same manner as the Lab's own QC program. This serves as an additional check on the Lab's ability to meet draft ANSI N13.30[a] recommendations and requirements of the contract.

The results of Internal Dosimetry's audit program are documented annually by means of a letter report to Field Dosimetry and to the Hanford Radiation Protection Historical Files. Discrepancies between the results of the Lab's and Internal Dosimetry's QC data are investigated, and corrective actions are taken as necessary.

8.1.3 Quality Assurance of In Vivo Measurements

The QA of in vivo measurements is detailed in Palmer et al. (1987). In brief, the program consists of daily equipment calibration and background checks using secondary reference sources and periodic calibrations using primary sources (i.e., NIST-traceable) in

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(a) American National Standards Institute (ANSI). 1987. Performance Criteria for Radiobioassay. Draft ANSI Standard N13.30, New York, New York.

8.1.3 Quality Assurance of In Vivo Measurements (contd)

phantoms. In addition, the WBC Facility participates in laboratory intercomparison studies, in which spiked phantoms are sent to national and international facilities and the results are compared.

The results of workers' counts are tracked on computer by payroll number and name and are transmitted to the ORE database weekly. The QA data are kept in hard-copy form in the WBC Facility library.

8.2 QUALITY ASSURANCE AND QUALITY CONTROL FOR DOSE ASSESSMENTS

The intention of the IDP is that internal dose assessments meet the DOE requirements as stipulated in DOE 5480.11 (1989). The methods used to assess internal dose are described briefly in Chapter 3.0 of this manual and are addressed more completely in the Technical Basis. Generally, the methods are consistent with those recommended by national and international authorities, such as the ICRP and the NCRP.

All internal dose assessments are performed by IDP technical professional staff members and include or reference all methods and data used in the evaluation. Documentation of the assessment should be sufficient, such that a technically qualified health physicist could reconstruct the assumptions, methods, and conclusions of the assessment.

Before an internal dose evaluation is issued, it is peer reviewed by a second technical professional staff member to verify its technical accuracy and completeness. In addition, the evaluation and its summary letter must both be approved by the Internal Dosimetry program manager and the O&EP Section manager before they are issued.

The original evaluation and a copy of the summary letter are placed in the workers' ORE files by Radiological Records staff. The original summary letter is sent to the designated contractor dosimetry representative.

8.3 INTERNAL DOSIMETRY PROGRAM RECORDS

The records generated by the IDP are maintained in files within the O&EP Section of PNL. The IDP manager is responsible for the designation and maintenance of these records. Additional information is provided in Section 9.0, Documents and Records.

CHAPTER 9.0

DOCUMENTS AND RECORDS

9.0 DOCUMENTS AND RECORDS

Documentation related to the services and activities of the IDP is of two general types: programmatic and technical assessment. These and the documentation of changes are briefly described in the following subsections.

9.1 PROGRAMMATIC DOCUMENTATION

Programmatic documentation includes a variety of reports and manuals, which provide information related to the design and operation of the IDP. Programmatic documentation is provided primarily by the following three documents:

- The Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1989)--includes technical methods, supporting evidence, and reference information used to provide the technical foundation for the IDP.

- The Hanford Internal Dosimetry Program Manual--includes a guide to the services and capabilities provided by the IDP including policies, recommendations for good practice, and general guidance to contractor dosimetry organizations.

- The draft "Hanford Internal Dosimetry Program Procedures Manual"(a)--includes procedures for the day-to-day operations of the Program including records management, communications, data review, and exposure evaluation documentation.

These documents help provide for the long-term consistency, continuity, and quality of the IDP. The purposes of each of the documents and their interrelationships are exhibited in Figure 9.1. In addition to these documents, there are a number of ancillary reports and documents that pertain to specific aspects of IDP operation. These document program plans, computer codes, Analytical Services Laboratory activities, and QA activities and are included in the summary list of documentation in Table 9.1.

(a) In preparation; to be issued in 1990. Information about this manual may be obtained from E. H. Carbaugh at PNL, Richland, Washington.

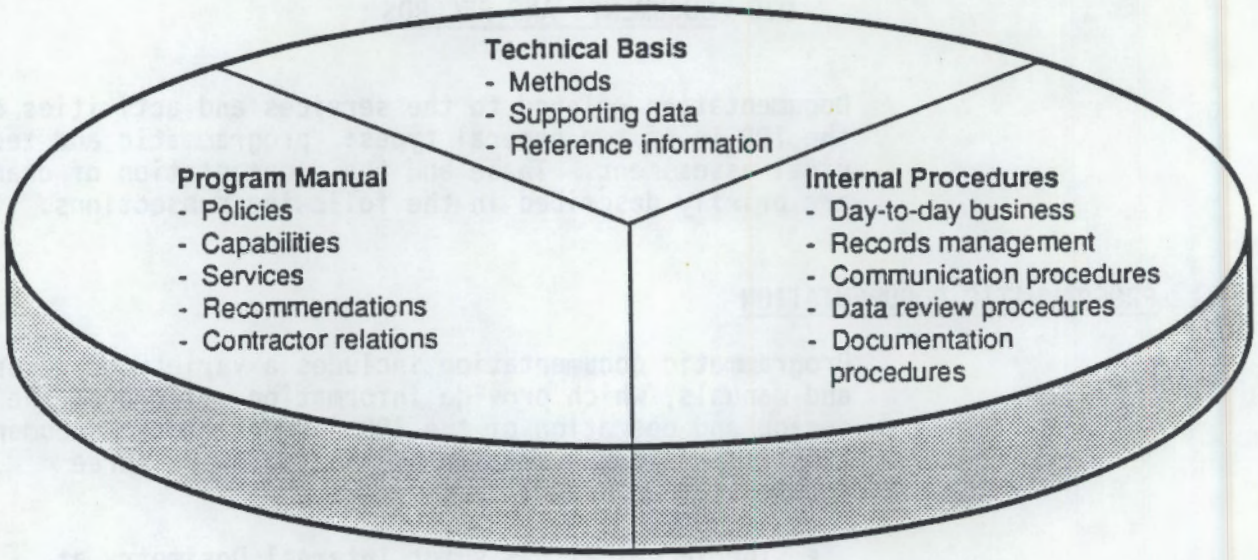

FIGURE 9.1. Hanford IDP Programmatic Documentation

9.2 TECHNICAL ASSESSMENT DOCUMENTATION

Technical assessment documentation includes reports and records that provide information related to the technical products of the IDP, that is, bioassay measurements and internal dose assessments. These assessments may be documented in formally issued topical reports, letter reports, or as database entries. A summary of the types of IDP technical assessment documentation and their disposition is provided in Table 9.2.

9.3 DOCUMENTATION OF CHANGES

Changes may be made to programmatic documents and to technical assessment records when new methods are developed and implemented, new requirements are established, or as a result of errors or deficiencies in practices or assessments. The processes for documenting these changes are provided below.

TABLE 9.1. Summary of Programmatic Documents for the Hanford Internal Dosimetry Program

Title or Subject	Content	Form[a]	Custodian	Storage	Disposition
Technical Basis for Internal Dosimetry at Hanford (PNL-6866, Sula, Carbaugh and Bihl 1989)	Technical support for program	1	IDP[b]	PNL[c] controlled	Permanent
Hanford Internal Dosimetry Program Manual	Policies, services, capabilities, and recommendations	1	IDP	PNL controlled	Permanent
Hanford Internal Dosimetry Procedures Manual (draft)	Daily operating procedures	1	IDP	To be PNL controlled (when issued)	To be Permanent (when issued)
Whole Body Counting Manual	Technical support for the Whole Body Counting Program including policies, services, and capabilities	1	WBCP[d]	PNL controlled	Permanent
Quality Assurance Manual	Good practices and standards for program operations	1	PNL	PNL controlled	Permanent
Vendor Procedures Manual	Excreta analysis and other procedures	2	RRL[e]	Historical Files[f]	Permanent
Vendor contract - statement of work	Requirements for services provided by the Analytical Services Laboratory	1	PNL	PNL Subcontracts	Permanent

TABLE 9.1. (contd)

Title or Subject	Content	Form(a)	Custodian	Storage	Disposition
Hanford Dosimetry Advisory Committee	Committee minutes	1	RRL	Historical Files	Permanent
Program change record	Program change documentation and support	1	RRL	Historical Files	Permanent
Vendor Quality Assurance Manual	Vendor's quality assurance program	2	RRL	Historical Files	Permanent
Vendor Quality Control Manual	Vendor's quality control program	2	RRL	Historical Files	Permanent
Vendor Control of Radiation Counters Manual	Bioassay Laboratory counting room procedures	2	RRL	Historical Files	Permanent
Program computer codes	Design and user's guide to software implemented by the IDP	1	RRL	Historical Files	Permanent
Quality assurance audits	Audit of internal dosimetry program	1	RRL	Historical Files	Permanent

(a) 1 = hard-copy report
2 = microfilm
(b) IDP = Internal Dosimetry Program
(c) PNL = Pacific Northwest Laboratory
(d) WBCP = Whole Body Counting Program
(e) RRL = Radiological Records Library
(f) Historical Files = Hanford Radiation Protection Historical Files

TABLE 9.2. Summary of Technical Assessment Documents for the Hanford Internal Dosimetry Program

Title or Subject	Content	Form[a]	Custodian	Storage	Disposition
Internal dose assessments	Documentation of worker dose assessment	1	RRL[b]	ORE personnel file	75 years
Annual summary report for active workers	Internal dose report	2	RRL	Ltrb[c]	As long as usable
INTERTRAC report--annual report for DOE contractors	Annual dose equivalent for active workers	2	RRL	Ltrb[c]	As long as usable
INTERTRAC report--termination	Internal dose report for terminated worker	2	RRL	ORE files	75 years
Bioassay data	Excreta and in vivo measurement results	3	RRL	ORE personnel file	75 years
Bioassay annual quality control for FY 19XX	Annual letter report of bioassay laboratory internal quality control samples	1	RRL	Historical Files[d]	Permanent

TABLE 9.2. (contd)

Title or Subject	Content	Form(a)	Custodian	Storage	Disposition
Results of the PNL audit program for FY 19XX	Annual letter report of summary of IDP quality control audit sample program	1	RRL	Historical Files	Permanent
Vendor laboratory records	Records and documents supporting excreta sample analyses	1	Vendor	--------To be determined--------	
Whole body counting records	Records and documents supporting in vivo measurements	1	WBC	--------To be determined--------	

(a) 1 = hard-copy report
2 = microfilm
3 = magnetic storage media
(b) RRL = Radiological Records Library
(c) Ltrb = IDP Program Manager's letter book
(d) Historical Files = Hanford Radiation Protection Historical Files

9.3.1 Program Change Record

Changes and additions to the IDP are recorded via the Program Change Record. The purpose of the record is to document program changes, to assure proper program review of changes, and to help assure that appropriate notification of the changes are made. The Program Change Record consists of the record form shown as Exhibit 9.1 and any attachments identified on the form. The change record includes a description of the change and its effective date. The records are maintained in the ORE historical file by year according to a sequentially assigned number. For example, the first change recorded in calendar year 1989 is numbered 89-1. Change records are approved by the IDP manager.

A Program Change Record is used to document changes to policies, practices, assumptions, analytical and computational methods, technical assessment techniques, and recording and reporting practices. Types of changes for which the record is used include those that

- affect the quality, meaning, accuracy, or interpretation of bioassay measurements or dose assessments
- alter procedures used to perform bioassay measurements
- affect the cost or scheduling of internal dosimetry services provided by PNL
- alter generic practices, techniques, or assumptions
- affect the manner in which internal dosimetry information is recorded or reported
- supersede information previously documented.

9.3.2 Revision/Update of Documents and Manuals

Changes may be made to information in documents and manuals at any time. Before the change can become effective, however, it must be documented via either a Program Change Record, or by revision of the document or manual. It is often most efficient to initially document the change via a Program Change Record and reserve the option to revise the document after several changes have accumulated.

9.3.3 Revision of Technical Assessments

Modifications to technical assessments are documented as follows:

- Dose Assessment--A revised Evaluation Report is prepared with a copy to the contractor dosimetry representative and a copy to the Hanford Radiation Protection Historical Files. The revised evaluation is identified using the Evaluation Number sequence described in Section 3.2.2. (It is the practice of Hanford contractors to obtain a signed statement from the subject individual acknowledging receipt of the revised doses).

- In Vivo Measurement--A notice of correction to an in vivo ORE record is issued by the WBC staff in the form of a letter to Internal Dosimetry. The correction letter describes the reason for the change and the new result. After Internal Dosimetry submits the correction to Radiological Records data processing personnel, the original correction letter is provided to the ORE personnel file.

- Excreta Measurement--A notice of correction to an excreta ORE record is issued by UST to Internal Dosimetry. The correction is reported using a Non-Conforming Data report and a cover letter. After Internal Dosimetry submits the correction to Radiological Records data processing personnel, the original letter and report are provided to the ORE personnel file.

Exhibit 9.1

Change Record Number: _____
Issue Date: _____

PROGRAM CHANGE RECORD
HANFORD INTERNAL DOSIMETRY PROGRAM

Category: WBC Bioassay Lab Other

2

change title: _____ effective date: _____
(descriptive phrase)

description:
(State the reason for and describe the change. Try to keep the description brief by referencing manuals, reports, letters, etc. when possible. Include as attachments supporting information not referenced.)

(use attachments or additional pages if necessary)

impact:
(Briefly state the affect the change will have on program quality, operation, cost, etc.)

(use attachments or additional pages if necessary)

supercedes (if manual, provide page and section):

originated by: _____ date: _____
project manager: _____
Internal Dosimetry Program Mgr. _____

notification (copies sent to):

ORE historical file Responsible Proj. Mgr. Internal Dosimetry file
Int.Dos.Staff (route) WBC Staff (route)

(List names and affiliation of others not covered by the above distribution list who should receive a copy of this change record.

CHAPTER 10.0

REFERENCES

10.0 REFERENCES

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APPENDIX A

REPORTING, SCREENING, AND FOLLOW-UP LEVELS FOR ROUTINE BIOASSAY MEASUREMENTS

APPENDIX A

REPORTING, SCREENING, AND FOLLOW-UP LEVELS FOR ROUTINE BIOASSAY MEASUREMENTS

This appendix lists levels of routine bioassay measurement results that initiate response by Internal Dosimetry according to practices discussed in Chapter 2.0.

The bioassay measurement laboratories provide prompt verbal notification to Internal Dosimetry for any results that exceed the reporting level. Reporting levels for excreta analyses processed using the routine processing code are identical to the contractual detection levels listed in Chapter 6, Tables 6.1 and 6.5, with the exception of plutonium in urine, which has a reporting level of 0.01 dpm per sample. All excreta analysis results processed using priority, expedite or emergency processing codes are verbally reported to Internal Dosimetry. The reporting level for "Routine" in vivo measurements have been set equal to the screening levels discussed below and listed in Table A.1.

The reporting level for "New Hire" or "Beginning Work" in vivo measurements is the detection of any positive result other than ^{40}K. The results of all "Incident" and "Field Request" in vivo measurements are verbally reported to Internal Dosimetry.

When Internal Dosimetry is advised of a "Routine" bioassay measurement result that exceeds the reporting level, the result is compared with the screening levels of Tables A.1 and A.2. The screening level is used to determine if additional investigation is required, or if the dose assessment process is initiated based on the specifics of the worker's assigned bioassay measurement program and history.

If the screening level is exceeded, the magnitude of the potential dose indicates the need for additional measurements. In some cases, notably for soluble uranium, follow-up levels for additional bioassay measurements have been established. For most nuclides, the follow-up levels are determined once the screening level has been exceeded, based on the criteria in Section 2.1.2.

TABLE A.1. Screening Levels for Routine Bioassay Measurement Results Based on a Potential First-Year Effective Dose Equivalent of 10 mrem[a]

Measurement Type	Radionuclide	Frequency of Measurement	Screening Level
Whole body count	^{40}K	Annual	200 nCi[b]
	^{60}Co	Annual	8 nCi[c]
	^{137}Cs with ^{90}Sr	Annual	9 nCi[d]
	^{137}Cs only	Annual	19 nCi
	^{154}Eu	Annual	8 nCi[e]
	Other radionuclides	-	Anything detected
Thyroid count on germanium detector	^{125}I	Quarterly	4 nCi[f]
Urinalysis, 24-hr simulated or total	^{90}Sr	Biennial	11 dpm/sample[g]
		Annual	26 dpm/sample[g]
	U natural	Annual	0.2 μg/sample[h]
		Quarterly	0.2 μg/sample[h]
Urinalysis 12-hr simulated	U natural	Annual	0.1 μg/sample[h]
		Quarterly	0.1 μg/sample[h]
Urinalysis single void	U natural	Annual	0.14 μg/l[i]
Urinalysis any volume	Tritium	Monthly	80 dpm/ml
		Biweekly	110 dpm/ml

(a) Except for the measurement/radionuclide/frequency combinations listed in this table, any detected internal activity in a routine bioassay measurement is of interest to Internal Dosimetry and could indicate an intake exceeding the 10 mrem first-year effective dose equivalent.
(b) Potassium-40 in the general public ranges up to about 200 nCi.
(c) Assumes an intake of a class Y corrosion product mixture with equal activities of ^{60}Co and ^{54}Mn.
(d) Assumes an intake mixture of equal activities of ^{137}Cs and ^{90}Sr. If the subject is on a routine monitoring program for ^{90}Sr, then the screening level for ^{137}Cs only is more appropriate.
(e) Assumes an activity ratio of 2:1 for ^{154}Eu:^{155}Eu at intake.
(f) Based on potential exposure each quarter with a possible dose of 2.5 mrem each quarter.
(g) Assumes the individual receives an annual whole body count and thus only ^{90}Sr is considered in the evaluation of the urine sample result.
(h) Based on the upper level for environmental urinary excretion of uranium, estimated at 0.2 μg/day for individuals living in this area.
(i) 0.14 μg/l is equivalent to a daily excretion rate of 0.2 μg/day, assuming a urine output rate of 1.4 l/day.

TABLE A.2 Screening and Follow-Up Levels for Possible Chemical Toxicity

Measurement Type	Radionuclide	Frequency of Measurement	Screening Level(a)	Follow-up Level(b)
12-hr simulated urinalysis	U natural (code QUS)	Monthly	1.2 μg/sample	4 μg/sample
		Biweekly	3.5 μg/sample	11 μg/sample
Single void urinalysis	U natural (code QUS)	Monthly	1.7 μg/l	6 μg/l
		Biweekly	5 μg/l	16 μg/l

(a) Levels shown indicate a potential intake at one-tenth of the assumed threshold for acute toxicity.
(b) Levels shown indicate a potential intake at one-third of the assumed threshold for acute toxicity.

APPENDIX B

COMPUTER REPORT SCREENS AND CODES OF THE OCCUPATIONAL RADIATION EXPOSURE DATABASE

APPENDIX B

COMPUTER REPORT SCREENS AND CODES

OF THE OCCUPATIONAL RADIATION EXPOSURE DATABASE

This appendix provides an explanation of selected computer report screens and data field codes pertinent to the Hanford Internal Dosimetry Program. Appendix B includes figures of data screens or hard-copy reports with annotations describing selected data fields. The data fields are cross-referenced to the tables, which follow the figures and contain explanations of the various codes used within the field. A list of the figures and tables is provided below.

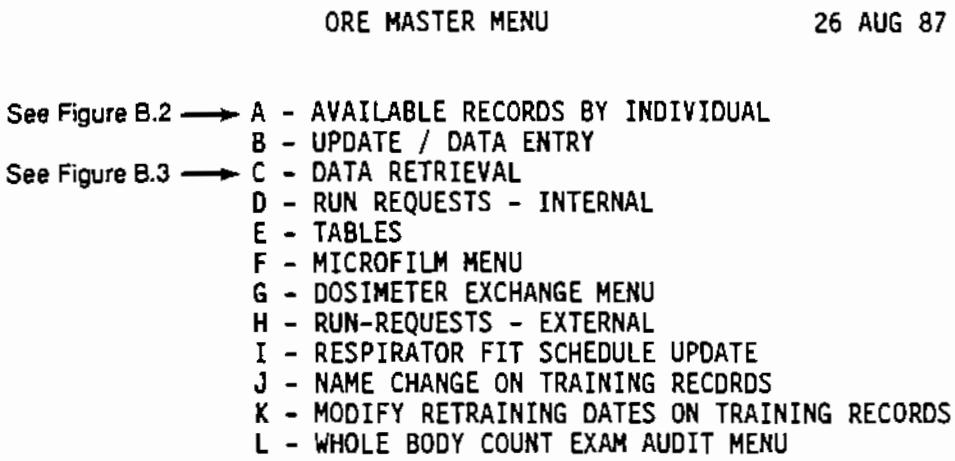

FIGURE B.1. ORE Master Menu

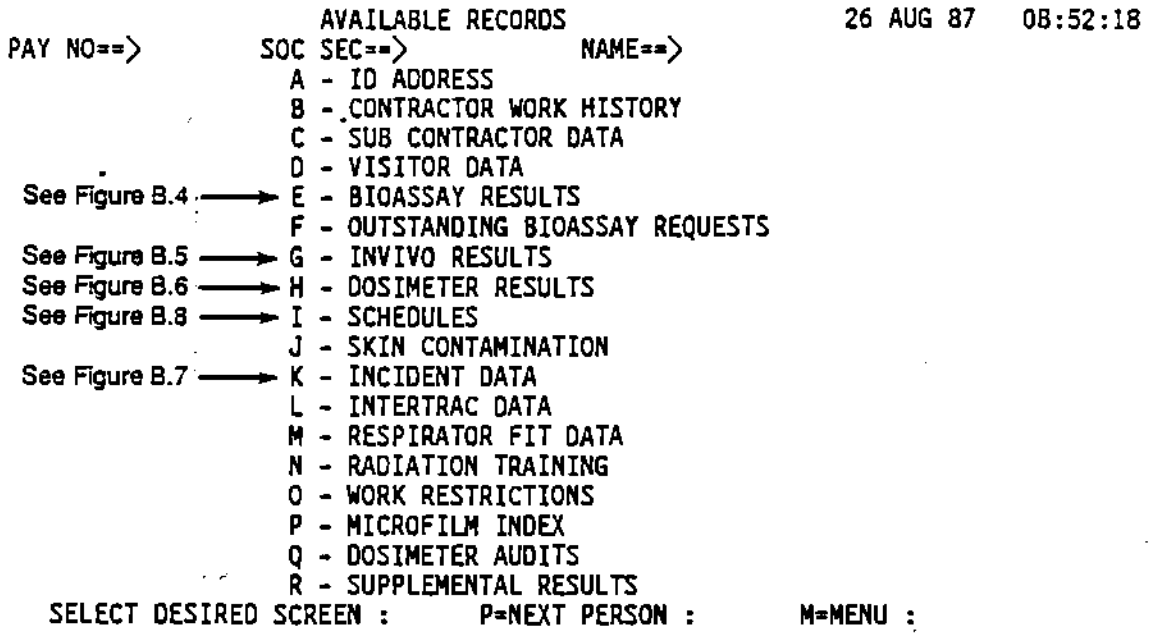

FIGURE B.2. Available Records - Submenu

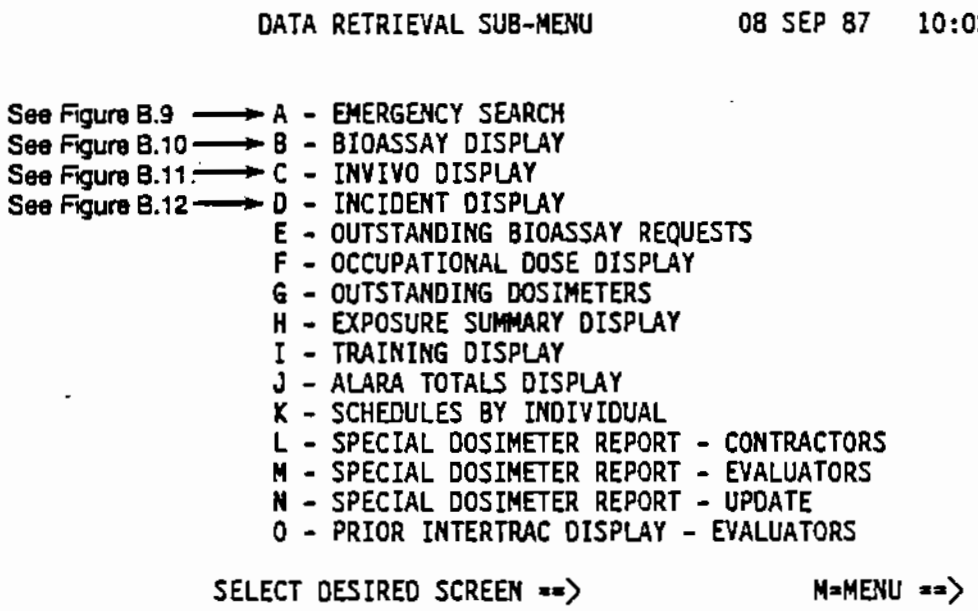

FIGURE B.3. Data Retrieval - Submenu

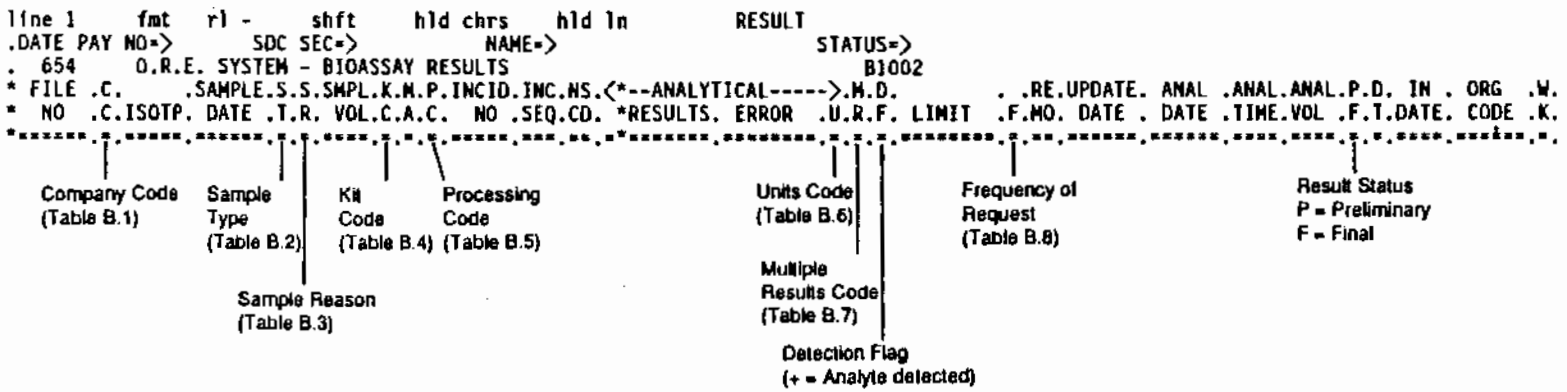

FIGURE B.4. Available Records - Bioassay Results Screen

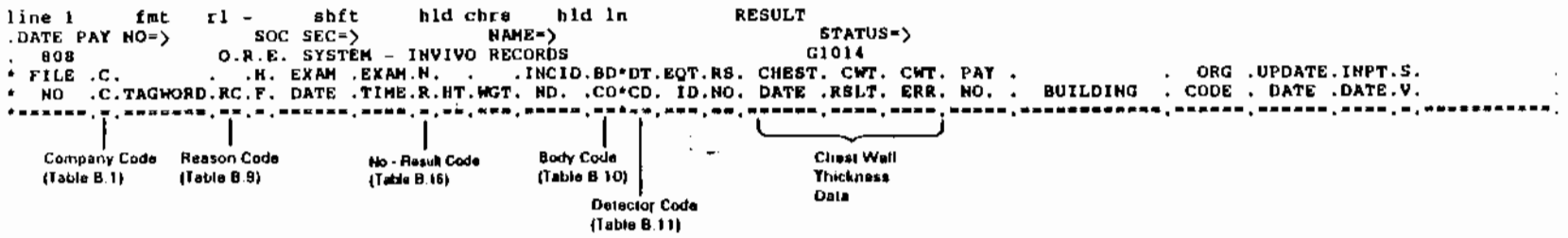

FIGURE B.5. Available Records - In Vivo Records Screen

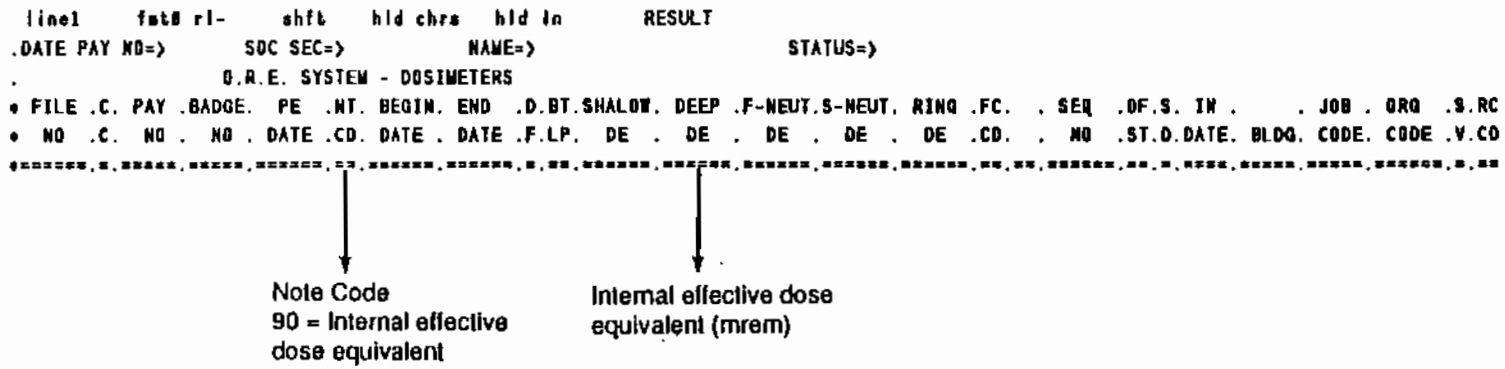

FIGURE B.6. Available Records - Dosimeter Results Screen

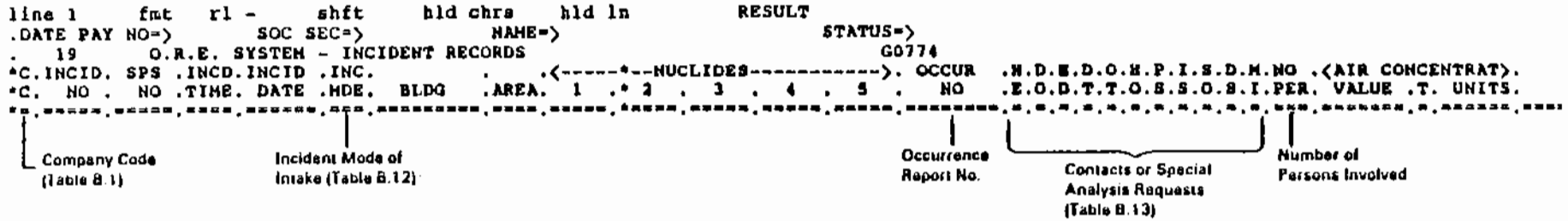

FIGURE B.7. Available Records - Incident Records Screen

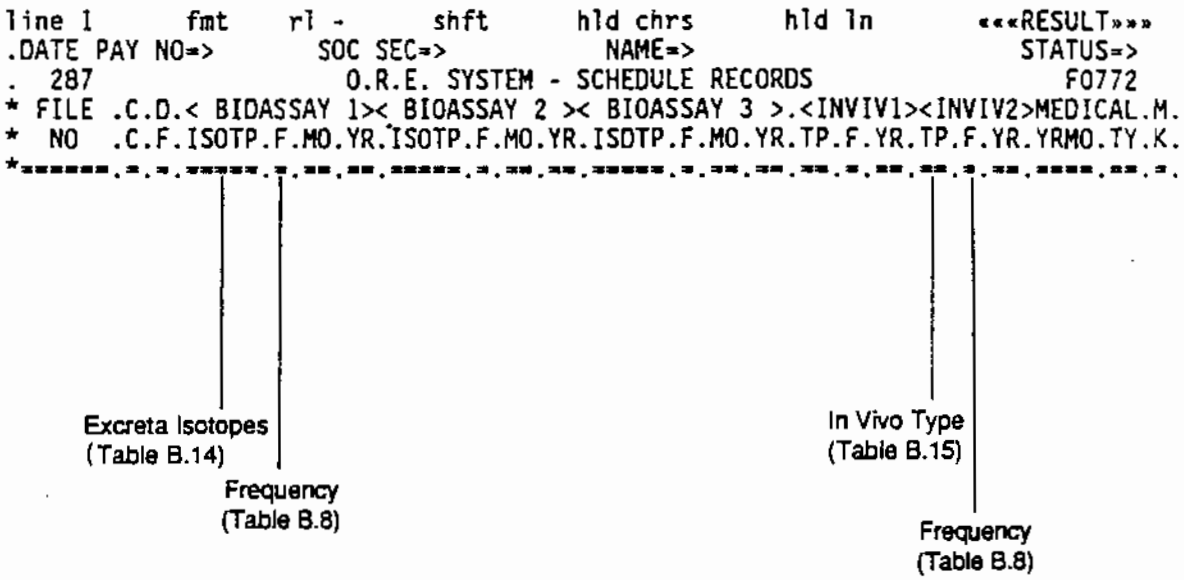

FIGURE B.8. Available Records - Schedules Screen

```
.DATE 27 APR 89  08:14:04      REPORT GENERATION      MAY
================================================================================
                          EMERGENCY SEARCH

        PAY NUM:          SOC SEC:              NAME:
                 -----              ---------          -- ----------------
        ADDRESS:                              CITY:                 STATE: WA
                 ------------------------       --------------          --
        PARAMETER DATES:          TO
                          ------    ------
================================================================================
                       INTERTRAC MASTER RECORD

    <= EVALUATION =>  P  O  R  I  A   BEGIN    END     INT  A  D  R  PRINCIPAL
     ND   SEQ  DATE   F  F  E  I  C   DATE     DATE    MDE  R  R  S  RADIONUCLIDE
    ----- --- ------  -  -  -  -  -  ------   ------  ---  -  -  -  ----------
================================================================================
            INTERTRAC ANNUAL DOSE RECORD

       EVALUATION
        NO    SEQ  ORGAN   NUCLID  YR  DOSE EQ (REM)
       -----  ---  ------  ------  --  ------------
================================================================================
                              INCIDENT

   INCIDENT   SPS              MAJOR    INCID
     NO        NO     DATE   NUCLIDE    MODE   BLDG       AREA   TREATMENT
   --------   ---    ------  -------   -----   ----       ----   ---------
================================================================================
                          SKIN CONTAMINATION

                                ...NASAL SMEARS...
          DATE      BLDG        QUANTITY     UNITS     JOB PERFORMED
         ------    ------       --------     -----     -------------
================================================================================
                          BIOASSAY  RESULTS                  See Figure B.13

          ....SAMPLE....  ANAL  K  INCIDENT  NS P .........ANALYTICAL.........
     ISOTP  DATE  T R  VOL  VOL   C  NUM  SEQ  CD C   RESULT    ERROR    LIMIT
     -----  ------ - - ----  ----  - -----  ---  -- - --------- -------- --------
================================================================================
                          INVIVO  DISPLAY                    See Figure B.14

  EXAM                                          OR    DT BD H INCID  CWT   CWT  CWT
  DATE  NUCLIDE QUANTITY  ERROR     MDA       CD RC CD CD F  NO.   DATE  RSLT ERR
 ------ ------- -------- -------- --------    -- -- -- -- - -----  ------ ---- ----
================================================================================
```

FIGURE B.9. Data Retrieval - Emergency Search Screen

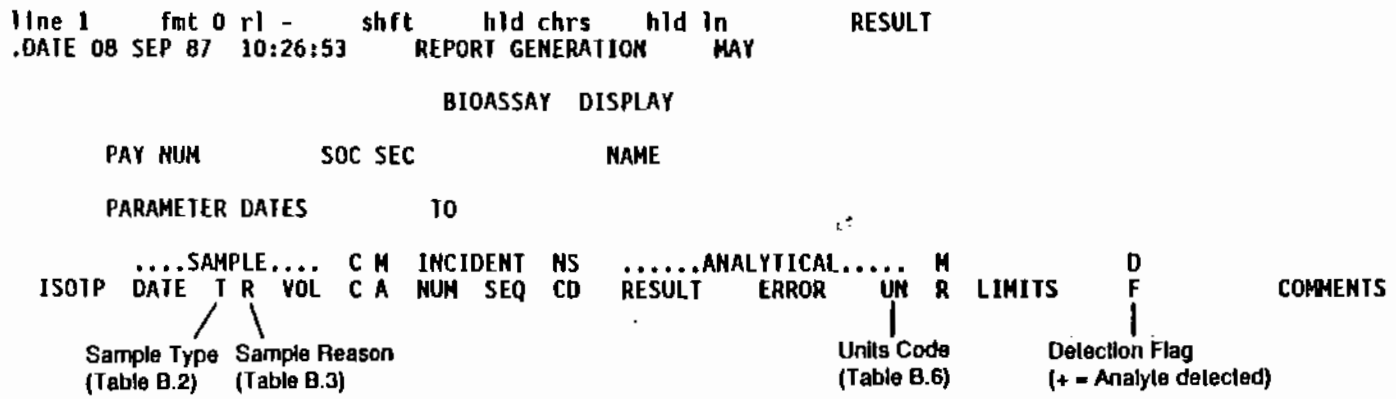

FIGURE B.10. Data Retrieval - Bioassay Display Screen

```
line 1     fmt 0 rl -     shft     hld chrs    hld ln          RESULT
.DATE 08 SEP 87  10:25:19     REPORT GENERATION     MAY

                              INVIVO  DISPLAY

      PAY NUM          SOC SEC              NAME

      PARAMETER DATES          TO

          EXAM                                                OR       DT   H  INCID
  TAGWORD DATE  NUCLID  QUANTITY     MDA      ERROR           CD  RC   CD   F   NO.
```

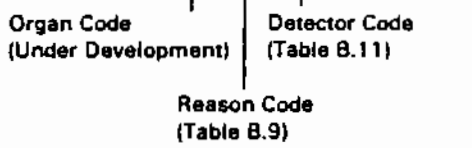

FIGURE B.11. Data Retrieval - In Vivo Display Screen

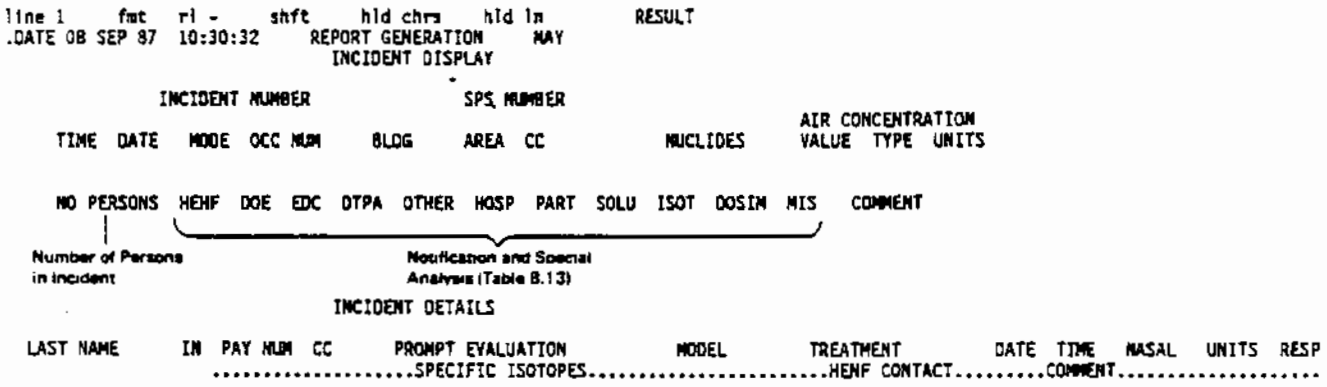

FIGURE B.12. Data Retrieval - Incident Display Screen

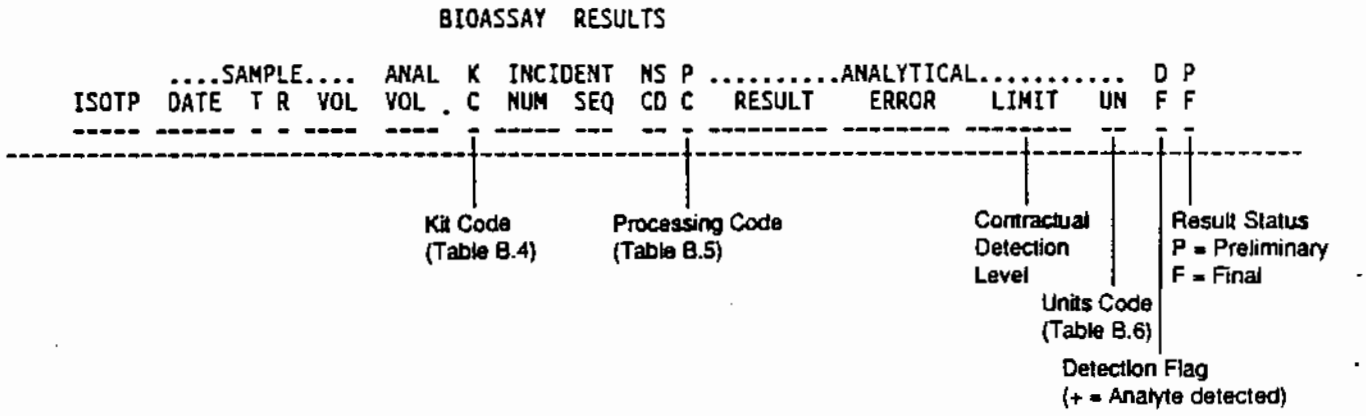

FIGURE B.13. Emergency Search - Bioassay Results Screen

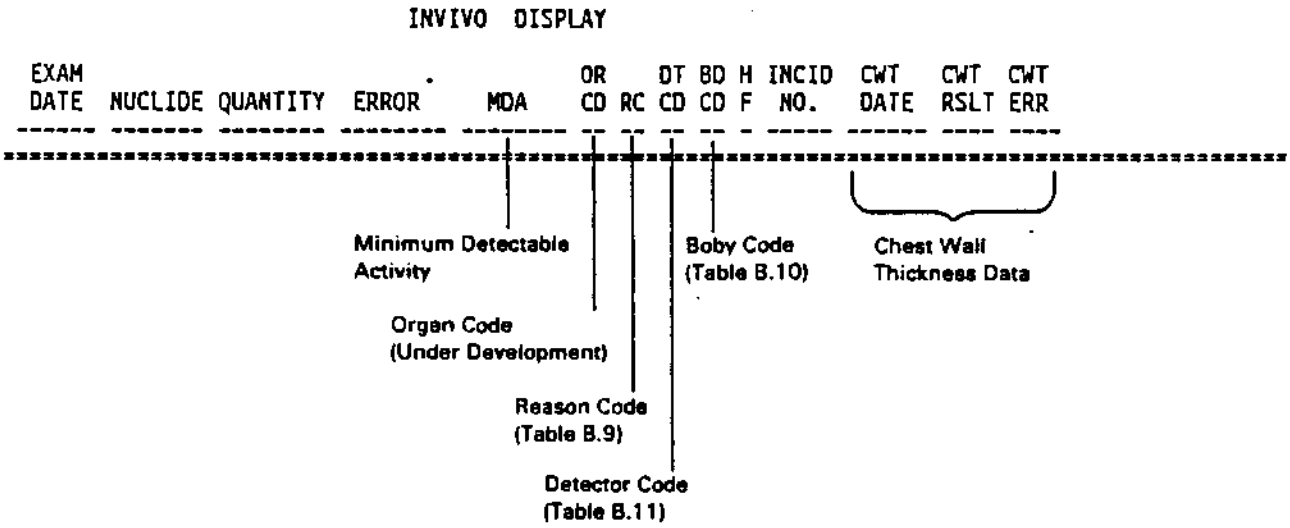

FIGURE B.14. Emergency Search - In Vivo Display Screen

TABLE B.1. Company Codes

Pay Number	ID Code	Company Title	Dates Assigned
G0000 to G9999	9	AEC, ERDA, DOE	1944
P0000 to P9999	9	Early service crew (FBI, Army, BPA, etc.) and Duplicate PR# for DOE)	
00001 to 00900	A	DuPont	12-21-42 to 09-13-46
00001 to 29999	A	General Electric	09-13-46 to 1966
00000 to 09999	A	Duplicate PR#, use an A	
00000 to 09999	A	Triplicate PR#, use a Q	
00000 to 09999	A	Fourth PR#, use a U	
00000 to 09999	A	Fifth PR#, use a W	
10000 to 19999	A	Duplicate PR#, use an Q (alpha)	
10000 to 19999	A	Triplicate PR#, use an QJ (alpha)	
20000 to 29999	A	Duplicate PR#, use an S	
70000 to 79999	A	ITT Support Services (absorbed by ARHCO)	03-01-66 to 09-01-71
60000 to 69999	B	Isochem	01-01-66 to 09-01-67
	B	Atlantic Richfield Hanford Company	09-01-67 to 06-30-77
	B	Rockwell Hanford Operations	07-01-77 ----------
6A000 to 62999	B	Rockwell Hanford Operations	-------- to 06-28-87
30000 to 39999	D	Battelle-PNL	01-04-65
3A000 to 32999	D	Battelle-PNL	
3000 to 3Z999	C	Environmental Management Operations	02-01-89
40000 to 49999	E	BCS Richland, Inc.	10-20-75
DG000 to DG999	F	Computer Sciences Corporation	07-01-65 to 10-20-75
EG000 to EG999	G	General Telephone Company	01-05-70
50000 to 59999	H	Douglas United Nuclear	11-01-65 to 09-01-67
5A000 to 52999	H	United Nuclear Industries	04-19-73 ----------
	H	UNC Nuclear Industries, Inc.	-------- to 06-28-87
CG000 to CG999	K	AII-Vitro Engineering Division	07-08-63
CV000 to CV999	K	AII-Vitro Engineering Division	to 01-01-74
V0000 to V9999	K	AII-Vitro Engineering Division	01-01-74 to 09-30-81
B0000 to B9999	K	Braun Hanford Company	10-01-81 to 02-28-82
K0000 to K9999	K	Kaiser Engineers Hanford	03-01-82 to 02-27-87
BG000 to BG999	M	Hanford Environmental Health Foundation	08-01-65

TABLE B.1. (contd)

Pay Number	ID Code	Company Title	Dates Assigned
HG000 to HG199	P	Washington Public Power Supply System (UNC)	03-31-72 to 12-30-82
K0000 to K9999	R	Kaiser Engineers Hanford	02-28-87
Z0000 to Z9999	R	Kaiser Engineers Hanford	
Y0000 to Y9999	R	Kaiser Engineers Hanford	
YA000 to YA999		Kaiser Engineers Hanford - Subcontractors badged for compliance	
M0000 to M9999	S	Shippingport	05-10-84
MA000 to M2999	S	Shippingport Subcontractors	05-10-84
Z0000 to Z9999	T	JA Jones Construction Company	06-01-53 ----------
Y0000 to Y9999	T	JA Jones Construction Company	-------- to 02-27-87
YA000 to YA999	T	JA Jones - Subcontractors badged for compliance	06-01-75 to 02-27-87
AZ000 to A2999	T	George A. Grant (Subcontractor)	01-01-65 to 06-07-75
BZ000 to IZ999	T	JA Jones (Subcontractors)	01-01-66 to 06-07-75
ZZ000 to Z2999	T	Conam Inspection, Inc. (JA Jones subcontractor)	12-26-73 to 09-30-77
ZA000 to ZY999	T	Construction without Z# and duplicate Z#	Any date
FG000 to FG099	T	Combustion Engineers	12-05-66 to 06-25-71
90000 to 99999	V	Westinghouse Hanford Co. (WADCO/ HEDL)	07-01-70 to 06-28-87
90000 to _____	W	Westinghouse Hanford Company	06-29-87
80000 to 89999	W	Westinghouse Hanford Company	
50000 to 59999	W	Westinghouse Hanford Company	
60000 to 69999	W	Westinghouse Hanford Company	
6A000 to _____	W	Westinghouse Hanford Company	
	X	Records combined in database for one or more companies	
AG000 to AG999	*	Resident Non-Employee	01-01-65
0G000 to 0G999	*	Resident Non-Employee	03-20-73
IG000 to IG999	*	Resident Non-Employee	06-07-79
XG000 to XG999	*	Resident Non-Employee	09-29-83
RG000 to RG999	*	Resident Non-Employee	11-22-83

TABLE B.1. (contd)

Pay Number	ID Code	Company Title	Dates Assigned
FG100 to FG999	*	Visitors	05-21-85
TR000 to TR299	*	U.S. Transuranium Registry	1985

* Any company.

TABLE B.2. Sample Type Codes

Code	Sample Type Description
B	Blood
F	Feces
S	Sputum
T	Tissue
U	Urine

TABLE B.3. Sample Reason Codes for Excreta

Sample Reason Code	Reason for Measurement	Description of Reason
R	Routine	Sample collected for routine surveillance (see Table 6.9)
H	New hire	Sample collected before a worker begins employment or enters a radiation zone
B	Beginning work	Sample collected before a worker begins a specific type of radiation zone work, or before an offsite trip where potential exposure could occur
E	Ending work	Sample collected after a worker completes a specific type of radiation zone work or after a return from a trip where potential offsite exposure could have occurred
F	Contractor	Sample collected by request of a contractor for a specific need (code used in 1987-88 for verifying intakes below an investigation level 1)
I	Incident	Sample requested after an incident of potential occupational exposure
X	Exposure evaluator	Sample requested by an EE for special purposes
T	Termination	Sample collected when a worker terminates employment. No entry into radiation zones should occur after sample is collected
Z	Visitor	Sample collected from a visitor to Hanford (new as of 1989)
Q	Research	Sample collected for research or quality control (new as of 1989)
C	Recount	Recount of an original measurement to confirm the detected activity reported to PNL Internal Dosimetry
V	Investigate high routine	Sample collected after the report of an elevated routine type measurement (i.e., R, B, E, F) to PNL Internal Dosimetry
U	Follow-up	Sample collected for long-term follow-up evaluation

TABLE B.3. (contd)

Sample Reason Code	Reason for Measurement	Description of Reason
D	Contractor request (baseline)	Sample requested by Field Dosimetry to re-establish a baseline excretion level (after entry clearance), following a potential intake less than an investigation level intake (used from 1987 to 1988 only)
J	Contractor request (other)	Sample requested by Field Dosimetry from 1987 to 1988 for any reason other than reason codes D or F.

TABLE B.4. Sample Kit Codes

Kit Code	Sample Media	Sample Description
1	Urine	Simulated 24-hour urine collection. Collected at home over a 2-day period. Used for routine sampling and when a larger volume sample is desired. Designated sample date is the day after kit delivery to the employee.
2	Urine	12-hour urine collection for termination sampling only. Collected at home overnight. Designated sample date is the date of kit delivery to the employee.
3	Urine	Total 24-hour urine collection. Collected at home and at work (if necessary) to collect ALL urine voided during a 24-hour period. Generally used for sampling immediately following an occurrence or for work restriction sampling. Designated sample date is the day after delivery or the date on which the sample collection began.
4	Urine	Single void (spot urine) collection. Collection in a single bottle, used for initial indications of an intake. Designated sample date is the date of voiding.
5	Feces	Collection of a single fecal voiding usually for investigation of a potential intake. Rapid or priority processing. Sample date is the date on which the sample is collected.
6	Urine	Partial day or simulated 12-hour collection. Usually collected at home overnight. Used for collection following an occurrence or when a large volume urine sample is not necessary, such as for tritium or uranium determination. Designated sample date is the date of delivery to the employee.
7	Urine	Simulated 12-hour collection Sunday-Monday sample (Friday delivery only). Generally used for uranium workers. Designated sample date is the Sunday in the sampling period.

TABLE B.4. (contd)

Kit Code	Sample Media	Sample Description
8	Feces	Collection of a single fecal voiding used for a special program for plutonium oxide workers. Designated sample date for shift workers is the Tuesday of long shift change, and for day workers is the appropriate Sunday.
9	Urine	Kit designed for collection of urine outside the local service area. Transportation is handled by private carrier. Generally used for termination samples not collected locally.

TABLE B.5. Processing Codes

Computer Code	Description
R	Routine processing
P	Priority processing
X	Expedite processing
E	Emergency processing

TABLE B.6. Units Codes

Computer Code	Description of Units
1	dpm/sample
2	dpm/volume analyzed
3	µg/l until 07-01-82 µg/sample after 07-01-82
4	µg/gram until 07-01-82 µg/sample after 07-01-82
5	µCi/l
6	µCi/l

TABLE B.7. Multiple Results Codes

Description	Multiple Result Code	Computer Code	Results Reported
Pu Isotopic	Q	IPU	^{238}Pu, $^{239,240}Pu$
Gamma Spectroscopy	W	ISPEC	^{40}K, ^{137}Cs, and others
Gamma Spectroscopy	*	LEPD	^{241}Am
Seq. Pu Isotopic, Am Isotopic, Cm	K	ITPAC	^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{244}Cm, ^{242}Cm
Seq. ^{90}Sr, Ce, Pm	S	ISCP	^{90}Sr, ^{144}Ce, ^{147}Pm
Seq. Sr-Total, Ce, Pm	I	SCP	Sr, ^{144}C, ^{147}Pm
Cm Isotopic	D	ICM	^{244}Cm, ^{242}Cm, and others
Eu Isotopic	F	IEU	^{152}Eu, ^{154}Eu, ^{155}Eu
U Isotopic	U	IU	$^{233,234}Pu$, ^{235}U, ^{238}U
Seq. Pu, ^{90}Sr	P	IPS	^{238}Pu, $^{239,240}Pu$, ^{90}Sr
Seq. Pu Isotopic, ^{241}Am	J	IPA	^{238}Pu, $^{239,240}Pu$, ^{241}Am
Seq. Pu Isotopic, Sr-Total	M	IPSR	^{238}Pu, $^{239,240}Pu$, Sr
Seq. Pu Isotopic, Sr-Total, ^{241}Am	L	IPSA	^{238}Pu, $^{239,240}Pu$, Sr, ^{241}Am
Sr Isotopic	Y	ISR	^{89}Sr, ^{90}Sr
Pu Isotopic, 241Pu	N	IPUBA	^{238}Pu, $^{239,240}Pu$, ^{241}Pu
Pu Isotopic, ^{241}Pu, ^{241}Am	Z	IPUBA	^{238}Pu, $^{239,240}Pu$, ^{241}Pu, ^{241}Am
Pu Isotopic/U-Natural	Q	IUPU	^{238}Pu, $^{239,240}Pu$, U
U-Natural (Soluble)	H	QUS	U
Th Isotopic	T	OTH	228Th, 230Th, 232Th
Ra Isotopic	R	IRA	224Ra, 225Ra

TABLE B.8. Bioassay Frequency Codes

Computer Code	Frequency of Bioassay
A	Annual
B	Biennial
F	Five years
Q	Quarterly
S	Semiannual
W	Weekly
X	Biweekly (every 2 weeks)

TABLE B.9. Reason Codes for In Vivo Measurements

Code	Reason	Description of Reason
1	Routine	Measurement is performed on a predetermined, periodic schedule for routine surveillance
2	New hire	Measurement is performed before worker begins employment or enters a radiation zone
3	Termination	Measurement is performed when a worker terminates employment. No entry into radiation zones should occur after count is performed
4	Unusual exposure (incident)	Measurement is requested after an incident of potential occupational exposure
5	Evaluator request	Measurement is requested by EE as an additional count to be performed along with the worker's routine count or requested for evaluation of prior exposure
6	Contractor request (verification)	Count is performed by request of a contractor for a specific need
7	Recount	Count is performed to verify an original count
8	Follow-up	Count is performed at some time after detection of activity in a worker
9	Beginning of work	Count is performed before a worker begins a specific type of radiation zone work, or before offsite trip where potential exposure could occur
10	End of work	Count is performed after a worker completes a specific type of radiation zone work or after a return from a trip where potential offsite exposure could have occurred
11	Visitor	Count is performed on a visitor to Hanford
12	Contract work	Count is performed by special contract work to the PNL Whole Body Counter
13	Research project	Count is performed specifically for a research project
14	Contractor request (baseline)	Count is requested by Field Dosimetry to re-establish baseline activity (after early clearance) from a potential intake that was less than an investigative level (used in 1987 and 1988 only)

TABLE B.9. (contd)

Code	Reason	Description of Reason
15	Contractor request (other)	Count requested by Field Dosimetry for any reason other than the two other contractor request codes (6 and 14). Used only in 1987 and 1988.
16	Investigate high routine	Measurement performed after the report of an unexpectedly high result

TABLE B.10. Body Location Codes for In Vivo Measurements

Computer Code	Body Location
01	Whole body
02	Head
03	Chest
04	Abdomen
05	Knee
06	Throat
07	Hand
08	Special
09	Thorax

TABLE B.11. In Vivo Detector Codes

Code	Type of Detector
A	4" x 9" NaI single crystal
B	3/8" x 5" NaI four-crystal array
C	3/8" x 5" NaI single crystal
D	1 mm x 1" NaI single crystal
D1	Wound count using D detector
E	3" x 3" NaI single crystal
E1	Thyroid count using E detector
F	3/8" x 5" NaI four-crystal array
G	4" x 11" NaI single crystal
H	6" x 11" NaI single crystal
I	32% and 35% GeLis
I2	Lung count using two coaxial detectors
J	Planar GeLi single crystal
J2	Lymph node count using J detector
K	18% GeLi single crystal
L	35% GeLi single crystal
M	Intrinsic germanium single array 10 cm^2
N	3/8" x 5" Phoswich single crystal
O	4" x 4" x 16" NaI single array
P	3/8" x 5" Phoswich single crystal
Q	Specialized counting
Q1	Head count using two intrinsic germanium detectors set at 0.25 keV/channel
Q2	Thyroid count using two intrinsic germanium detectors set at 0.25 keV/channel
R	Intrinsic germanium three-crystal array 20 cm^2
R1	Liver or head count using three intrinsic germanium detectors set at 0.5 keV/channel
S	6" x 11" NaI and two 2 GeLis @ 32% and 35%
S1	Sled counter

TABLE B.11. (contd)

Code	Type of Detector
T	Intrinsic germanium five-crystal array 20 cm^2
U	4" x 9" NaI (4) and 6" x 11" NaI
U1	Sum spectra calculation
U2	Also includes individual detector calculation
V	Intrinsic germanium six-crystal array 20 cm^2
V1	Lung count using V-detector array set at 0.5 keV/channel
V2	Lung count using V-detector array set at 0.25 keV/channel

TABLE B.12. Mode of Intake Codes

Code	Mode of Intake
ABS	Absorption
ING	Ingestion
INH	Inhalation
NON	None (no intake)
UNK	Unknown
WND	Wound

TABLE B.13. Contacts and Special Analysis Requests

Code	Description
DO	DOE - Department of Energy
DS	Dosimeter
DT	DTPA - chelation agent administered
ED	EDF - Emergency Decontamination Facility
HE	HEHF - Hanford Environmental Health Foundation
HO	Hospital
IS	Isotopic
MI	Miscellaneous
OT	Other
PS	Particle Size
SO	Solubility

TABLE B.14. ORE Isotope Codes

Isotope	Multiple Result Code	Isotope	Multiple Result Code
AM241			
C 14		NP237	
CE144		PB210	
CM242		PM147	
CM244		PO210	
CS137		PU	
CO 60		PU238	
EU154		PU239	
EU155		PU240	
EU156		PU241	
GS		PU242	
H 3		QUS	H
I 131		RA224	
IAM	A	RA226	
IBK	B	RA228	
ICF	C	RU106	
ICM	D	SR	
IES	E	S 35	
IEU	F		
IPA	J		
IPS	P		
IPSA	L	SR 89	
IPSR	M	SR 90	
IPU	Q	TAC	
IPUB	N	TC 99	
IPUBA	Z	TH228	
IRA	R	TH230	
IR192		TH232	
ISCP	S	TH234	
ISPEC	W	U	
ISR	Y	U DEP	
ITH	T	U 233	
ITPAC	K	U 235	
IU	U	U 238	
IUPA	V	US	
IUPU	O	ZN 65	
K 40			
LEPD	*		
MFP			
MN 54			
NA 24			

TABLE B.15. Codes for In Vivo Schedule Type

Code	Type of Measurement
WB	Whole body count
C	Chest count
C2	Extended chest count
T	Thyroid

TABLE B.16. In Vivo No-Result Codes

Code	Explanation of Code
C	External contamination other than radon detected on the subject. Measurement invalid; no results obtained.
F	Failure of equipment or faulty setup of equipment. Measurement invalid; no results obtained.
I	Interference from localized activity in another part of the subject's body. Measurement invalid; no results obtained.
L	Location of internal or external activity was qualitatively determined by mapping, masking, or collimating. May include one or more measurement counts. These measurements are qualitative for identifying location of activity and do not yield quantifiable estimates of activity.
M	Medically administered radioactivity interfered with measurement. Measurement invalid; no results obtained.
R	Radon interference from subject's clothing, hair, or skin. Measurement invalid; no results obtained.
S	The subject's actions interrupted completion of the count. Measurement invalid; no results obtained.
X	Measurement invalid; no results obtained. Other no-result codes do not apply. See comment field for a brief description.

Notes

1) For invalid results, the ORE database shows "XX000" in the nuclide field and "00000" in the amount and detection level fields. A zero for detection level is presented as "<MDA>".

2) The comment field may have a brief explanation in addition to the codes listed above.

APPENDIX C

ANALYTICAL PROCEDURES

APPENDIX C

ANALYTICAL PROCEDURES

This appendix contains summaries of the procedures used by the Analytical Services Laboratory (Lab) to analyze indirect bioassay samples and the Whole Body Counter (WBC) Facility for performing direct bioassay measurements.

C.1 INDIRECT BIOASSAY SAMPLES

All indirect bioassay samples are analyzed to determine their content of various radionuclides according to detailed, written procedures, which are described briefly for each radionuclide as follows.

C.1.1 Tritium in Urine

One milliliter of the sample is mixed with scintillator solution and counted directly in a liquid scintillation spectrometer.

C.1.2 Urine--Rapid and Expedite Processing

Total Radiostrontium — Up to 100 ml of the sample is precipitated as a carbonate, dissolved and reprecipitated as a nitrate, scavenged with barium chromate, converted to carbonate, and counted in a low-background gas-flow proportional counter.

Plutonium — Plutonium is converted to (+IV) valence state using sodium nitrite and adsorbed on an anion exchange column. Iron and thorium are removed by nitric and hydrochloric acid. The plutonium is desorbed from the column, using ammonium iodide, and electrodeposited on a planchet. Alpha-emitting isotopes are counted using alpha spectrometry. Plutonium-241 activity is determined by dissolving the material from the planchet with nitric and hydrochloric acid and by counting the beta emissions in a liquid scintillation spectrometer.

Americium and Curium — The sample is wet-ashed using nitric acid and mixed with anion exchange resin to remove plutonium and other heavy metals. The residual solution is coprecipitated with calcium oxalate and redissolved with nitric acid. The americium and curium are concentrated with bidentate organophosphorus solvent (DDCP), electrodeposited on a planchet, and counted using alpha spectrometry.

C.1.2 Urine--Rapid and Expedite Processing (contd)

Uranium — One hundred microliters of sample are fused with a sodium fluoride-lithium fluoride flux. The mass of uranium in the resulting solution is determined by measuring the yellow-green fluorescence using a fluorophotometer.

C.1.3 Feces--Rapid and Expedite Processing

Total Radiostrontium — The sample is wet- and dry-ashed. Strontium is precipitated as the nitrate, scavenged with barium chromate, converted to carbonate, and counted in a low-background gas-flow proportional counter.

Plutonium — The sample is wet- and dry-ashed. Then the procedure is the same as that for urine (see Section C.1.2).

Americium and Curium — The procedure is the same as that for urine (see Section C.1.2).

Uranium — The sample is wet-ashed only. Then the procedure is the same as that for urine (see Section C.1.2).

C.1.4 Urine and Feces--Priority and Normal Processing

For all analyses except tritium, the samples are first wet- and dry-ashed. Entire samples are used except for the low-sensitivity uranium analysis. Additional wet- and dry-ashing, sometimes using perchloric and hydrofluoric acids, may be needed on fecal samples.

Tritium analysis and the low-sensitivity uranium analysis are not available for fecal samples.

Strontium-90 — Strontium is precipitated as the carbonate and then as the sulfate. The redissolved material is scavenged with hydroxide followed by two barium chromate precipatations. This is followed by carbonate, nitrate, and a final carbonate precipatation. The carbonate is mounted on a planchet and counted with a low-background gas-flow proportional counter. If this count is less than 1 dpm, the procedure is terminated. If the first count is greater than 1 dpm, ^{90}Y is allowed to grow into equilibrium with the ^{90}Sr, then it is separated by hydroxide and oxalate precipitations, ignited to yttrium oxide, and the beta emissions are counted. The first count gives the total strontium activity, and the second (yttrium) count gives the ^{90}Sr activity.

Plutonium — The procedure is essentially the same as that for rapid and expedite processing, except for the increased counting time.

C.1.4 Urine and Feces--Priority and Normal Processing (contd)

Americium and Curium The ash is dissolved in nitric acid and sodium nitrite and mixed with anion exchange resin to remove plutonium and other heavy metals. Americium and curium in the residual solution are precipitated with calcium oxalate, redissolved with nitric acid, reprecipitated with oxalate, dissolved again with nitric, and precipitated with fuming nitric. The americium and curium are then concentrated with bidentate organophyosphorus (DDCP), stripped with hydrochloric acid, and adsorbed on a cation exchange column using ammonium thiocyanate as a complexing agent to remove iron and thorium. The americium and curium are removed from the column, electrodeposited on a planchet, and counted by alpha spectrometry.

Uranium To process uranium, two methods are used, depending on the sensitivity desired.

With the more sensitive method, the entire sample is used. The sample is wet-ashed with hydrochloric acid and adsorbed onto an anion exchange resin. The uranium is then desorbed from the column and extracted with hexone. The uranium is back-extracted into water by evaporating the hexone. The sample is then fused with a sodium fluoride-lithium fluoride flux, and the mass is determined using fluorophotometry.

With the less sensitive method, only 100 ml of the sample is used, and the anion exchange step is skipped.

Analyses for other radionuclides are available as indicated in Tables 6.2 through 6.6.

C.1.5 Combinations

Usually more than one procedure can be performed on one sample. For instance, 1 ml of a urine sample can be extracted for tritium analysis before proceeding with any of the other analyses. Other possible combinations are plutonium and strontium, plutonium and americium/ curium, plutonium and uranium, and plutonium, strontium, and americium/curium.

C.2 DIRECT BIOASSAY MEASUREMENTS

Details concerning procedures, equipment, and data processing for direct bioassay measurements are provided in the Whole Body Counting Manual (Palmer et al. 1987). Pertinent information is provided as follows.

C.2.1 Whole Body Counts

Initial whole body counts are performed using the preview counter, which is a standup counter using five NaI detectors. The count time is typically 200 seconds. Roughly, radioactivity can be spatially identified as emanating from the head, chest, abdomen, and legs. Most radionuclides with gamma-ray energies from about 200 to 3000 keV can be quantified, e.g., ^{137}Cs, ^{60}Co.

If a radionuclide other than ^{40}K is detected, the person is asked to shower, change into clean coveralls, and is counted using a shadow-shield, moving-bed counter with two intrinsic germanium detectors. The germanium detectors have much better photopeak resolution, which generally eliminates interferences from several radionuclides.

If skin contamination is detected, Field Dosimetry is contacted.

The detection of some radionuclides trigger additional counts. For example, detection of ^{137}Cs usually triggers a chest count to check on the presence of ^{144}Ce.

C.2.2 Chest Counts

The presence of high-energy gamma-emitting radionuclides in the chest is determined by whole body counting. The presence in the chest of gamma- or x-ray-emitting radionuclides with energies in the range of a few tens of keV to 200 keV is determined by chest counting. The chest counter is typically used for counting ^{241}Am, ^{235}U, ^{234}Th (as an indicator of ^{238}U), ^{144}Ce, ^{154}Eu, ^{155}Eu, ^{232}Th, and to a lesser extent ^{238}Pu and ^{239}Pu.

The chest counter is an array of six germanium planar detectors placed three on each side of the lung. The person being counted is seated in a chair in a slightly reclined position. Typical counts are 1000 seconds long, but counts up to 4000 seconds can be arranged if desired.

If material is detected in the chest, then an ultrasound measurement of the thickness of the chest wall is made, and the calculated activity in the lung is corrected for the absorption of the low-energy rays in the chest wall.

When activity such as ^{241}Am can exist in both the lung and bone, a head count is also performed, and the apparent activity from the chest count is corrected for the contribution from the bones in the chest region. The corrected activity represents the activity actually in the lung.

C.2.3 Head Counts

Head counts are performed to quantify the skeletal activity of low-energy x- or gamma-ray-emitting radionuclides, such as ^{241}Am. The head counter consists of two germanium planar detectors placed high on the forehead. The typical count time is 3000 seconds. The results of the head count are converted to activity in the total skeleton based on the distribution of ^{241}Am observed in the skeleton of a total body donation to the U.S. Transuranium Registry.

C.2.4 Thyroid Counts

Thyroid counts are performed using a single 3-in. x 3-in. NaI(Tl) detector for ^{131}I and two germanium planar detectors for ^{125}I or ^{129}I. The typical count time is 2000 seconds.

C.2.5 Liver Counts

Liver counts are performed using an array of three germanium planar detectors. The typical count time is 2000 seconds. This count is calibrated for ^{241}Am only. The result is corrected for skeletal interference, but it is not corrected for thickness of overlying tissue.

C.2.6 Wound Counts

Wound counts may be performed at either the EDF or at the 747-A Building depending on the circumstances. For low-energy x or gamma rays, a single germanium detector is used. For contamination emitting higher-energy gamma rays, the count is usually performed at the 747-A Building with a large-volume germanium detector. The typical count time is 10 minutes. The activity of isotopes of plutonium should be considered approximate, unless the depth of the activity in the tissue is known.

APPENDIX D

SAMPLE KIT INSTRUCTIONS

APPENDIX D

SAMPLE KIT INSTRUCTIONS

The Analytical Services Laboratory's user instructions for each of their nine sampling kits are reproduced here in Exhibits D.1 through D.9. Each of the instruction cards is printed on a different color of card stock for easy visual discrimination. The color is noted parenthetically under the exhibit title.

Exhibit D.1

Instructions for Kit Code 1

(Blue)

INSTRUCTIONS

FOR ROUTINE BIOASSAY AT-HOME SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Please collect **ALL** urine during the periods one-half hour before retiring and one-half hour after rising for two consecutive days. (Simulated 24 hour home sample.)

If Kit was delivered on:	Start collection on:	End collection on morning of:	Kit will be picked up
Monday ►	Monday ►	Wednesday ►	Wednesday
Tuesday ►	Tuesday ►	Thursday ►	Thursday
Wednesday ►	Wednesday ►	Friday ►	Friday
Thursday ►	Saturday ►	Monday ►	Monday
Friday ►	Saturday ►	Monday ►	Monday

- Urine passed only during the specified periods should be collected.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, tighten each cap, replace the bottles in the cardboard box and return the kit to the same place you received it.

- The bioassay sampling kit will be picked up at the same place it was dropped off on the pickup date indicated above.

U.S. TESTING CO., INC.
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Exhibit D.2

Instructions for Kit Code 2

(White)

INSTRUCTIONS

FOR TERMINATION BIOASSAY SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Your employer has requested a final urine specimen from you to complete your individual radiation exposure history record. This is part of your employer's termination procedure.

- Please collect **ALL** urine passed within one-half hour of retiring on the above sample date and within one-half hour of rising.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, tighten each cap, replace the bottles in the cardboard box and return the kit to the same place you received it.

- The bioassay sampling kit will be picked up at the same place it was dropped off on the pickup date indicated above.

U.S. TESTING CO., INC.
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Exhibit D.3

Instructions for Kit Code 3

Home Fraction
(Red)

INSTRUCTIONS

FOR 24 HOUR TOTAL URINE SAMPLING HOME FRACTION

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Please collect **ALL** urine passed from **MIDNIGHT TO MIDNIGHT** on the above sample date. This kit is provided for home collection. A second kit may be provided for your use while at work.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, tighten each cap, replace the bottles in the cardboard box and return the kit to the same place you received it.

- The bioassay sampling kit will be picked up at the same place it was dropped off on the pickup date indicated above.

U.S. TESTING CO., INC.
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Exhibit D.3 (contd)

Instructions for Kit Code 3

Work Fraction
(Red)

INSTRUCTIONS

FOR 24 HOUR TOTAL URINE SAMPLING WORK FRACTION

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Please collect **ALL** urine passed during **WORKING HOURS** on the above sample date. This kit is provided for work collection. A second kit may be provided for your use while at home.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, tighten each cap, replace the bottles in the cardboard box and return the kit to the same place you received it.

- The bioassay sampling kit will be picked up at the same place it was dropped off on the pickup date indicated above.

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Exhibit D.4

Instructions for Kit Code 4

(Goldenrod)

INSTRUCTIONS

FOR SINGLE-VOID URINE SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Unless you have been instructed otherwise, please collect a single **NORMAL** voiding of urine in one of the bottles provided.

- Cap the bottle tightly, replace the bottle in the kit, and return the kit to the same place you received it.

- The kit will be picked up at the same place it was dropped off either today or tomorrow.

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Exhibit D.5

Instructions for Kit Code 5

Front of Card
(White)

Sample Date _____

Delivery Date _____ Pickup Date _____

INSTRUCTIONS

FOR COLLECTING A FECAL SAMPLE

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any problems or discrepancies in the information on the label. Phone Richland (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.
- Please collect a stool specimen (fecal sample) on the above date.
- Place the equipment on your porch after sampling has been completed.
- Equipment will be recovered on the pickup date indicated above.

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ADDITIONAL INSTRUCTIONS ON BACK OF CARD

Exhibit D.5 (contd)

Instructions for Kit Code 5

Back of Card
(White)

Directions for use:

1. Remove container and holder from sample kit, and remove lid.

2. Pull up toilet seat, place unit on bowl in center toward rear of bowl.

3. Put toilet seat on frame to hold unit in place. **CAUTION:** Stool specimen must not contain urine.

4. After stool specimen has been collected, remove plastic bag from rim of the container and fold over the stool sample. Replace cover and return to sample box.

Exhibit D.6

Instructions for Kit Code 6

(Yellow)

INSTRUCTIONS

FOR SPECIAL URINE SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- **UNLESS YOU HAVE BEEN INSTRUCTED OTHERWISE,** please collect **ALL** urine passed within one-half hour of retiring on the above sample date and within one-half hour of rising.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, tighten each cap, replace the bottles in the cardboard box and return the kit to the same place you received it.

- The bioassay sampling kit will be picked up at the same place it was dropped off on the pickup date indicated above.

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Richland, Washington 99352

Exhibit D.7

Instructions for Kit Code 7

(Green)

INSTRUCTIONS

FOR SOLUBLE URANIUM IN URINE SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

Routine collection and analysis of urine samples is an important part of the radiation dosimetry program for individuals working with soluble uranium. Therefore, it is requested that you read and carefully follow the instructions below.

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any errors by phoning (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.

- Please collect **ALL** urine excreted within one-half hour before retiring on Sunday evening and one-half hour after rising on Monday morning.

- Keep the bottles capped when not in use.

- Four bottles are provided in the kit. Begin with any bottle and use as many as necessary. Each bottle may be filled until approximately ¾ full.

- After final sampling has been completed, please place all bottles, whether used or not, into the cardboard carrier and refold the handle to close the box.

- Your kit will be picked up on Monday morning from the same place where it was delivered. **Be sure to leave your kit outside where it can be picked up on Monday morning.**

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Richland, Washington 99352

Exhibit D.8

Instructions for Kit Code 8

Front of Card
(Peach)

INSTRUCTIONS

FOR COLLECTING A FECAL SAMPLE

IMPORTANT: IF POSSIBLE, DO NOT USE UNTIL 24 HOURS AFTER LEAVING WORK PLACE.

- Check the kit for your correct name, address, and payroll number **BEFORE** collecting a sample. **DO NOT USE** this kit if it is not addressed to you. Please notify U.S. Testing, Bioassay Section, of any problems or discrepancies in the information on the container. Phone Richland (509) 375-3131, ext. 39, collect, between 7:30 A.M. and 5:00 P.M.
- Please collect specimen (fecal sample), following the instructions given below.
- Place the equipment on your porch after final sampling has been completed.
- Equipment will be recovered on the pickup date.

Check time out of zone:

☐ Less than 1 day

☐ 1-3 days

☐ More than 3 days

ADDITIONAL INSTRUCTIONS
ON BACK OF CARD

Exhibit D.8 (contd)

Instructions for Kit Code 8

Back of Card
(Peach)

Directions for use:

1. Remove container and holder from sample kit, and remove lid.
2. Pull up toilet seat, place unit on bowl in center toward rear of bowl.
3. Put toilet seat on frame to hold unit in place. **Caution:** Stool specimen must not contain urine.
4. After stool specimen has been collected, remove plastic bag from rim of the container and fold over the stool sample. Replace cover and return to sample box.

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Exhibit D.9

Instructions for Kit Code 9

(White)

INSTRUCTIONS FOR TERMINATION FOLLOW-UP SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

1. Discard the outer box. Write the start date here:_____

2. Please collect ALL urine while at home until all bottles are used.

3. Three bottles are provided in the kit. Begin with any bottle and fill each bottle at least to the fill line but not higher than the bottle neck.

4. Keep the bottle capped when not in use.

5. After final sampling has been completed, recheck each cap for tightness. Replace the bottles in the cardboard box with the instruction care. Seal the box by moistening the gummed surface of the tape provided and centering over the box closure.

6. Return the package to U.S. Testing by calling Airborne Express at _____ and requesting a package pickup with the changes to be paid by the receiver. Airborne can pickup the package at either your home or workplace. You may also go to a U.S. Post Office and ship the package COD, Third class.

7. If you have any questions please call U.S. Testing, Bioassay Section, at (509) 375-3131, ext. 39, collect, between 7:30 a.m. and 5:00 p.m.

U.S. TESTING CO., INC.; BIOASSAY SECTION

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