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HANFORD INTERNAL DOSIMETRY PROJECT MANUAL

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SUMMARY

This document describes the Hanford Internal Dosimetry Project, as it is administered by Pacific Northwest Laboratory (PNL) in support of the U.S. Department of Energy and its Hanford contractors. Project services include administrating the bioassay monitoring program, evaluating and documenting assessment of potential intakes and internal dose, ensuring that analytical laboratories conform to requirements, selecting and applying appropriate models and procedures for evaluating 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 project, including interpretation of 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 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 levels used by the program, list field codings used in the online computer database, briefly describe the analytical procedures used for measurements, include copies of the bioassay sampling kit instructions, and provide the Hanford Internal Exposure Incident Response Plan.

This document was originally developed as a controlled manual with distribution limited to those Hanford site personnel who routinely use the project services. This uncontrolled document 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 1994. There is no plan or intent to update uncontrolled copies as changes are made in the Hanford project.

PREFACE

This manual is a guide to the services provided by the Hanford Internal Dosimetry Project (IDP), which is operated for the U.S. Department of Energy - Richland Operations Office by the Pacific Northwest Laboratory.[a] The manual describes the roles of and relationships between the IDP and the radiation protection programs of the Hanford contractors. Regarding internal exposure monitoring, this manual also provides recommendations and guidance for consideration in implementing radiation protection programs.

The recommendations of this manual are provided as guidance, not requirements, to contractor organizations and personnel responsible for designing and operating bioassay monitoring programs. It is assumed that each contractor will decide whether to implement these recommendations and assign individual workers to bioassay programs.

(a) Pacific Northwest Laboratory is operated by Battelle Memorial Institute for the U.S. Department of Energy under Contract DE-AC06-76RLO 1830.

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1.0 INTRODUCTION

The Hanford Internal Dosimetry Project (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 CHARTER OF THE HANFORD INTERNAL DOSIMETRY PROJECT

The IDP is a sitewide service project operated by the Pacific Northwest Laboratory (PNL) for all Hanford U.S. Department of Energy (DOE) and DOE-contractor personnel. Its budget is authorized by the DOE Richland Operations Office (RL), and is administered and staffed by the Personnel Dosimetry Section within the PNL Health Protection Department. The Hanford Site Services Handbook (RL 1993) assigns, by charter, the following responsibilities to PNL:

- assessing and documenting occupational doses from intakes of radionuclides
- determining compliance with applicable internal dose standards
- administering the routine bioassay monitoring program required by site contractors
- providing technical guidance to contractors on internal dosimetry matters
- establishing models for evaluating internal radionuclide deposition
- performing or initiating actions for prompt evaluation of the internal exposure of personnel involved in accidents or emergencies.

1.2 PROJECT SERVICES

The IDP is administered as specified by the Hanford contractors. It provides the following services for the benefit of all site employees:

- administering the routine bioassay monitoring program for internally deposited radionuclides

1.2 PROJECT SERVICES (contd)

- investigating and documenting evaluations of potential internal exposures for exposure record files and contractor staff
- ensuring that the Analytical Services Laboratory conforms to the technical requirements of the analytical services contract
- selecting and applying appropriate models, procedures, and practices for evaluating internal radionuclide deposition and the resulting dose
- guiding and supporting Hanford contractors in technical 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.

1.3 LIMITATIONS OF SERVICE

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. This includes identifying needs for bioassay monitoring and determining when potential internal exposures have occurred. The IDP is not responsible for reviewing air sampling data or other workplace monitoring data to originally identify potential intakes. However, review of such data by the IDP is considered germane to an investigation of a potential intake once a potential intake has been identified.

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.

1.3 LIMITATIONS OF SERVICE (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 deals 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.

The IDP provides bioassay services that, if properly used, should be capable of identifying and evaluating an intake resulting in a committed effective dose equivalent (CEDE) of 100 mrem. However, the capability for such sensitivity depends, in some cases, on prompt identification of potential intakes by the contractor, using workplace monitoring and personnel survey techniques. Periodic bioassay monitoring does not necessarily provide adequate sensitivity to detect intakes resulting in 100-mrem CEDE.

1.4 PROJECT DIRECTION

Direction for the IDP comes from DOE Orders 5480.11 (1988), 5484.1 (1981), and the Hanford Site Radiological Control Manual (RL 1992). Where DOE Orders 5480.11 and 5484.1 may conflict with the Hanford Site Radiological Control Manual, the latter has precedence.

Additional technical guidance is found primarily in the recommendations and standards of the International Commission on Radiological Protection (ICRP), the National Council on Radiation Protection and Measurements (NCRP), and the American National Standards Institute (ANSI).

1.5 PROJECT 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 responsibility of the contractor.

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

The IDP is also a member of the Hanford Personnel Dosimetry Advisory Committee (HPDAC). The HPDAC is an advisory body consisting of RL, contractor, and dosimetry project representatives, and is established to review substantive current issues and proposed changes to Hanford personnel dosimetry programs. Its purpose is to identify technical, political, and/or administrative issues necessary for maintaining long-term continuity of such programs, and to ensure technical quality and consistency of dosimetry practices. Decisions and recommendations made by the HPDAC are not binding on the IDP, but carry significant weight.

1.6 CONTENTS OF THIS MANUAL

This document, the Hanford Internal Dosimetry Project Manual, is one of three programmatic documents of the IDP. The other two are the Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1991), which is hereafter referred to as the Technical Basis, and the Hanford Internal Dosimetry Procedures Manual (PNL-MA-565). The purpose, scope, and interrelationship of these three documents is described in Chapter 9.0.

This manual also describes

- the policies upon which the design and operation of the IDP are based (Chapter 2.0)
- 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)
- the available bioassay services and instructions for obtaining them (Chapter 6.0)
- the IDP response to potential internal exposure incidents (Chapter 7.0)
- the quality assurance and quality control features of the IDP (Chapter 8.0)
- 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 tables of data field codes used in the REX database. 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. Appendix E contains the Hanford Internal Contamination Incident Response Plan.

1.7 APPLICABILITY OF THE CURRENT REVISION

This revision of the Hanford Internal Dosimetry Project Manual supersedes all previous versions, and incorporates or supersedes all applicable Program Change Records through the date that this revision was issued.

2.0 PRACTICES OF THE HANFORD INTERNAL DOSIMETRY PROJECT

It is IDP policy to comply with DOE Orders and the Hanford Site Radiological Control Manual (RL 1992). 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.

This chapter describes the conduct of the IDP and provides for interpretation of applicable regulations and guidance for use at Hanford. The Hanford Personnel Dosimetry Advisory Committee (HPDAC) has reviewed and concurred with these practices. Modifications to them require advisory review by the HPDAC.

2.1 ASSESSMENT AND DOCUMENTATION OF INTERNAL DOSE

This section presents criteria used to assess, document, and revise internal doses at Hanford.

2.1.1 Criteria for Assessing Internal Dose

Assessment of potential internal exposure is conducted for

- any potential occupational intake reported to PNL Internal Dosimetry staff by site radiation protection organizations
- any bioassay measurement that indicates a potential occupational internal exposure, not previously evaluated, resulting in a 12-month annual internal effective dose equivalent greater than 10 mrem
- any "baseline" bioassay measurement that indicates any detectable intake not previously evaluated and that is not readily associated with a nonoccupational source
- any employee, hired by RL or a DOE contractor, who has incurred an occupational internal exposure.

2.1.1 Criteria for Assessing Internal Dose (contd)

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

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

A potential intake is considered to be confirmed if

- a bioassay result exceeding the decision level and the screening level is associated with a known incident, or
- a bioassay result exceeding the decision level and the screening level is followed by two consecutive bioassay measurements, one of which exceeds the decision level or screening level.

If confirmatory follow-up measurements are not obtained following a bioassay result that exceeds the decision and screening levels, an intake will be assumed to have occurred unless there is overriding evidence that one did not. In this circumstance, the assumption on an intake is taken as "confirmation" and any appropriate internal doses will be calculated, recorded, and reported. The overriding evidence must be discussed in the evaluation.

Hanford visitors who receive "baseline" bioassay measurements that detect radioactivity and have "ending work" measurements consistent with their baseline measurements will not have their prior occupational dose assessed by Internal Dosimetry unless the site contractor requesting the measurements specifically requests Internal Dosimetry to do so. Instead, the requesting site contractor and PNL's Hanford Radiological Records Project (HRRP) staff will be notified by letter of the activity detected.

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.

CEDEs Less Than 500 mrem

If the available evidence suggests that the Committed Effective Dose Equivalent (CEDE) from an intake does not exceed 500 mrem and specific information is not readily available, generalized (default) models and assumptions may be used 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 to the potential exposure period for acute intakes or through 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 the Reference Man or Woman in ICRP 23 (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.
- Current guidance in the Hanford Site Radiological Control Manual (RL 1992) requires that the dose to the embryo/fetus be calculated separately from the dose to the mother. The recorded internal dose to an embryo/fetus is

2.1.2 Dose Assessment Practices (contd)

CEDEs Less Than 500 mrem (contd)

calculated as the sum of the dose equivalent to the embryo/fetus from radionuclides deposited in the embryo/fetus and the dose equivalent to the embryo/fetus arising from radionuclides deposited in the declared pregnant woman. For most radionuclides, the dose to the embryo/fetus will be similar to or less than the dose to the corresponding maternal tissues.

CEDEs Above 500 mrem

At projected CEDEs above 500 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.
- Consideration may be given to individual-specific physiological characteristics.

Recording Doses

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 a CEDE exceeding 100 mrem or for any organ receiving an annual dose equivalent of more than 100 mrem. (For radionuclides such as tritium and radiocesium, which provide dose homogeneously to all organs, the dose may be recorded as whole body dose; however, it is understood that the same dose applies to all organs.)
- The CEDE will be assigned to the year of intake. If the associated organ dose exceeds 100 mrem committed dose equivalent, the committed organ dose equivalent will also be recorded in the year of intake.

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 lists the assessed dose equivalents. A copy of the documented assessment is provided to HRRP for placement in the worker's radiation exposure 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.

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 initiated the preceding year for which final assessments have not been completed.

Chronic internal exposures are assessed on a calendar-year basis for continuing exposures.

2.1.4 Dose Assessment Revisions and Updates

The dose assessment for an active worker with a prior intake will be reviewed and updated every five years if the assessed dose from any or all intakes in a year is greater than 1.0 rem CEDE and if the principal radionuclide has an effective half-life in any assessed organ of greater than one year. After the first update, a decision on the feasibility of another five-year update will be made, depending mostly on whether future bioassay measurements would be expected to contain detectable activity.

Assessments for active workers are revised when information demonstrates a change in the currently assessed committed effective dose equivalent of 0.5 rem or a factor of 1.5 of the previously assigned dose for that intake, 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 form 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 HPDAC.

2.2 INTERNAL DOSE REPORTS

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

2.2.1 Reports Provided to Contractor Dosimetry Organizations

Final exposure evaluation reports are provided to contractor dosimetry organizations upon completion of internal exposure evaluations. Preliminary reports (verbal or written) are provided upon request. The reports contain the following information:

- 50-year CEDE for the assessed exposure
- year of intake
- facility at which intake occurred
- any long-term follow-up bioassay recommendations.

2.2.2 Reports Provided to the Hanford Radiological Records Project

The IDP will provide internal dose information to the Hanford Radiological Records Project through the Radiation Exposure System (REX).

2.3 BIOASSAY MONITORING PROGRAM

Internal Dosimetry provides – to the extent that Hanford Site contractors and the RL will support and that technical capabilities will allow – a bioassay monitoring program capable of detecting an intake potentially resulting in a CEDE of 100 mrem.

Facility-specific radionuclide mixtures and characteristics are considered in the development of the bioassay monitoring program. Bioassay capabilities are optimized, considering sensitivity requirements and costs.

2.4 PROJECT 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.

Changes in practices and recommendations presented in the document are by Program Change Records. Each Program Change Record is distributed to program clients and the RL program monitor. A copy of the record is maintained in the Historical Files.

The following items are also documented or referenced in the Historical Files:

- operating procedures
- technical bases
- biokinetic models
- computer codes
- In Vivo Radioassay and Research Facility (IVRRF) Statement of Work
- Excreta Laboratory Statement of Work.

3.0 INTERNAL DOSE ASSESSMENT

The process of assessing internal dose 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:

- identifying a potential exposure
- collecting exposure information
- evaluating and documenting dose equivalent.

A successful internal exposure assessment effort at Hanford depends on the support of both the contractor dosimetry organization (i.e., Field Dosimetry) and the IDP. 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.

Evaluating the data, assessing internal dose, and documenting 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, is 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:

- preliminary evaluation
- final evaluation
- reevaluation.

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. A preliminary evaluation will also be issued by February 1 for evaluations initiated in the preceding calendar year.

Final Evaluation

A final evaluation represents the conclusion of the internal dose assessment process based on the follow-up investigation. (See Exhibit 3.1, Internal Dose Evaluation Report Form, at the end of this chapter.) 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 report ranges from 1 month, for simple cases, to 1 year, for complex cases requiring long-term bioassay data. Final evaluations may be revised by issuing a reevaluation report if additional evidence is obtained affecting the conclusion of the previous final evaluation.

Reevaluation

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

3.1.3 General Approach

Internal dose assessments 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 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.

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 investigating the potential exposure, documenting the results, and reporting conclusions. Figure 3.1 depicts the steps that make up the complete assessment process.

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.)
Special (nonroutine) bioassay measurement shows detectable activity above natural background.	Measurement results indicate internally deposited radionuclides.
Routine bioassay measurement shows activity.	Measurement results exceed the screening level of the routine bioassay monitoring program. (See Appendix A.)
Bioassay result for a worker with a known internal deposition shows an unanticipated increase.	When recent and previous known bioassay measurements are compared, 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 CEDE may be in error by 0.5 rem or a factor of 1.5 of the previously assigned dose, whichever is higher.
Field Dosimetry requests a special internal dose assessment.	Request by Field Dosimetry.
Prior work history or baseline 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.

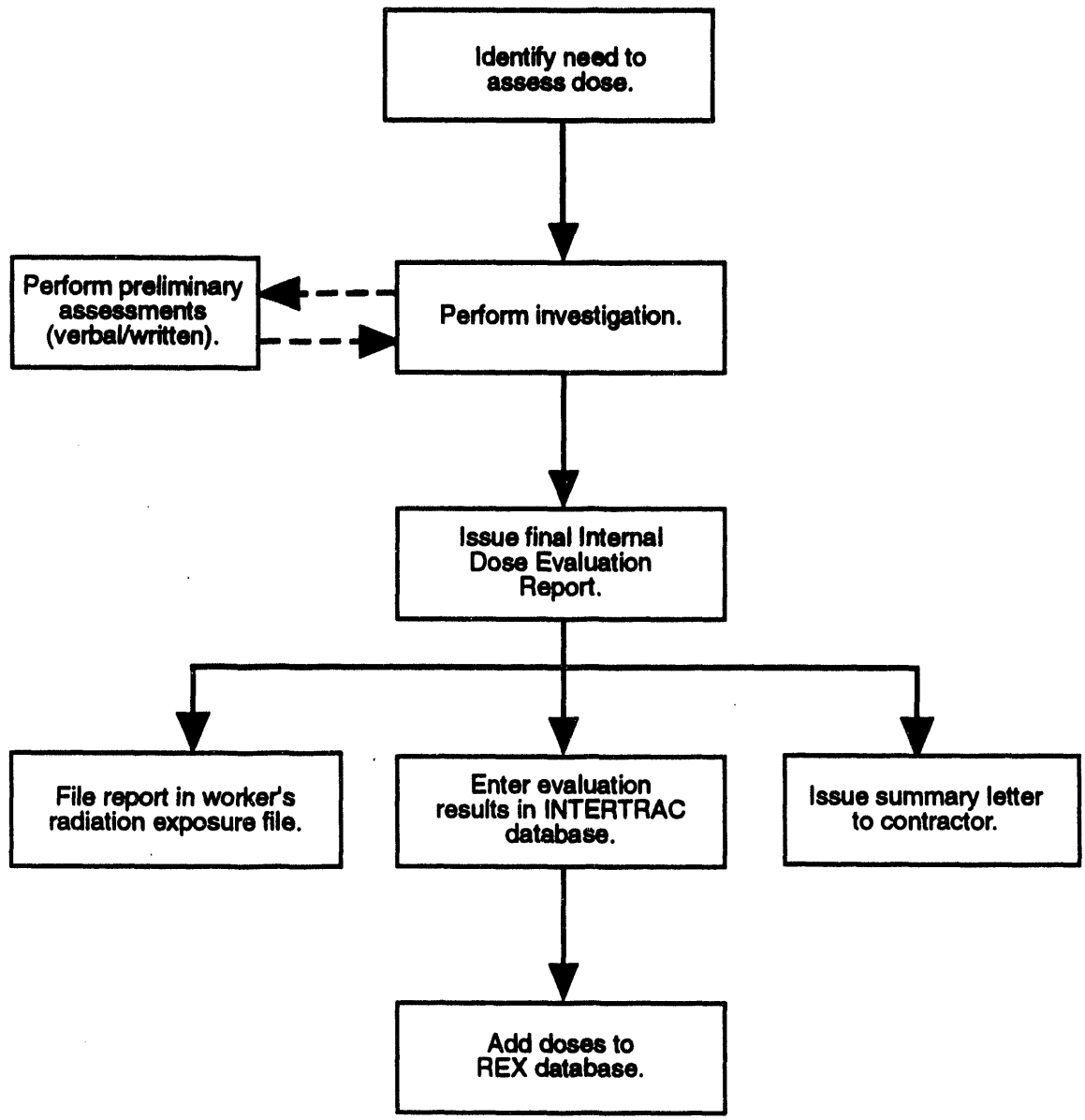

FIGURE 3.1. Internal Dose Assessment Process

3.2.1 Investigation

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

Special 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 special 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 measurements depend on the significance and complexity of the exposure case.

Special 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 special bioassay measurements can be decreased with time post-intake, until, for long-retained nuclides, the measurements can be continued on an annual monitoring frequency. It is recommended that special bioassay measurements continue until the measurement results are consistently less than detectable or below the screening level established for routine bioassay monitoring. Other information which may be important to the assessment is listed in Table 3.2.

The investigation determines that either an intake did or did not occur. If the conclusion is that an occupational intake did occur, the magnitude of the intake or deposition and the committed effective dose equivalent (CEDE) are determined and assigned. Annual doses may also be determined and assigned. If an occupational intake is not confirmed, no dose is assigned.

TABLE 3.2. Information Supporting the Internal Dose Assessment

Information Type	Examples
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 Radionuclides 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 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 one 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

Internal Dose Evaluation Report

Occupational internal exposures to radionuclides are assessed and formally documented through the Internal Dose Evaluation Report. This 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 report.

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

Exhibit 3.1 (at the end of this chapter) shows the form used to document Internal Dose Evaluation Reports. 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 included with the 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 next 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 evaluation number may also be referred to as the Dose Evaluation Management System (DEMS) number, which is used to track evaluations.

3.2.2 Documentation (contd)

Internal Dose Evaluation Form (contd)

The following information is provided in the evaluation report:

- the evaluation number
- the worker's name, payroll number, and social security number
- the date or period of exposure (actual or assumed)
- the area and building where the exposure occurred or is assumed to have occurred
- a summary of the exposure scenario, if known
- mode(s) of intake (actual or assumed)
- radionuclides addressed by the assessment.

The evaluation report also contains

- a summary of data used in the assessment
- a description of assessment methods and assumptions
- CEDEs
- the committed dose equivalent to organs meeting the criteria in Section 2.1.2
- references, as required
- the author's name and signature
- the peer reviewer's signature.

3.2.3 Assessment Reporting

Summary Letter

A letter summarizing the conclusions of the evaluation is sent to Field Dosimetry. The evaluation report and a copy of the summary letter are sent to the HRRP Library for inclusion in the worker's radiation exposure file.

3.2.3 Assessment Reporting (contd)

Summary Letter (contd) The summary letter contains the following information:

- the worker's name and payroll number
- the date or period of the exposure(s)
- the area and building where the exposure occurred
- the assigned CEDE(s)
- recommendations for further follow-up sampling.

A copy of the evaluation report will be provided to Field Dosimetry upon request. Currently, Hanford employees seeking a copy of their evaluation reports should request copies through Field Dosimetry. Requests from former Hanford employees are processed by the HRRP staff.

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 document (see Chapter 9.0). The methods and approaches used for investigating, evaluating, and reporting internal dose assessments are summarized in this section. These "default" methods are used unless available information points to a more appropriate method or assumption. If methods and techniques 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 content and retention patterns are preferred to indirect (excreta) methods that require the use of excretion functions and biokinetic models.

3.3.1 General Approach (contd)

Assumptions used in the dose assessment process should be conservative but realistic. Caution should be exercised when multiple conservative assumptions are compounded. 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. However, 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, appropriate conservative assumptions should be used. For particle size input to the biokinetic model of the respiratory tract, the default particle size input is 1.0 μm AMAD (activity median aerodynamic diameter). For transportability class input to the model, the transportability characteristics should be determined based on the known or

3.3.3 Solubility and Particle Size Assumptions (contd)

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 that are 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 beta, gross alpha), 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 radiation exposure file, but is not used for determining compliance with either stochastic or nonstochastic dose equivalent limits. This approach is analogous to the approach required by the Hanford Site Radiological Control Manual (RL 1992) 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.

Respiratory Tract Model

The general model for the respiratory tract presented in ICRP 30 (1979) is used to evaluate retention and elimination of inhaled particulates by the respiratory system.

3.3.6 Biokinetic Models (contd)

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 (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. The codes 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.
CINDY	A dosimetry code specifically developed for implementing DOE 5480.11 (1989) internal dose provisions.
GENCOMP	A code to solve first-order differential equations for catenary compartments using a wide variety of input options for the first compartment.

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 bioassay program design
- initial dose assessments when available bioassay and other data regarding the exposure are minimal
- 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 CEDEs 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 500 mrem CEDE, then models, methods, and assumptions are reviewed to determine their applicability.

3.3.9 Dose Assessment Flowcharts

Flowcharts have been developed to guide the assessment process for several situations where doses are usually small and may be complicated by the fact that sources might be environmental rather than occupational. These flowcharts were developed to allow practical decisions to be made without severely impacting the worker or the work when the consequences of a wrong decision are small. The following flowcharts and supporting items are provided at the end of this chapter:

Exhibit	Title
3.2	Determining Occupational and Nonoccupational Intakes
3.3	Baseline Samples - Tritium
3.4	Baseline Samples - Elemental or Isotopic Uranium
3.5	Assessing Chronic Exposure - QUS
3.6	Detection of Cesium-137 in the Whole Body Exam
3.7	Cesium-137 Questionnaire

3.3.10 Internal Dose Assessment to the Embryo/Fetus

The internal dose to the embryo/fetus considers contributions from radionuclides deposited in the embryo/fetus and dose equivalent arising from radionuclides deposited in the declared pregnant woman. Until better information is available, the dose calculation methods described in the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 8.36, "Radiation Dose to the Embryo/Fetus" (NRC 1992), shall be used.

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 IDP 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

3.4 GOOD PRACTICE RECOMMENDATIONS FOR FIELD DOSIMETRY (contd)

Dosimetry as 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, the program should be established by radionuclide and exposure scenario, rather than by measurement type. General guidance on the needs of the bioassay monitoring program 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.

- Maintain procedures for collecting workplace and personnel monitoring data, evaluating the data, documenting the results, and maintaining records.

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. Special bioassay measurements are required if a worker incurs a potential intake of 0.02 ALI in an incident or over a short period of time.

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 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 committed dose from internal exposure significantly impacts administrative control levels.
- 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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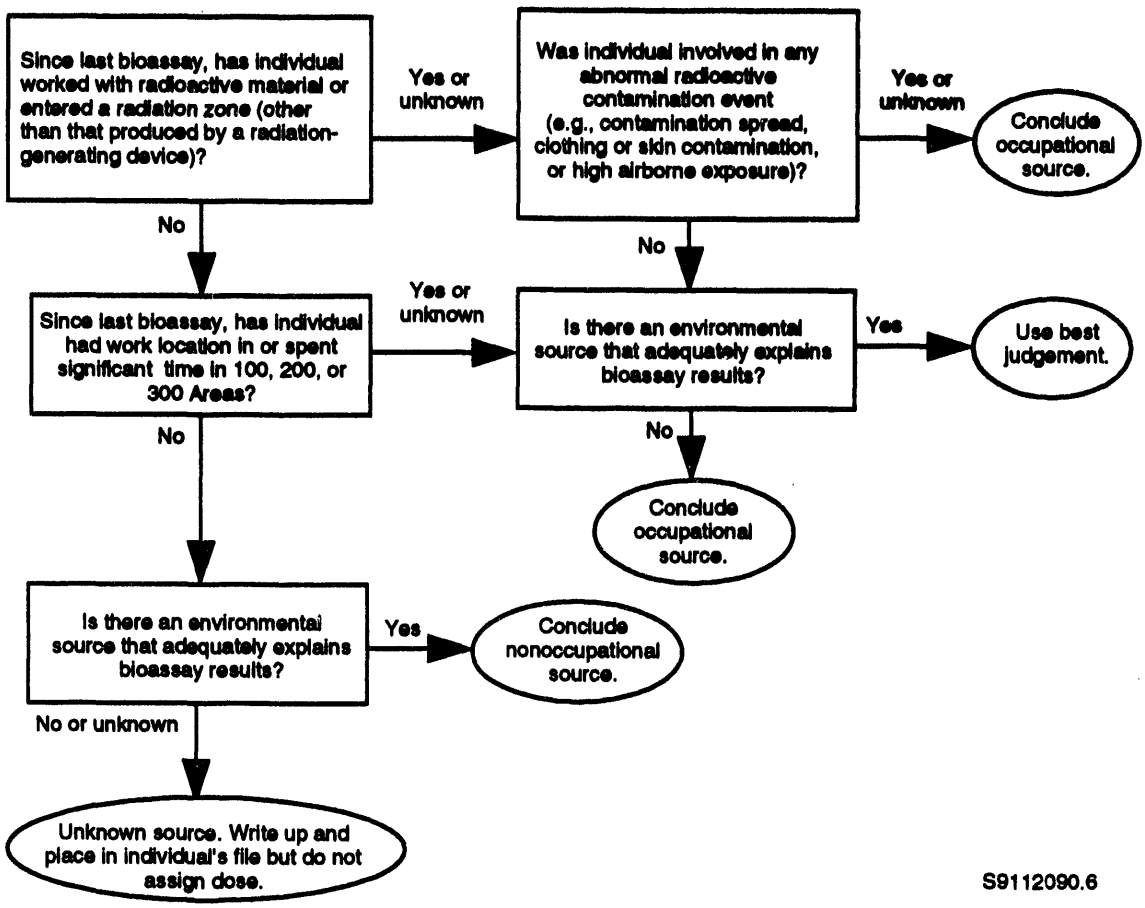
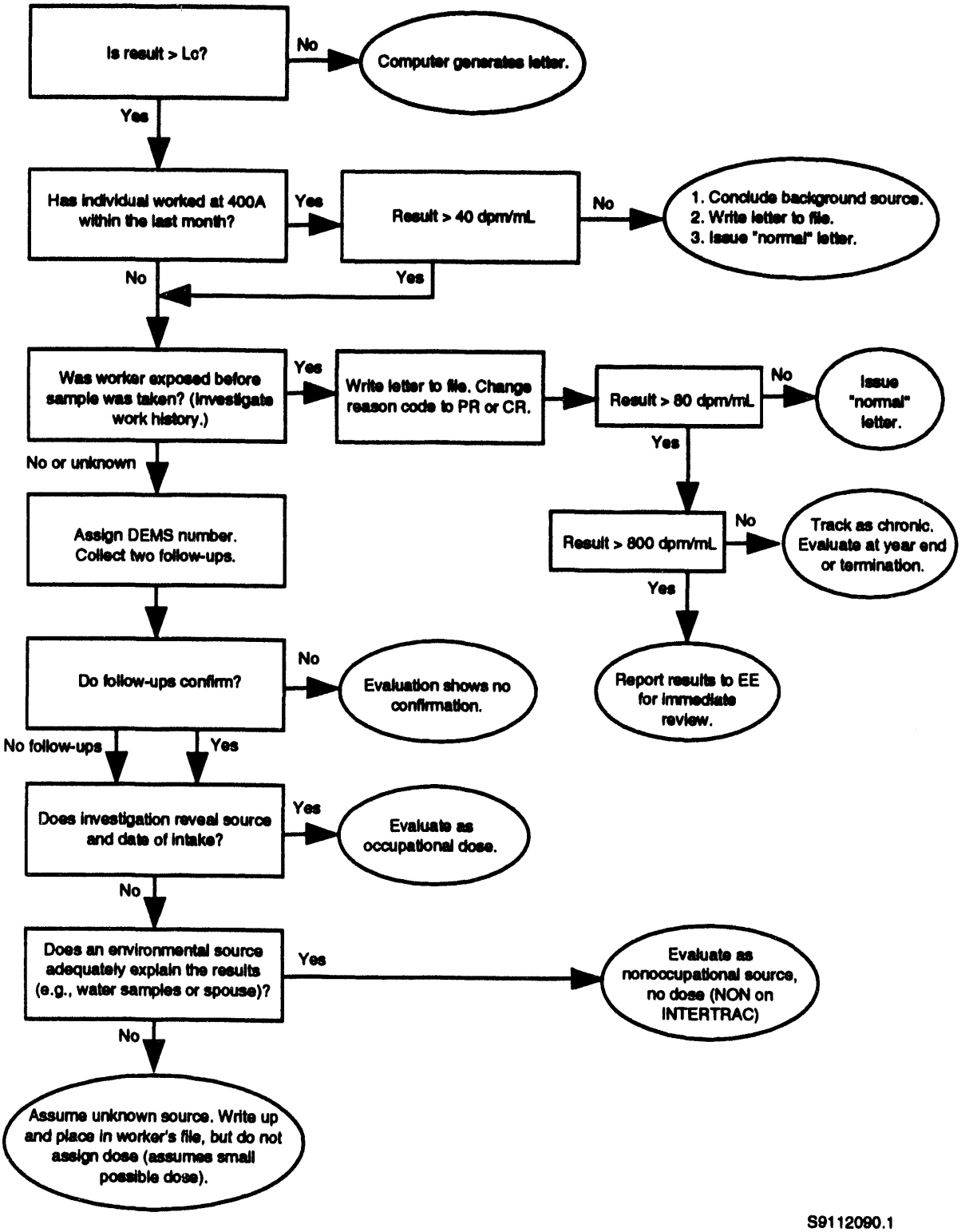
EXHIBIT 3.2. Determining Occupational and Nonoccupational Intakes*



*Does not apply to ^{241}Am or plutonium because of possible increases over long time periods.

EXHIBIT 3.3. Baseline Samples - Tritium



S9112090.1

EXHIBIT 3.4. Baseline Samples - Elemental or Isotopic Uranium

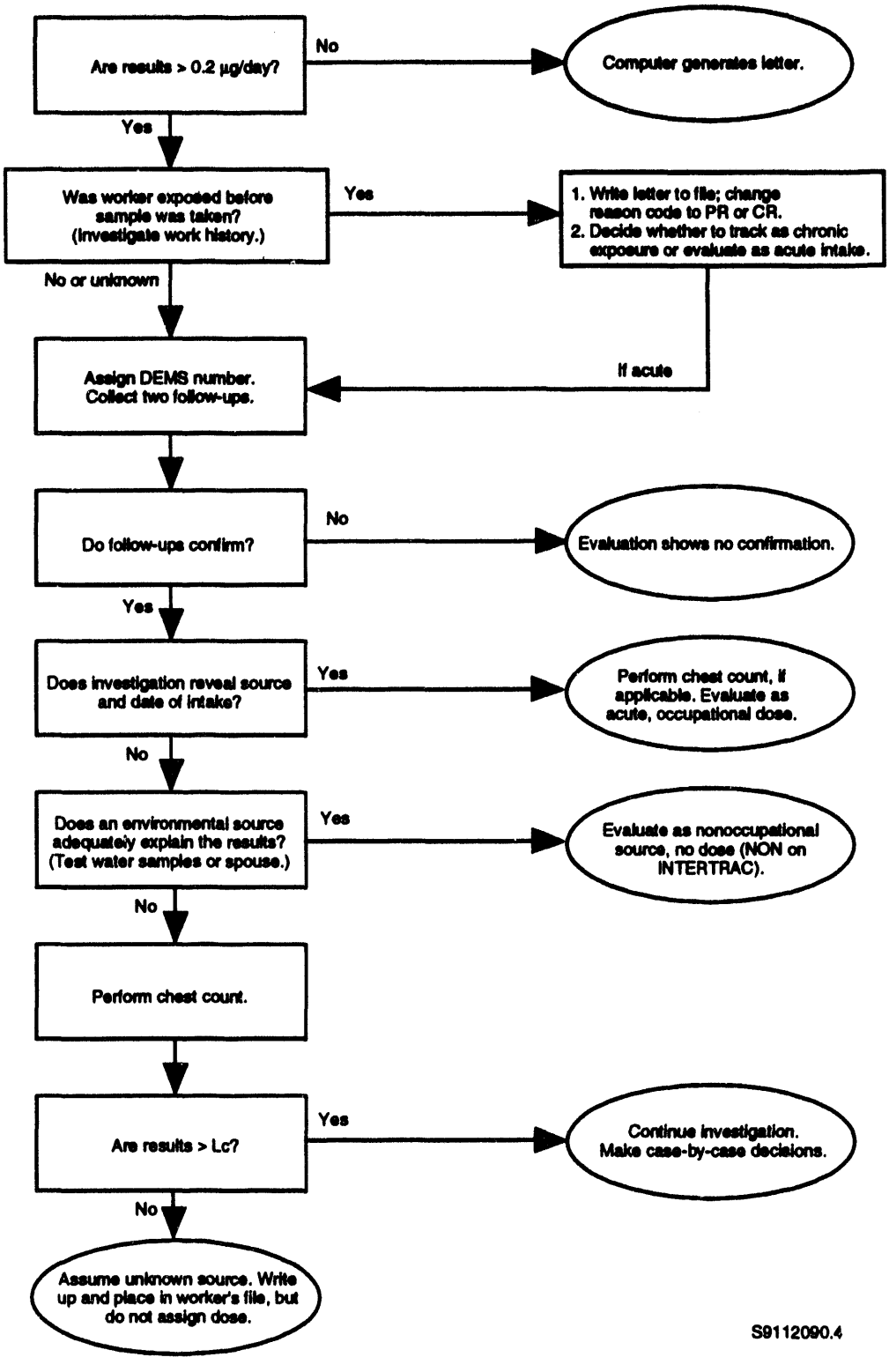
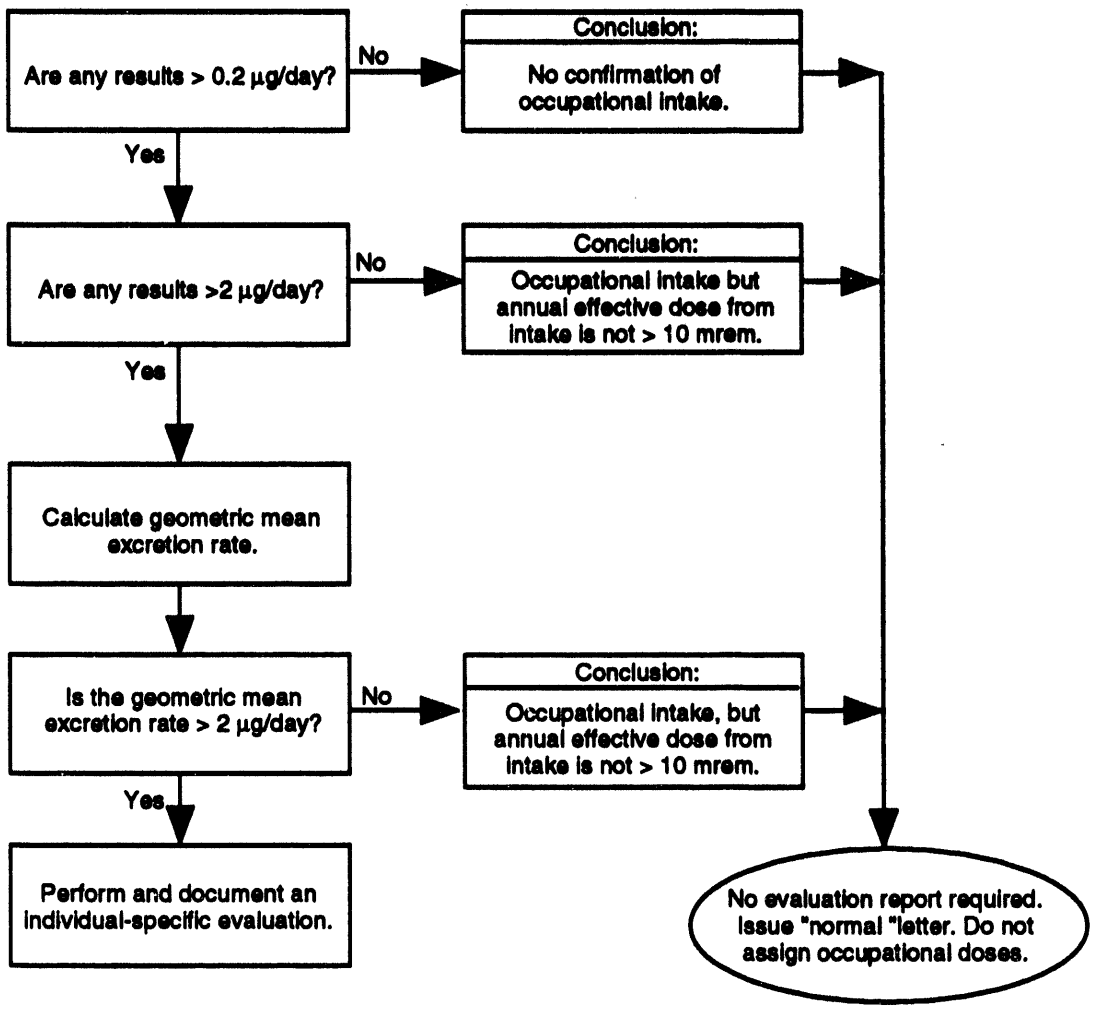
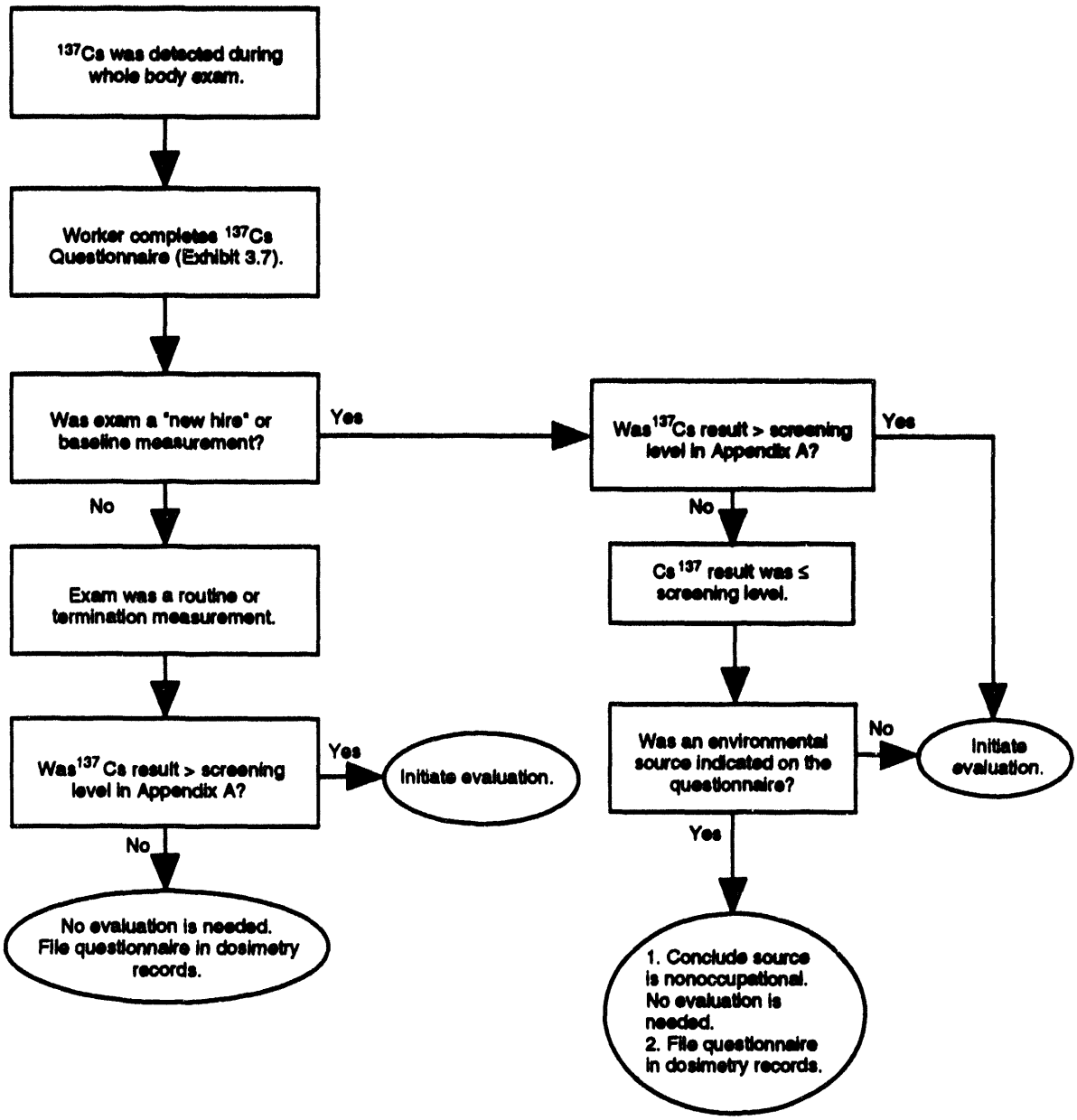


EXHIBIT 3.5. Chronic Exposure Assessment - QUS



S9112090.3

EXHIBIT 3.6. Detection of Cesium-137 in the Whole Body Exam



S9112090.2

EXHIBIT 3.7. Cesium-137 Questionnaire

CESIUM-137 QUESTIONNAIRE

Name: _____ Payroll No.: _____

Contractor: _____ Date of WBC: _____

Your whole body count (WBC) on the above date detected the presence of a small quantity of cesium-137. This isotope can result from environmental as well as occupational sources. Please answer the following questions to help determine the follow-up required.

1. Have you recently (last two years) been to Europe or Russia? YES NO

   If YES, please describe:

   Locale visited/resided: _____

   When were you there: _____

   Any potential occupational contact with radioactive material while you were there:

   _____

2. Do you eat wild "big game" meat? (e.g., deer, elk, etc.) YES NO

   If YES, please describe:

Type of Game	Where Bagged	How often do you eat it?	How much do you eat?

3. Since your last whole body exam, have you been involved in any personal contamination or other radiological incidents? YES NO

   If YES, please describe:

Type of Incident	Isotope(s) Involved (if known)	Date(s) (may be approximate)

4. If you wish to make any additional comments that you think might be helpful in determining source of the detected cesium-137, please note them here:

   _____

   _____

   _____

   _____

   _____

Please sign and date this form as indicated below. Return it to the technician who gave it to you or mail it to Internal Dosimetry at MSIN No. A3-60. If you have any questions, contact your dosimetry representative.

_____ _____

Your Signature Date

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EXHIBIT 3.7. Cesium-137 Questionnaire (contd)

FOR INTERNAL DOSIMETRY ONLY

☐ Nonoccupational Source ☐ Below Occupational Screening Level ☐ Investigation Needed

Comments:

Internal Dosimetry _____ Date _____

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4.0 RECORDING AND REPORTING INTERNAL DOSES

Reports of occupational dose equivalent are required as specified in the Hanford Site Radiological Control Manual (RL 1992) and in DOE Orders 5480.11 (1989) and 5484.1 (1981). The occupational dose equivalent is composed of the dose equivalent received from external sources of radiation and internally deposited radionuclides. This chapter provides information on the recording and reporting of the internal dose component, as performed by the IDP. Assessed internal doses are provided to the Hanford Radiological Records Project (HRRP). After compiling the data, HRRP prepares the occupational dose reports.

4.1 INTERNAL DOSE RECORDS

Evaluation Report

The official record of internal dose is the Internal Dose Evaluation Report. Section 3.2.2 ("Documentation") describes the contents of this report, which is issued for each assessed internal exposure. Completed reports are maintained by HRRP in the radiation exposure files.

4.2 INTERNAL DOSE DATABASE

INTERTRAC-REX

Dose information from Internal Dose Evaluation Reports is maintained by the HRRP in the INTERTRAC (Internal Dose Tracking System) subset of the REX computer database. INTERTRAC contains annual and committed organ and effective dose equivalent information from the Internal Dose Evaluation Report for each assessed intake. This information is used to generate dose summaries for tracking and reporting occupational doses to individuals. REX provides online access to recorded internal doses for all active Hanford workers. Each contractor has access to files for their own employees.

INTERTRAC-Paradox

A backup of the INTERTRAC-REX data is separately maintained by Internal Dosimetry using the Paradox database software. INTERTRAC-Paradox preceded the REX system and was the database from which the INTERTRAC-REX data were loaded. At this time, it serves only as a backup to the REX system.

4.2 INTERNAL DOSE DATABASE (contd)

INTERTRAC-Paradox (contd)

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

4.3 REPORTS OF INTERNAL DOSE

Evaluation Summary

Summary 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. Contractor dosimetry organizations should communicate the information in the summary letter to the affected worker.

Dose Summaries

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 HRRP. Special requests for internal dosimetry information may be made to the IDP.

Chronic Exposure

Several groups of Hanford workers are considered to be chronically exposed to radionuclides during the course of their work. Typically, these groups include those individuals working with tritium or 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 for those workers having routine bioassay results that suggest an annual internal effective dose that could exceed 10 mrem, or for those workers having a baseline bioassay result that exceeded the decision level and that resulted in initiation of an evaluation (see the exhibits in Section 3.0 for flowcharts detailing conditions requiring initiation of an evaluation). Throughout the year, the routine bioassay measurements are reviewed and the contractor is advised if there is an indication that the committed 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 (1979) and ANSI N13.6-1966 (ANSI 1966), Practice for Occupational Radiation Exposure Records Systems. Access to the records is provided through HRRP, as follows:

- Current employees may contact their company's radiation protection representative, who will arrange to obtain the requested records.
- Individuals may request their records either in person or by mail. Verbal requests are not accepted.
- Employers requesting records of current or former Hanford workers should contact HRRP.
- Requests by the U.S. Transuranium Registry should be made by contacting HRRP.
- 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 HRRP.

In the above cases, the following items 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 REX 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.

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

The Hanford Site Radiological Control Manual, or HSRCM (RL 1992), requires workers to participate in a bioassay program if they are likely to receive intakes in a year resulting in a committed effective dose equivalent (CEDE) of 100 mrem or more. The HSRCM further specifies particular criterion for participation in periodic, baseline, termination (or end of assignment), and special bioassay monitoring. Elaboration on the technical basis of some of these criteria is provided in the following subsections.

Periodic Bioassay

Article 521 of the HSRCM requires workers to participate in periodic bioassay monitoring under the following conditions:

- Worker uses respiratory protection device for radiological protection
- Work in a High Contamination Area involves contact with or disturbance of contamination
- Work with unencapsulated radioactive material exceeding the values listed in Table 5.1. If such work is limited to observing, supervising from a distance, or entering the room without contacting the material, then bioassay is not required unless workplace monitoring indicates that a loss of material control occurred.
- Work with contaminated soil at or exceeding the values listed in Table 5.2
- Exposure to low-level airborne activity below posting requirement such that the total exposure for a year would exceed 40 DAC-hours.

TABLE 5.1. Amount of Radioactive Material Requiring Bioassay Monitoring[a]

Type of Material[b]	Activity Requiring Bioassay (μCi)		
	Bench Top	Fume Hood	Glovebox
Pu, Am-241, Pu mixtures with Am	0.1	1.0	10
Uranium, very soluble, class D	300 mg	3E3 mg	3E4 mg
Uranium, moderate to insoluble, class W or Y	1.	10	100
Mixed fission/activation products	4E2	4E3	4E4
Strontium-90, insoluble, class Y	80	800	8000
Radioiodines, half-life > 1 day < 1 year	8E3	8E4	8E5
I-129	2E3	2E4	2E5
Tritium (HTO and HT) (nucleotide precursors)	1E4	1E5	1E6

(a) Involves actually working with or contact with the material. Not intended to include occasional observation, unrelated work in the same room, or other activities involving much less risk of contamination.

(b) For other types of radioactive material, other containments, or unique situations, consult with company internal dosimetry organization for guidance.

TABLE 5.2. Criteria for Bioassay Monitoring for Work Involving Exposure to Contaminated Soil[a]

Nuclide, Form[b]		Soil Contamination (pCi/g)[c] Acute[d]	Chronic[e]
Uranium - Total[f]			
	class D or W	40,000	1,000
	class Y	3,000	70
Pu-α	class W	400	20
Th-232	class W	60	2
Th-228	class W	600	20
Sr-90	class D	1E+06	4E+04
Cs-137	class D	2E+07	4E+05
Co-60	class Y	2E+06	5E+04
Tritium in groundwater[g]		5,000 μCi/L	1,000 μCi/L

(a) Criteria are established for two potential scenarios. "Acute" implies normally not exposed to contamination but potential exists for a single, heavy exposure. "Chronic" implies frequent exposure to less dusty conditions. Bioassay would be required if either scenario applied to a worker.
(b) For other nuclides or chemical forms, consult with company internal dosimetry organization for guidance.
(c) Units apply to uniform concentrations representative of the soil being disturbed, not to small spotty contamination.
(d) Assumes a 360-mg inhalation intake of dust in a single exposure.
(e) Assumes a 48-mg/day inhalation intake rate for 250 working days/year.
(f) U-natural, U-234, U-235, or U-238 in any combination. Based on recycled uranium common at Hanford. Same numbers apply for uranium in units of ppm or μg/g soil.
(g) Assumes consumption of one cup (acute) or one cup per day of groundwater at indicated contamination.

5.1 CONDITIONS FOR MONITORING WORKERS (contd)

Periodic Bioassay (contd)

The HSRCM permits end-of-assignment monitoring in lieu of periodic monitoring if the work period is shorter than the periodic interval.

Additional consideration for periodic bioassay programs should be given to the following:

- Knowledge of or prior experience with the work performed or the facility involved.
- Workers who are subjected to a wide range of potential internal exposure conditions.

Baseline and Termination Bioassay

The HSRCM (Article 522) also identifies the following particular circumstances under which baseline and termination bioassay monitoring is required:

- Baseline monitoring is required if a worker had previous exposure to radionuclides relevant to future work at Hanford or if the exposure history is missing or inconclusive.
- Baseline monitoring is required if a worker is going to work with radioactive material that is frequently detectable from nonoccupational sources, regardless of prior exposure.
- Termination or end of assignment bioassay monitoring is required for any worker who participated in or qualified for participation in bioassay monitoring, unless it is documented in the worker's radiation exposure file that the worker was not potentially exposed to unencapsulated material in the workplace.

Special Bioassay

Special bioassay is required (by HSRCM Article 522) under any of the following conditions, unless the intake was caused by radon daughters (also see Table 7.1):

- Facial contamination indicates a potential for intake.
- Nasal contamination.
- Air monitoring indicates the potential for intakes resulting in a CEDE exceeding 100 mrem.

5.1 CONDITIONS FOR MONITORING WORKERS (contd)

Special Bioassay (contd)

- An unplanned intake is suspected for any other reason.
- Results for periodic or end-of-assignment work indicate an unexpected intake resulting in a CEDE of 100 mrem or more.

Special bioassay is also required by HSRCM Article 541 if skin contamination can result in an intake. The levels of skin contamination requiring special bioassay are listed in Table 7.1.

DOE 5480.11

Participation in an internal dose evaluation and routine bioassay monitoring programs is also required by Section 9.g.(2) of DOE 5480.11 (1989), which requires that programs be adequate to demonstrate compliance with the dose equivalent limits. The criteria of DOE 5480.11 for participation in a bioassay program have been superseded by the more specific and more conservative requirements of the HSRCM.

The DOE 5480.11 requirement to demonstrate internal dose compliance with the dose equivalent limits is interpreted to mean that the dosimetry program must be capable of identifying and assessing CEDEs of 5000 mrem. Because total effective dose equivalent (TEDE) includes external dose as well as the CEDE, the design goal for dose assessment at Hanford is to be able to identify and confirm an intake resulting in 100 mrem CEDE. For some circumstances (e.g., class Y forms of plutonium and uranium) this goal can only be achieved through special (nonroutine) bioassay monitoring, promptly initiated by workplace indicators.

General Recommendation Based on Committed Dose

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

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

5.1 CONDITIONS FOR MONITORING WORKERS (contd)

General Recommendation Based on Committed Dose (contd)

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 5.3.

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:

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

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

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

TABLE 5.3. Derived Air Concentrations and Annual Limits on Intake for Common Radionuclide Mixtures

Radionuclide Mixture[a]	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.

5.1.2 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 5.3.

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 (1979).

5.1.2 Annual Limit on Intake (contd)

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 5.4 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:

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

where ALI is the annual limit on intake. Potential intake fractions are listed in Table 5.4 as a function of the type of containment and physical form. The information in Table 5.4 should be considered for general guidance only. Actual facility experience should be used when possible. This approach was used to derive the amount of radioactive material shown in Table 5.1 as requiring bioassay monitoring.

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.

TABLE 5.4. 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).

5.1.4 Worker Group Monitoring

Worker group monitoring can be a suitable alternative to individual worker monitoring for working situations with very low potential for intakes or where doses from any intakes would be quite small. The approach is to monitor only a representative portion of the workers on a rotating basis. With this program design it is assumed that all workers have the same risk for exposure in any period, and that a bioassay result for one worker can be taken as characteristic for the entire group.

Worker group monitoring can be used in one of two ways. First, it can be used as an expedient method for verifying that workers do not require being on an

individual-specific bioassay program. Secondly, it can be used to provide data for low-level chronic exposure situations where a combined set of bioassay data from many workers is used to assign doses to individual workers.

Consistent with recommendations of the NCRP (1987), the following guidance is offered for establishing the magnitude of a worker group bioassay monitoring program:

Worker Population	Number Monitored
>120	10%
12 to 120	12%
<12	All

If a screening level applied to a worker group is exceeded and an intake is confirmed, then all members of the group should be placed on individual bioassay programs, unless an investigation shows that just the one worker was exposed due to unusual circumstances.

5.1.5 Environmental Restoration and Remediation Activities

Special criteria have been developed for application to environmental restoration and remediation (ER) work at Hanford. This work may involve short-term soil sampling activities, excavation of dirt, transport of contaminated soil, or sample well or monitoring borehole drilling operations. The soil involved may range from essentially uncontaminated overburden at burial grounds to soil contaminated with a wide range and magnitude of radionuclides at liquid effluent disposal sites such as cribs or ponds.

Criteria for two types of exposure conditions were addressed: the single job involving acute exposure to very high dust loadings in air near the worker tolerance level for dust, and the long-term job involving chronic exposure to moderately high dust loadings. The acute exposure assumed a 360-mg inhalation intake (e.g., 2 hours of exposure to 150 mg/m^3 dust loading) of 1-μm-AMAD dust. The chronic exposure assumed an inhalation intake rate of 48 mg/day of 1-μm-AMAD dust for 250 working days/year (e.g., 2 h/day exposure to a 20-mg/m^3 dust loading.

5.1.5 Environmental Restoration and Remediation Activities (contd)

Soil contamination criteria are shown in Table 5.2. As long as the geometric mean soil concentrations do no exceed those listed, worker bioassay measurements are not required. Use of the arithmetic mean soil concentration (as a convenient substitute for the geometric mean) is acceptable, and will result in conservative determinations of the need for bioassay. The soil concentration values shown are for the most restrictive inhalation class considered likely to be encountered.

In addition, based on the highest measured tritium contamination levels in Hanford groundwater, there is no need for workers to be on a tritium bioassay program. Tritium bioassay for ER work need not be considered unless concentrations in water exceed 1000 μCi/L.

Exposure to multiple radionuclides must address the additive impact of all nuclides. The need for bioassay can then be established by calculating an "index for bioassay" value as the sum of the ratios of each nuclide to its respective criterion value, as shown below:

$$\text{Index for Bioassay} = \frac{\text{conc. 1}}{\text{criteria 1}} + \frac{\text{conc.2}}{\text{criteria 2}} + \text{etc.}$$

If the index value exceeds one, then a bioassay program should be established. The issue of what type of bioassay to perform remains. Where sources consist of a single contaminant, the choice is generally obvious. If multiple contaminants are involved, the predominant nuclide may be the best choice. However, some bioassay procedures are substantially more sensitive than others, and if one nuclide can be used as an indicator for another (because of known source interrelationships), then a more sensitive bioassay procedure for a less predominant radionuclide may be adequate. IDP staff can be consulted for advice on specific situations.

5.1.5 Environmental Restoration and Remediation Activities (contd)

Further details on these criteria are provided in the supporting report.[a]

5.1.6 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 may add significantly to dose in outyears and the 50-year committed dose.

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

(a) Letter report to T. J. Kelly (WHC) from Eugene H. Carbaugh (PNL) dated December 3, 1991, "Bioassay Criteria for Environmental Restoration Workers." Copy maintained in the permanent files of the Hanford Radiological Records Project.

5.1.7 Baseline and End-of-Assignment Bioassay

Baseline and end-of-assignment samples or measurements should be obtained for a worker whose work assignments will require or have required routine bioassay monitoring (HSRCM 1992; 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 present task, and provide accurate feedback on the effectiveness of radiation protection measures for specific work assignments.

Baseline and end-of-assignment 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.

Ending work measurements may be performed in lieu of and at the scheduled time of routine measurements. This does not apply to visitors and terminating employees who should have specially scheduled measurements.

5.1.8 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.

5.1.9 Visitors

The HSRCM does not require visitor bioassay. Special bioassays will be performed if conditions encountered while at Hanford require them. If baseline measurements are performed at the beginning or end of visit, any abnormal results will be reported to the responsible Hanford contractor. Internal doses for detectable baseline results will be assessed only if a specific request is made by the contractor.

5.1.10 Pregnant Women and Minors

The HSRCM dose limits for declared pregnant women and minors are substantially more restrictive than those for occupational workers. Special bioassay appropriate to work conditions should be obtained at the time of declaration of pregnancy. If exposure continues, special bioassay should also be obtained as soon as possible after birth or termination of pregnancy.

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 CEDE 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.

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.

A "broad-base" bioassay program involving multiple analyses may be appropriate for workers who rotate between facilities on occasional or short-notice assignments. Such a program is intended to satisfy current baseline requirements for many facilities, rather than imply that a worker is likely to incur intakes individually or collectively totaling 100-mrem CEDE.

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 workplace monitoring (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 workplace monitoring.

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 100-mrem CEDE objective given in Section 2.3
- MDAs for various radionuclides and bioassay measurements
- likelihood and ratios of combinations of radionuclides associated with an intake for a particular facility or task
- cost of bioassay measurements and the cost of lost productive time while workers are participating in the bioassay program.

Longest Interval Between Bioassays

Generally, annual measurements are suggested as a convenient minimum frequency to match annual reporting requirements for worker doses. Routine bioassay measurement periods longer than five effective half-lives are also generally not recommended, because the potential deviation of individuals from assumed retention or excretion patterns can substantially affect doses associated with the program design.

5.3 BIOASSAY MEASUREMENT FREQUENCY (contd)

Longest Interval Between Bioassays (contd)

For situations involving mixtures of nuclides (e.g., ^{137}Cs and ^{90}Sr) an annual individual bioassay measurement (e.g., whole body count) may be used in combination with a less frequent radionuclide-specific measurement (e.g., biennial ^{90}Sr urine sample analysis).

5.3.1 Minimum Detectable Dose for Bioassay Intervals

Selected minimum detectable doses associated with various nuclides, bioassay techniques, and intervals are shown in Exhibits 5.1 through 5.5. For acute intakes, the analyses assume that an intake occurs on the day following a bioassay measurement and the bioassay measurement has fallen below the MDA by the next scheduled measurement. For chronic intakes, a uniform daily intake pattern is assumed to exist for the monitoring interval. Dosimetry methods and factors are those described in the Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1991).

5.3.2 Recommended Bioassay Measurements and Intervals

A summary of recommended combinations of measurements for various nuclides and situations is given in Table 5.5 for single nuclides and for some typical Hanford radionuclide combinations. These programs are recommended primarily based on the ability of routine measurements to meet first-year effective dose equivalents of 10 mrem. This criterion constitutes the basis for routine screening levels (see Appendix A) to initiate the dose evaluation process. If the criterion cannot be met, then any positive result must be investigated.

Internal Dosimetry can design optimum programs based on characterized sources and potential intake patterns.

TABLE 5.5. 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 considered. Biennial ^{90}Sr samples are also recommended to check for an unexpected ^{90}Sr source.
^{154}Eu and ^{155}Eu at N-Reactor	Annual whole body counts.
^{131}I	Monthly whole body count or bimonthly thyroid count.
^{129}I, ^{125}I	Annual thyroid counts.
^{90}Sr	Annual urine sample.
Tritium	Monthly urine samples for potential chronic or multiple acute exposures. If data indicate potential annual dose in excess of 100 mrem, change to biweekly frequency.
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. Quarterly monitoring based on acute exposure for low-risk infrequent entry workers.
Depleted-to-slightly-enriched uranium metal and various oxides resulting in a mixture of class D and 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 (e.g., quarterly) urine samples and less frequent (annual or semi-annual) chest counts is used. Urinalysis results above the screening level trigger special chest counts.

Case Description	Program Description
Plutonium mixtures containing ^{238}Pu, ^{239}Pu, ^{240}Pu, ^{241}Pu, and possibly ^{241}Am in various amounts. Applies to either inhalation class W or Y.	No program at present is adequate to detect 100-mrem CEDE. Annual plutonium urine samples and annual chest counts are used. Chest counts quantify lung burden when ^{241}Am is detectable.

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 CEDE of 100 mrem or a first-year dose of 10 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.
- 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 committed effective dose equivalent of 100 mrem by periodic 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.

Exhibit 5.1

Bioassay Capability for Tritium

Urine Bioassay Analysis

Tritium (H3) MDA: 20 dpm/mL

The tritium monitoring program is based on liquid scintillation analysis for tritium oxide in urine. Because only 1 mL is analyzed, virtually any volume of sample can be used. For convenience single void or simulated 12-hour samples are generally collected and a small aliquot analyzed. Program capability is shown below.

Minimum Detectable Effective Dose Equivalent (CEDE) for Acute and Chronic Exposures to Tritium Oxide

Days Post-Intake	Acute Exposure, mrem	Chronic Exposure[a] (365 d/y), mrem
1	0.027	0.64
2	0.029	0.64
7	0.041	0.64
14	0.066	0.64
30	0.20	0.64
60	1.6	0.64
90	13	0.64
180	6,500	0.64
365	2.4E+9	0.64

(a) Assumed constant equilibrium in body water at 20 dpm/mL.

Exhibit 5.2

In Vivo Bioassay Capability for High-Energy Gamma Emitters

Whole Body Counting

Bioassay measurements for high-energy gamma-emitting radionuclides are performed using the IVRRF preview counter, or other systems of comparable or better sensitivity (e.g., coaxial germanium whole body counter, remote whole body counter). The minimum detectable doses for single nuclides or selected mixtures of mixed fission or activation products based on single nuclide measurement are shown below for the forms commonly encountered at Hanford.

Minimum Detectable Effective Dose Equivalents (mrem) for Single Acute Intake Based on MDA Detection in Preview Counter at the Indicated Day Post-Intake (DPI)

Nuclide	Class	MDA[a] (nCi)	DPI[b]	Measurement Interval	First-Year	CEDE
^{60}Co	Y	5.7	365	Annual	4.9	13
^{137}Cs	D	3.2	365	Annual	1.5	1.6
			730	Biennial[c]	15	17
^{137}Cs + ^{90}Sr[d]	D	3.2 (of ^{137}Cs)	365	Annual	3.3	14
			730	Biennial[c]	35	150
^{54}Mn	W	4.4	365	Annual	26	26
^{59}Fe	W	7.5	180	Semiannual	8.9	8.9
			365	Annual	190	190
^{154}Eu + ^{155}Eu[e]	W	12 (of ^{154}Eu)	365	Annual	11	44
	Y		365	Annual	14	51
^{131}I	D	3.6	30	Monthly	9.5	9.5

(a) MDA = minimum detectable activity.
(b) DPI = day post-intake.
(c) Not recommended.
(d) Assumes that the activity ratio for ^{137}Cs:^{90}Sr is 1:1 at intake.
(e) Assumes that the activity ratio for ^{154}Eu:^{155}Eu is 3.5:1 at times of intake, based on 8 years of decay following operating N-Reactor equilibrium condition of 2:1.

Exhibit 5.2 (contd)

Thyroid Counting for Radioiodine

Thyroid counting ^{125}I and ^{129}I is the recommended approach over urine sample analysis for those nuclides. Thyroid counting for ^{131}I is significantly more sensitive than whole body counting for that nuclide. Thyroid counts are performed with a planar germanium detectors. The program capability for thyroid counting is shown below:

Minimum Detectable Effective Dose Equivalents (mrem) for Single Acute Class D Intake Based on MDA Detection in Thyroid Counter at the Indicated Day Post-Intake (DPI)

Nuclide	MDA (nCi)	Day Post-Intake	Measurement Interval	First-Year	CEDE
^{125}I	0.01	30	Monthly	0.002	0.002
		90	Quarterly	<0.006	<0.006
		180	Semiannual	0.028	0.028
		365	Annual[(a)]	0.72	0.72
^{129}I	0.01	30	Monthly	0.009	0.010
		90	Quarterly	0.013	0.014
		180	Semiannual	0.022	0.024
		365	Annual[(a)]	0.067	0.071
^{131}I	0.02	30	Monthly	0.053	0.053
		60	Bimonthly	0.83	0.83
		90	Quarterly	11	11

(a) Recommended frequency supplemented by workplace screening using portable survey meter with NaI detector.

Exhibit 5.3

Bioassay Capability for Strontium

Strontium-90 Bioassay Monitoring

Urine sample analysis is the preferred method for ^{90}Sr bioassay monitoring. For low-risk potential exposure situations, it may be convenient to use an annual whole body exam to monitor for ^{137}Cs as an indicator for the presence of ^{90}Sr. Program capabilities are shown below:

Minimum Detectable Effective Dose Equivalents (mrem) for Single Acute Class D Intake Based on MDA Detection (10 dpm/d) in Urine at the Indicated Day Post-Intake

Day Post-Intake	Measurement Interval	First-Year	CEDE
1	Special	0.003	0.020
2	Special	0.004	0.026
7	Special	0.010	0.065
30	Monthly	0.27	1.8
90	Quarterly	1.1	7.5
180	Semiannual	1.9	13
365	Annual[a]	3.8	26
730	Biennial	9.0	62

(a) Recommended frequency.

Minimum Detectable Effective Dose Equivalents (mrem) for Single Acute Class D Intake of Equal Activities of ^{137}Cs and ^{90}Sr Based on MDA Detection (3.2 nCi: ^{137}Cs) by Whole Body Counting at the Indicated Day Post-Intake (DPI)

Day Post-Intake	Measurement Interval	First-Year	CEDE
1	Special	0.30	1.3
2	Special	0.32	1.4
7	Special	0.35	1.5
30	Monthly	0.40	1.7
90	Quarterly	0.60	2.3
180	Semiannual	1.0	4.4
365	Annual[a]	3.3	14
730	Biennial	35	150

(a) Recommended frequency.

Exhibit 5.4

Bioassay Program for Uranium

Urine Bioassay Analyses

Elemental Uranium (U) MDA: 0.06 μg

Used for natural, depleted, or recycled uranium mixtures, in any chemical form. Simulated 24-hour sample collected. A screening level of 0.2 μg/d is used as an upper range of the normal expected excretion, implying an occupationally attributable excretion of 0.14 μg/d may exist above the geometric mean environmental level of 0.06 μg/d, established for the Hanford work force. Minimum detectable dose analyses for natural uranium mixtures and various intake scenarios are shown in Tables IV.1 through IV.4.

Isotopic Uranium (IU) MDA: 0.02 dpm

Used for single isotopes of uranium or mixtures enriched to greater than 5% (by weight) of ^{235}U. Simulated 24-hour sample collected. Screening levels of 0.15 dpm are used for $^{233+234}U$ and ^{238}U, and anything >Lc for ^{235}U, corresponding to 0.2 μg/d for natural uranium; thus, the minimum detectable dose analyses for uranium mixtures are comparable to those for the elemental uranium procedure.

Quick Soluble Uranium (QUS) MDA: 0.5 μg

Used primarily for monitoring exposure to class D or similarly soluble forms of elemental uranium, where chemical toxicity is the principle concern. Simulated 12-hour sample collected, typically after 24 to 48 hours of no exposure. MDA is based on excretion rate of 1 μg/d. Minimum detectable dose analyses are equivalent to the elemental uranium urinalyses for class D material (shown in Tables IV.5 and IV.6), multiplied by a factor of 4 due to the less sensitive nature of the QUS analysis.

In Vivo Measurements

Chest Count (1200 s)

Isotope	MDA	Implied Uranium Present (nCi of uranium mixture) Natural U	Depleted U	Recycled U
^{235}U	0.20 nCi	8.6	13	8.6
^{234}Th	2.9 nCi	6.0	3.1	7.8

Detection of uranium in the lungs is generally used only for relatively insoluble (class W or Y) forms. The ^{235}U and ^{234}Th measurements can be used as independent checks on potentially positive results. The ^{234}Th (assumed to be in secular equilibrium with ^{238}U) is slightly more sensitive in terms of total uranium than ^{235}U detection for most Hanford mixtures, and is the basis for the minimum detectable dose analyses.

TABLE IV.1. Minimum Detectable Effective Dose Equivalents (mrem) for Class W Acute Inhalation Intakes of Natural Uranium Mixture[a] for Elemental Uranium in Urine or Chest Counting

Day Post-Intake	Measurement Interval	Elemental U in Urine[b] First-Year	CEDE	^{234}Th by Chest Count[c] First-Year	CEDE
1	Special	0.040	0.045	190	210
2	Special	0.12	0.13	230	250
7	Special	0.31	0.34	290	320
14	Special	0.46	0.51	310	340
30	Monthly	0.89	0.99	400	440
90	Quarterly	2.4	2.6	830	920
180	Semiannual	7.1	7.6	2700	3000
365	Annual	59	65	2.9E+4	3.2E+4
730	Biennial	1100	1200	3.6E+6	4.0E+6

(a) Multiply doses by 1.4 for recycled uranium and by 0.50 for depleted uranium mixtures.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Based on detection of 2.9 nCi of ^{234}Th by chest counting, implying the presence of 6.0 nCi natural uranium mixture in the lungs.

TABLE IV.2. Minimum Detectable Effective Dose Equivalents (mrem) for Class Y Acute Inhalation Intakes of Natural Uranium Mixture,[a] Detected by Elemental Uranium in Urine or Chest Counting

Day Post-Intake	Measurement Interval	Elemental U in Urine[b]		^{234}Th by Chest Count[c]	
		First-Year	CEDE	First-Year	CEDE
1	Special	3.0	16	680	3,300
2	Special	8.8	48	830	4,000
7	Special	24	130	1,000	4,800
14	Special	38	200	1,000	4,800
30	Monthly	74	400	1,100	5,100
90	Quarterly	130	680	1,100	5,100
180	Semiannual	130	720	1,200	5,500
365	Annual	130	720	1,500	7,200
730	Biennial	140	760	2,100	9,900

(a) Multiply doses by 1.4 for recycled uranium and 0.50 for depleted uranium.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Based on detection of 2.9 nCi of ^{234}Th by chest counting, implying the presence of 6.0 nCi natural uranium mixture in the lungs.

TABLE IV.3. Minimum Detectable Effective Dose Equivalents (mrem) for Class W Chronic Inhalation Intakes (365 days/yr) of Natural Uranium Mixture[a] Detected by Elemental Uranium in Urine or Chest Counting

Day Post Onset of Intake	Measurement Interval	Elemental U in Urine[b] First-Year	Elemental U in Urine[b] CEDE	^{234}Th by Chest Count[c] First-Year	^{234}Th by Chest Count[c] CEDE
30	Monthly	2.1	2.6	3,000	3,800
90	Quarterly	1.6	2.0	1,500	1,800
180	Semiannual	1.5	1.8	1,100	1,400
365	Annual	1.4	1.7	1,000	1,300
730	Biennial	1.4	1.7	1,000	1,300

(a) Multiply doses by 1.4 for recycled uranium and by 0.50 for depleted uranium mixtures.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Based on detection of 2.9 nCi of ^{234}Th by chest counting, implying the presence of 6.0 nCi natural uranium mixture in the lungs.

TABLE IV.4. Minimum Detectable Effective Dose Equivalents (mrem) for Class Y Chronic Inhalation Intakes (365 days/yr) of Natural Uranium Mixture[a] Detected by Elemental Uranium in Urine or Chest Counting

Day Post Onset of Intake	Measurement Interval	Elemental U in Urine[b] First-Year	Elemental U in Urine[b] CEDE	^{234}Th by Chest Count[c] First-Year	^{234}Th by Chest Count[c] CEDE
30	Monthly	100	890	6,400	57,000
90	Quarterly	79	700	2,300	20,000
180	Semiannual	62	550	1,200	11,000
365	Annual	43	380	640	5,700
730	Biennial	28	250	380	3,400

(a) Multiply doses by 1.4 for recycled uranium and by 0.50 for depleted uranium mixtures.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Based on detection of 2.9 nCi of ^{234}Th by chest counting, implying the presence of 6.0 nCi natural uranium mixture in the lungs.

TABLE IV.5. Minimum Detectable Effective Dose Equivalents (mrem) for Class D Acute Inhalation Intakes of Natural Uranium Mixture[a] Based on Elemental Uranium Detected in Urine[b]

Day Post-Intake	Measurement Interval	Intake (μg)	Effective Dose Equivalent (mrem) First-Year	CEDE
1	Special	1.4	8.0E-4	2.7E-3
2	Special	3.4	1.9E-3	6.5E-3
7	Special	15	8.5E-3	2.8E-2
14	Special	27	1.6E-2	5.2E-2
30	Monthly[c]	82	4.7E-2	1.6E-1
90	Quarterly	930	5.3E-1	1.8
180	Semiannual	16,000	9.4	31
365	Annual	82,000	47	160
730	Biennial	88,000	50	170

(a) For recycled uranium, multiply intakes by 1.3 and doses by 2.0. For depleted uranium, multiply intakes by 0.53 and doses by 0.26.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Recommended frequency based on potential chemical toxicity of intakes

TABLE IV.6. Minimum Detectable Effective Dose Equivalents (mrem) for Class D Chronic (365 d/y) Inhalation Intakes of Natural Uranium Mixture,[a] Based on Elemental Uranium Detected in Urine[b]

Day Post-Intake	Measurement Interval	Intake Rate (μg/d)	Effective Dose Equivalent (mrem) First-Year	CEDE
1	Special	0.74	0.13	0.53
2	Special	0.54	0.097	0.39
7	Special	0.41	0.074	0.30
14	Special	0.37	0.066	0.27
30	Monthly[c]	0.33	0.059	0.23
90	Quarterly	0.30	0.054	0.21
180	Semiannual	0.30	0.054	0.21
365	Annual	0.30	0.054	0.21
730	Biennial	0.30	0.054	0.21

(a) For recycled uranium, multiply intake by 1.3 and doses by 2.0. For depleted uranium, multiply intake by 0.53 and doses by 0.26.
(b) Based on screening level of 0.2 μg/d urine excretion, implying an occupationally attributed 0.14 μg/d above the environmental geometric mean level of 0.06 μg/d.
(c) Recommended frequency based on potential chemical toxicity for acute intake provides a substantial margin of safety for the less limiting chronic exposure condition.

Exhibit 5.5

Bioassay Program for Plutonium

In Vivo Lung Counting MDA: 0.30 nCi for ^{241}Am for 1200-s count

Plutonium in the lungs can be monitored by measuring the ^{241}Am daughter of ^{241}Pu using planar germanium-detector chest-counting techniques. This method is state-of-the-art for in vivo detection in the lungs, but is limited in usefulness to aged plutonium mixtures, where sufficient time has elapsed to allow significant ^{241}Am ingrowth. Program capabilities for chest counting are shown in Tables V.1 and V.2. The capability in terms of minimum detectable dose assumes that material at the time of intake is either an aged 6% ^{240}Pu or aged 12% ^{240}Pu mixture, as discussed in the Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1991). Urine sampling is generally more effective than chest counting for routine monitoring of class W forms of plutonium. Chest counting is primarily of value immediately following intakes, or as a monitoring technique for class Y (or less soluble) forms of plutonium.

Urine Bioassay Analyses

Plutonium in Urine (IPU) MDA = 0.02 dpm/sample $^{239+240}Pu$ (assumed 0.02 dpm/d)

Isotopic plutonium is normally analyzed in a simulated 24-hr urine sample. The MDA is assumed to apply to a daily excretion rate. The minimum detectable doses for fresh and aged plutonium mixtures are shown in Table V.3.

Low-Level Plutonium in Urine (IPUL) MDA = 0.005 dpm ^{239}Pu/sample (0.0025 dpm/d)

This procedure has been proposed primarily for application to class Y forms of plutonium where the IPU MDA does not provide adequate capability. The minimum detectable doses for fresh and aged plutonium mixtures are shown in Table V.4.

TABLE V.1. Minimum Detectable Effective Dose Equivalents (rem) for Acute Intakes of Class Y Plutonium Mixtures Based on MDA Chest Count of ^{241}Am (0.3 nCi) at Indicated Day Post-Intake

Day Post-Intake	Measurement Interval	Aged 6% ^{240}Pu		Aged 12% ^{240}Pu	
		First-Year	CEDE	First-Year	CEDE
1	Special	0.66	7.4	0.24	3.2
2	Special	0.77	8.7	0.28	3.7
7	Special	0.92	10	0.34	4.5
14	Special	0.92	10	0.34	4.5
30	Monthly	0.92	10	0.34	4.5
60	Bimonthly	0.99	11	0.36	4.8
90	Quarterly	0.99	11	0.36	4.8
180	Semiannual	1.1	12	0.39	5.2
365	Annual[(a)]	1.4	16	0.51	6.7
730	Biennial	1.9	21	0.70	9.2

(a) Recommended frequency.

TABLE V.2. Minimum Detectable Effective Dose Equivalents (rem) for Acute Intakes of Class W Plutonium Mixtures Based on MDA Chest Count of ^{241}Am at the Indicated Day Post Intake

Day Post-Intake	Measurement Interval	Aged 6% ^{240}Pu		Aged 12% ^{240}Pu	
		First-Year	CEDE	First-Year	CEDE
1	Special	0.38	9.9	0.14	4.5
2	Special	0.47	12	0.17	5.5
7	Special	0.60	16	0.22	7.0
14	Special	0.65	17	0.24	7.6
30	Monthly	0.85	22	0.31	9.8
60	Bimonthly	1.2	31	0.45	14
90	Quarterly	1.8	45	0.65	21
180	Semiannual	5.6	150	2.1	65
365	Annual	60	1,600	22	700
730	Biennial	7,700	2.0E+5	2,800	8.9E+4

TABLE V.3. Minimum Detectable Effective Dose Equivalents (rem) for Aged 6% Pu Mixtures[a] Based on MDA Detection (0.02 dpm/d) of ^{239}Pu in Urine by Isotopic Plutonium Analysis (IPU)

Day Post-Intake	Measurement Interval	Class W		Class Y	
		First-Year	CEDE	First-Year	CEDE
1	Special	8.6E-4	2.2E-2	2.6E-2	3.4E-1
2	Special	1.3E-3	3.3E-2	3.8E-2	5.1E-1
7	Special	6.1E-3	1.6E-1	2.0E-1	2.6E+0
14	Special	9.3E-3	2.4E-1	3.0E-1	4.0E+0
30	Monthly	1.2E-2	3.1E-1	3.9E-1	5.1E+0
60	Bimonthly	1.6E-2	4.0E-1	4.7E-1	6.2E+0
90	Quarterly	1.9E-2	4.8E-1	4.8E-1	6.4E+0
180	Semiannual	2.5E-2	6.4E-1	4.6E-1	6.1E+0
365	Annual[b]	4.3E-2	1.1E+0	4.2E-1	5.5E+0
730	Biennial	8.6E-2	2.2E+0	3.8E-1	5.0E+0

(a) For other Pu mixtures, multiply Aged 6% Pu effective dose equivalent by the applicable conversion factor below:

	First-Year		CEDE	
	Class W	Class Y	Class W	Class Y
Fresh 6% Pu	1.00	1.00	1.06	1.03
Fresh 12% Pu	1.00	1.00	1.41	1.31
Aged 12% Pu	1.00	1.00	1.22	1.17

(b) Recommended frequency.

TABLE V.4. Minimum Detectable Effective Dose Equivalents (mrem) for Aged 6% Pu Mixtures[a] Based on MDA Detection (0.0025 dpm/d) of ^{239}Pu in Urine by Low-Level Isotopic Plutonium (IPUL Analysis)

Day Post-Intake	Measurement Interval	Class W		Class Y	
		First-Year	CEDE	First-Year	CEDE
2	Special	0.16	4.1	4.8	64
7	Special	0.76	20	25	330
14	Special	1.2	30	38	500
30	Monthly	1.5	39	49	640
60	Bimonthly	2.0	50	59	780
90	Quarterly	2.4	60	60	800
180	Semiannual	3.1	80	58	760
365	Annual[b]	5.4	140	53	690
730	Biennial	11	280	48	630

(a) For other plutonium mixtures, multiply Aged 6% Pu effective dose equivalent by the applicable conversion factor below:

	First-Year		CEDE	
	Class W	Class Y	Class W	Class Y
Fresh 6% Pu	1.00	1.00	1.06	1.03
Fresh 12% Pu	1.00	1.00	1.41	1.31
Aged 12% Pu	1.00	1.00	1.22	1.17

(b) Recommended frequency as alterative procedure to simulated 24-hour urine sample analyses for class Y mixtures.

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 may be obtainable by contacting Internal Dosimetry.

Frequently used telephone numbers and mail stops for bioassay services are

- Internal Dosimetry Office, 376-7245, A3-60
- IVRRF, 376-6102, B1-60
- Dosimetry Records, 376-6342, 376-8203, A3-60
- IT Analytical Services, Inc. (ITAS), Richland, 375-3131.

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 "container not out" sample on a day specified by Field Dosimetry, within 10 days after the originally scheduled pickup.

6.1 INDIRECT BIOASSAY MEASUREMENT SERVICES (contd)

- analyzing urine and fecal samples in four processing categories: routine, priority, expedite, and emergency.
- analyzing miscellaneous samples, such as blood, body tissue, cloth, or air filters, by emergency or priority processing. Some chemical analyses, such as that for creatinine, are also available.

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.

Kit Codes

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

Lab Capability

The analytical and reporting requirements for the four processing categories as of FY 1993 are detailed in Tables 6.1 through 6.6. Changes in these requirements may occur from year to year. Therefore, Internal Dosimetry should be contacted if the most current information is needed.

Note that the detection levels listed are "contractual" and are extracted from the contract statement of work (SOW) for the analytical laboratory. Actual detection levels, as determined by statistics such as those in ANSI N13.30-1989, are generally equal to or lower than the contractual detection levels (CLs).

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

Individual Analyses (and Codes)	Constituents Reported	Contractual Detection Level (dpm/sample)		Determination Time (business days following sample receipt)	Reporting Time		Oral Reporting Level[a] (dpm/sample)	
		Urine	Fecal		Oral	Electronic & Written[a]	Urine	Fecal
Pu(α) isotopic (IPU)	Pu-238, Pu-239,240	0.02	0.2	20			0.01	2.0
Pu(α) isotopic, low level (IPUL)	Pu-239,240	0.005		30			0.003	
Am-241 (AM241)	Am-241	0.02		20			0.01	
Cm(α) isotopic (ICM)	Cm-242, Cm-243,244, + others[b]	0.02		20			0.01	
U(α) isotopic (IU)	U-233,234, U-235, U-238	0.02		20	(By close of business on day of determination)	(Within 5 business days)	(f)	
Cm(α) and Am(α) (ICA)	Am-241, Cm-242, Cm-243,244, + others[b]	0.02		20			0.01	
Tritium (H3)	H-3	20 dpm/mL		5			10 dpm/mL	
Sr-90 (SR90)[c]	Sr-90	10		30			5	
Pm-147	Pm-147	30		20			15	
Gamma spectroscopy (ISPEC)	K-40, Cs-137, + others[d]	(see Table 6.5)		20				
Spectroscopy (LEPD)	Am-241	5		20				
U-natural (U)	Elemental U	0.06 μg/sample		20			0.2 μg/sample	
U-natural (QUS, QUS1, QUS2)	Elemental U	0.5 μg/sample		4			1 μg/sample	
Sequential Analyses (and Codes)								
Pu(α) isotopic and Sr-90 (IPS)	(Same as for individual analyses above)	(Same as for individual analyses above)		35	(By close of business on day of determination)	(Within 5 business days)		
Pu(α) isotopic and Am-241 (IPS)				25				
Pu(α) isotopic, U-nat (IUPU)				25				
Pu(α) isotopic, U iso (ITPAC)[e]				25				
Actinide (α) isotopic (ITPAC)[e]				25				
Pu(α) isotopic and H-3 (IPUH)				25				
Pu(α) isotopic, Sr-90, H-3 (IPSH)				35				
U-natural and H-3 (UH)				25				

(a) Time allowed following determination of results to receipt of results by Battelle.
(b) Report Cm-245, Cm-246, and Cm-248 if the measured activity exceeds the oral reporting level.
(c) If total strontium is less than 15 dpm, yttrium ingrowth is not required.
(d) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. If ordered, report results for radionuclides in Table 6.5 specified in the processing instructions, regardless of the activity measured.
(e) Pu(α) isotopic, Am-241, and Cm(α) isotopic.
(f) Oral report level is 0.01 for U-235; 0.15 for U-233, U-234, and U-238.
(g) Oral report required only when analytical results exceed level specified.

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

Individual Analyses (and Codes)	Constituents Reported	Contractual Detection Level[a] (dpm/sample)		Determination Time (business days following sample receipt)	Reporting Time	
		Urine	Fecal		Oral[b]	Electronic & Written[c]
Pu(α) isotopic (IPU)	Pu-238, Pu-239,240	0.02	0.2	8		
Cm(α) iso, (ICM)	Cm-242, Cm-243,244, + others[d]	0.02	0.8	8		
U(α) isotopic (IU)	U-233,234, U-235, U-238	0.02	0.3	8	(By close of business on day of determination)	(Within 5 business days)
Ra(α) isotopic (IRA)	Ra-224, Ra-226	0.03	1.5	8		
NP-237 (NP237)	Np-237	0.02	0.1	8		
AM-241 (AM241)	Am-241	0.02	0.8	8		
Cm(α) and Am(α) (ICA)	Am-241, Cm-242, Cm-243,244, + others[e]	0.02	0.8	8		
U-natural (U)	Elemental U	0.06 μg/sample	0.3 μg/sample	8		
U-nat (QUS, QUS1, QUS2)	Elemental U	0.5 μg/sample	—	4		
Tritium (H3)	H-3	20 dpm/mL	—	3		
C-14 (C14)	C-14	10 dpm/mL	200	3		
Sr-total (SR)	Sr-89, + 90	10	30	7		
Sr-isotopic (ISR)	Sr-89, Sr-90	30, 30 respectively	45, 30 respectively	15[m]		
Sr-90 (SR90)	Sr-90	10	10	15[m]		
Pm-147 (PM147)	Pm-147	40	220	8		
Pu-241 (PU241)	Pu-241	10	10	9		
Gamma spectroscopy (ISPEC)	K-40, Cs-137, + others[f]	(See Table 6.5)	(See Table 6.5)	3		
Gamma spectroscopy (LEPD)	Am-241	5	5	8		
Sequential Analyses (and Codes)						
Pu(α) iso and Sr-90 (IPS)	(Same as for individual analyses above)	(Same as for individual analyses above)	(Same as for individual analyses above)	9[g]	(By close of business on day of determination)	(Within 5 business days)
Pu(α) iso, Am-241 (IPA)				9		
Pu(α) iso, Am-241, Sr-90 (IPSA)				9[g]		
Pu(α) iso, Pu-241 (IPUB)				9[h]		
Pu(α) iso, Pu-241, Am-241 (IPUBA)				9[h]		
Pu(α) iso, U-nat (IUPU)				9[g]		
Pu(α) iso and U iso (IPIU)				9		
Pu(α) iso and H-3 (IPUH)				9		
Pu(α) iso, Sr-90, and H-3 (IPSH)				9[g]		
U-natural and H-3 (UH)				9[g]		

TABLE 6.2. (contd)

Notes to Table 6.2:

(a) CL is stated in terms of dpm/sample for fecal samples of 20 to 500 g.
(b) Oral report is required for all analytical results.
(c) Time allowed following determination of results to receipt of results by Battelle.
(d) In addition, report Cm-245, Cm-246, and Cm-248 if the measured activity exceeds the oral reporting level.
(e) Sr-90 is to be determined within 15 business days. Total strontium to be determined within 7 business days and reported orally upon determination. If total strontium is less than 15 dpm or Sr-90 is less than 5 dpm, yttrium ingrowth is not required.
(f) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. If ordered, report results for radionuclides in Table 6.5 specified in the processing instructions, regardless of the activity measured.
(g) Sr-90 is to be determined within 16 business days. Total strontium is to be determined within 9 business days and reported orally upon determination. If total strontium is less than 15 dpm or Sr-90 is less than 5 dpm, yttrium ingrowth is not required.
(h) Pu-241 is to be determined within 16 business days.
(i) U-natural is to be determined within 12 business days.

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

Individual Analyses (and Codes)	Constituents Reported	Contractual Detection Level[a] (dpm/sample)		Reporting Time	
		Urine	Fecal	Oral[b]	Electronic & Written[c]
Pu(∝) isotopic (IPU)	Pu-238, Pu-239,240	0.08	3		
Cm(∝) isotopic (ICM)	Cm-242, Cm-243,244, + others[d]	1.2	70		
U(∝) isotopic (IU)	U-233,234, U-235, U-238	0.12	4		
Ra(∝) isotopic (IRA)	Ra-224, Ra-226	0.3	3	(By 9 a.m. on 2nd business day following sample receipt)	(Within 5 business days)
Am-241 (AM241)	Am-241	0.08	6		
Np-237 (NP237)	Np-237	0.12	3		
U-natural (U)	Elemental U	0.5 μg/sample	5 μg/sample		
Tritium (H3)	H-3	100 dpm/mL	-		
C-14 (C14)	C-14	20 dpm/mL	2000		
Pm-147 (PM147)	Pm-147	50	2000		
Sr-total (SR)	Sr-89,90	50	150		
Gamma spectroscopy (ISPEC)	K-40, Cs-137, + others[e]	(See Table 6.5)	(See Table 6.5)		
Gamma spectroscopy (LEPD)	Am-241	5	5		
Sequential Analyses (and Codes)					
Pu(∝) iso, Am-241 (IPA)					
Pu(∝) iso, Sr-total (IPSR)	(Same as for individual analyses above)	(Same as for individual analyses above)		(By 9 a.m. on 2nd business day following sample receipt)	(Within 5 business days)
Pu(∝) iso, Sr-total, Am-241 (IPSA)					
Pu(∝) iso, U-natural (IUPU)					

(a) Detection level in terms of dpm/300 mL for urine samples in excess of 300 mL. Detection level is stated in terms of dpm/sample for fecal samples of 20 to 500 g.
(b) Oral report required for all analytical results.
(c) Time allowed following oral report for delivery of electronic results to the Battelle Technical Administrator.
(d) Report Cm-245, Cm-246, and Cm-248 if their measured activity exceeds the oral reporting level.
(e) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. 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.

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

Individual Analyses (and Codes)	Constituents Reported	Contractual Detection Level[a] (dpm/sample) Urine	Contractual Detection Level[a] (dpm/sample) Fecal	Reporting Time: Oral (hours following sample receipt) Urine/Fecal[b]	Reporting Time: Electronic & Written[c]
Pu(∝) isotopic (IPU)	Pu-238, Pu-239,240	0.5	9	5/8	
Cm(∝) isotopic (ICM)	Cm-242, Cm-243,244, + others[d]	10	240	6/8	
U(∝) isotopic (IU)	U-233,234, U-235, U-238	1	12	5/8	
Ra(∝) isotopic (IRA)	Ra-224, Ra-226	2.0	10	6/8	
Am-241 (AM241)	Am-241	1	20	5/8	
Np-237 (NP237)	Np-237	1	10	5/8	
U-nat (U)	Elemental U	7 µg/sample	8 µg/sample	3/8	
Tritium (H3)	H-3	100 dpm/mL	-	3/-	(Within 5
C-14 (C14)	C-14	100 dpm/mL	10,000	3/8	business days)
Pm-147 (PM147)	Pm-147	80	8,000	6/8	
Sr-total (SR)	Sr-89,90	80	450	4/8	
Gamma spectroscopy (ISPEC)	K-40, Cs-137, + others[e]	(See Table 6.6)	(See Table 6.6)	3/3	
Gamma spectroscopy (LEPD)	Am-241	20	20	3/3	
Sequential Analyses (and Codes)					
Pu(∝) iso, Am-241 (IPA)				5/8	
Pu(∝) iso, Sr-total (IPSR)	(Same as for individual analyses above)	(Same as for individual analyses above)	(Same as for individual analyses above)	5/8	(Within 5
Pu(∝) iso, Sr-total, Am-241 (IPSA)				5/8	business days)
Pu(∝) Iso, U-natural (IUPU)				5/8	

(a) Detection level in terms of dpm/300 mL for urine samples in excess of 300 mL. Detection level is stated in terms of dpm/sample for fecal samples of 20 to 500 g.

(b) Oral report required for all analytical results. These time requirements apply for up to six samples submitted at any one time, except for gamma spectroscopy analysis, for which the requirements apply for up to five samples submitted at one time, and gamma spectroscopy for Am-241 (LEPD), for which the requirements apply to two samples submitted at one time. However, additional samples up to 25 (20 for LEPD) at one time must be completed within 24 hours.

(c) Time allowed following oral report for delivery of results to the Battelle Technical Administrator.

(d) Report Cm-245, Cm-246, and Cm-248 if their measured activity exceeds the oral reporting level.

(e) Report all isotopes present at levels exceeding one-half the appropriate CL listed in Table 6.5. 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.

TABLE 6.5. Contractual Detection Levels for Routine, Priority, and Expedite Processing of Gamma Spectroscopy Analyses[a]

Isotope	CL, Urine (dpm/sample)[b]	CL, 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

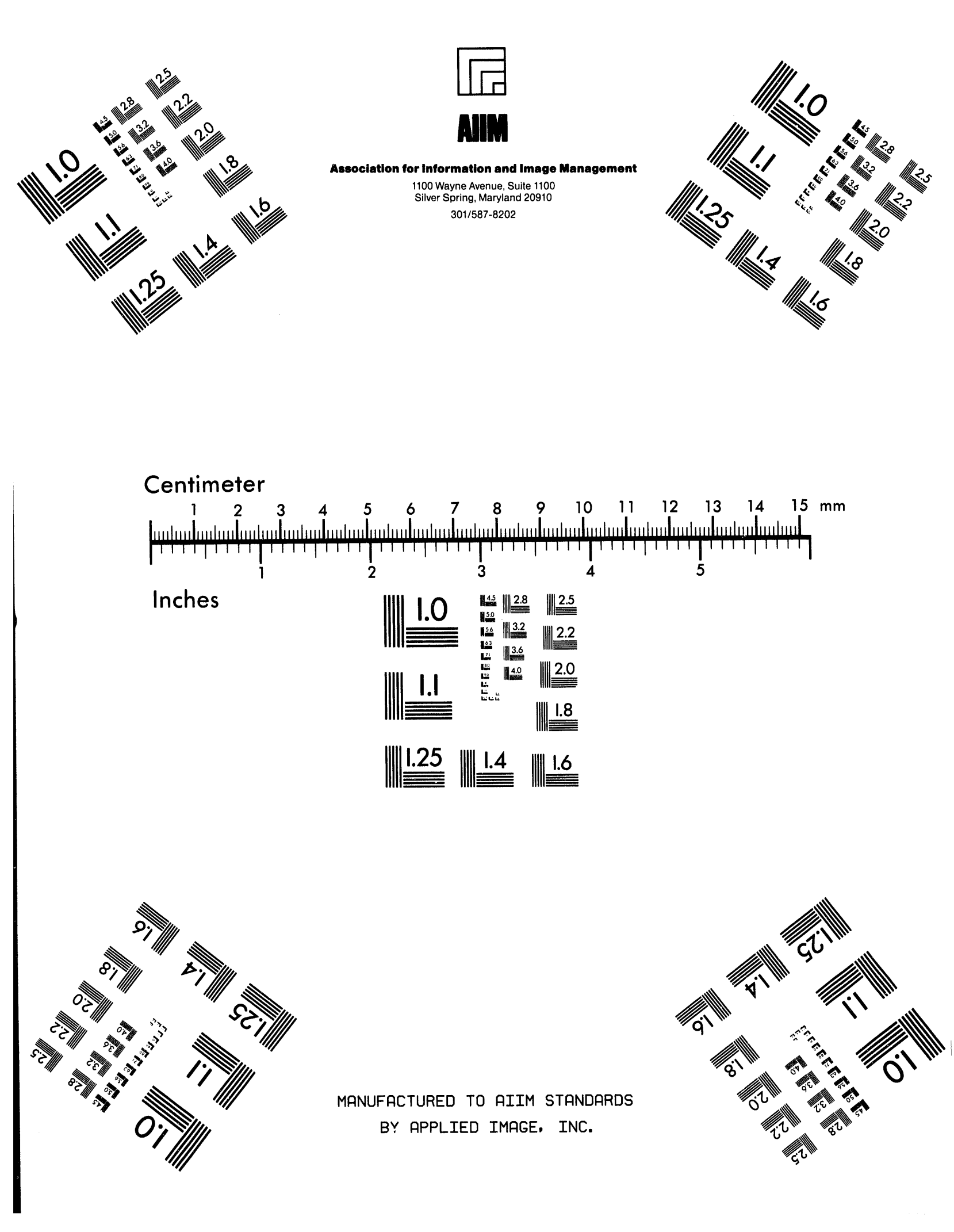
(a) The Contractor shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and CLs listed shall be interpreted as a minimum requirement; the Contractor shall detect and quantify all other gamma emitters present at a nominal detection level of 20 dpm for each unspecified nuclide with E_γ >100 keV as relative to the energy and photon abundance ^{137}Cs.

(b) CL is in units of dpm/L, for samples greater than or equal to 1 L.

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

Isotope	CL, Urine (dpm/sample)[b]	CL, 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 Contractor shall resolve and quantify unknown mixtures of gamma-emitting radionuclides. The nuclides and CLs listed shall be interpreted as minimum requirements; the Contractor shall detect and quantify all other gamma emitters detectable using the same conditions as for the CLs listed.
(b) CL is in units of dpm/L, for samples greater than or equal to 10 mL.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6.1 INDIRECT BIOASSAY MEASUREMENT SERVICES (contd)

Minimum Sample Size

Minimum volumes for valid samples are specified in the analytical laboratory SOW. They generally depend on the same kit code and processing category. Values are shown below:

Kit Code	Routine Processing	Other Processing
1	500 mL	20 mL
2	20 mL	20 mL
3	500 mL	20 mL
4	20 mL	20 mL
5	(not applicable)	20 g
6	250 mL	20 mL
7	250 mL	20 mL
8	20 g	(not applicable)
9	20 mL	20 mL
A	1000 mL	(not applicable)

Tritium is an exception to the above. The minimum volume for tritium analysis is 20 mL, regardless of kit code.

6.2 IN VIVO MEASUREMENT SERVICES

Routine in vivo measurements are performed at the 747-A Building or at the 200E remote whole-body counter. In vivo measurement services are summarized below and details are provided in the Whole Body Counting Manual[a] and the "In Vivo Bioassay Statement of Work." 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.

(a) 1990 internal manual, PNL-MA-574, Pacific Northwest Laboratory Richland, Washington.

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. Whole body counts are scheduled by Field Dosimetry through the Hanford Health System (HHS). A limited number of walk-ins can also be accommodated.

The whole body measurement may consist of one or more counts using different equipment. Generally, a screening count will be performed on the preview counter, which is a stand-up 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 uses four germanium detectors to better resolve and quantify radionuclides, especially in the presence of interfering radionuclides, such as radon progeny. Sled count times are substantially longer than preview count times.

Table 6.7 lists the detection capabilities for radionuclides routinely quantified by the preview counter. 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 IVRRF 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 length of the count. Detection capabilities for chest counts are listed in Table 6.8.

The remotely operated preview counter, located in the 200-East Area, can be used in place of the 747-A preview counter. If activity other than ^{40}K is detected, confirming measurements are obtained at 747-A.

TABLE 6.7. Nominal Minimum Detectable Amount (MDA) Values for Whole Body Exams

Nuclide	Preview Counter MDA (nCi)[a]	Sled Counter MDA (nCi)[b]
^{40}K	11.8	9.1
^{60}Co	5.7	1.1
^{137}Cs	3.2	1.2
^{54}Mn	4.4	1.0
^{154}Eu	12.1	2.6
^{22}Na	3.2	0.91
^{59}Fe	7.5	1.9
^{95}Zr		1.9
^{65}Zn		2.1
^{106}Rh		11
^{131}I	3.6	1.5
^{140}La		0.71
^{208}Tl	3.5	0.79
^{144}Pr		16
^{51}Cr		14
^{24}Na		0.53
^{110}Ag		1.4
^{214}Bi	9.8	2.9
^{58}Co		1.2
^{134}Cs		1.2

(a) The MDA values are for routine 200-s measurements with the preview counter (five cylindrical sodium-iodide detectors in a vertical array). The corresponding values for 200-s measurements with the remote counter (six rectangular sodium-iodide detectors) will be comparable.

(b) The MDA values are for the 1200-s scanning measurements with the four coaxial germanium detector system positioned posteriorly to the supine subject. The corresponding values for 600- or 2400-s measurements will be increased or decreased, respectively, by a factor of approximately 0.6.

TABLE 6.8. Nominal Minimum Detectable Activity (MDA) Values for Planar Germanium Detector In Vivo Measurements

Measurement and Radionuclide	MDA
Normal Chest Count[a]	
^{241}Am	0.30 nCi
^{235}U	0.20 nCi
^{234}Th	2.9 nCi
Extra-Sensitive Chest Count[b]	
^{241}Am	0.18 nCi
^{235}U	0.12 nCi
^{234}Th	1.7 nCi
Skeleton Burden by Head Count[c]	
^{241}Am	0.5 nCi
Liver Count[d]	
^{241}Am	0.17 nCi
Thyroid Count[e]	
^{125}I	0.01 nCi
^{131}I	0.02 nCi
Transuranic Wound Count (600-s count time)	
^{241}Am (59.5 keV x-ray)	Determined as needed
^{239}Pu (17.0 and 20.4 keV x-rays)	Determined as needed

(a) Values are for 1200-s measurements with six detectors. The values for 1800-s measurements with four detectors will be comparable.
(b) Values are for 3000-s measurements with six detectors.
(c) Value is based on 3000-s measurement with two detectors positioned on the forehead.
(d) Value is based on 1800-s measurement with three detectors positioned over the liver.
(e) Values are based on 600-s measurement with two detectors positioned over the thyroid.

6.2.2 Chest Counts (contd)

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. Ultrasound measurements are routinely scheduled on a 2-year interval for workers with long-term detectable chest count activity. Lung corrections for liver content are not currently performed, but may be considered for unusual circumstances.

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 using germanium detectors, assuming normal count times. Slightly lower MDAs can be achieved if longer count times can be arranged. The MDA values for wound counts or other tissues (e.g., lymph nodes) are highly variable, depending on the circumstances of measurement. Contact Internal Dosimetry if additional information is required.

6.3 SCHEDULING AND RECORDKEEPING

This section discusses scheduling of bioassay measurements, reporting of routine results to Field Dosimetry, and recordkeeping. 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

Internal Dosimetry coordinates all bioassay measurement requests to the Lab, either through the IDP or HRRP using the REX 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.

Baseline, Termination, End of Assignment

To schedule a worker for a baseline, termination, or end-of-assignment sample, Field Dosimetry must perform two steps:

1. Field Dosimetry completes an Employee and Dosimetry Changes form (Exhibit 6.1) and enters the information into the REX database. This deletes the old schedule (if there is one) and establishes the new schedule. The completed form is submitted to HRRP for inclusion in the worker's radiation exposure file. (An Employee and Dosimetry Changes form is not needed for beginning and ending work samples for planned offsite exposures.)

2. The sample request is called in by Field Dosimetry to the Internal Dosimetry clerk for verification of scheduling and transmittal to the Analytical Lab.

Periodic

Field Dosimetry initiates the request for a periodic bioassay measurement schedule by completing the Employee and Dosimetry Changes form (Exhibit 6.1), and entering the information into the REX database. The completed form is sent to HRRP for verification and filing in the worker's radiation exposure file.

About one month before the scheduled sample time, a list of scheduled periodic samples is sent to Field

TABLE 6.9. Bioassay Measurement Reason Codes for the REX System

Code	Name	Description
BL	Baseline	Measurement is performed to establish a reference level against which subsequent measurements will be compared. Generally, this may be for new employees, or for established employees, prior to commencing work with radioactive materials, beginning a specific type of radiation zone work, or making an offsite trip where potential internal exposure could occur.
PR	Periodic	Measurement is performed at a regularly scheduled interval.
EA	End of Assignment	Measurement is performed following completion of specific work assignment, but not end of employment.
SP	Special	Measurement is performed as part of a specific investigation of potential internal dose. May include response to off-normal work conditions, or follow-up of abnormal periodic measurements.
CR	Contractor Request	Measurement requested by employer for reasons other than periodic, baseline, end work, or special investigation.
RA	Reanalysis A	First reanalysis of sample by taking another aliquot and repeating the same radiochemical or chemical analysis.
RB	Reanalysis B	Second reanalysis of sample by taking another aliquot and repeating the same radiochemical or chemical analysis.
R1	Recount 1	First recount of original excreta sample or repeat in vivo exam.
R2	Recount 2	Second recount of original excreta sample or repeat in vivo exam.
QR	Quality and Research	Measurement performed as part of quality control, quality assurance, or research work.
TM	Termination	Final bioassay at termination of employment.
12	Contract Work	In vivo measurement performed under contract to customers rather than Hanford employees.
20	Source Count	In vivo source count made for system calibration or as a function check, usually using a known check source.
30	Background Count	In vivo system background measurement performed for system calibration or as a functional check.

6.3.2 Scheduling Indirect Bioassay Measurements (contd)

Periodic (contd) Dosimetry for review. The reviewed list is then electronically transmitted to the Lab one week before the scheduled sample month, and this pattern is repeated until another Employee Dosimetry Changes form is received.

If the periodic sample is not collected, is of insufficient volume, or is "lost in lab," the Lab notifies Internal Dosimetry, who then notifies Field Dosimetry. Field Dosimetry reschedules the sample request through REX. Internal Dosimetry transmits the request electronically to the Lab.

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

Special, Reanalysis, Recount Special measurement requests, reanalysis, and recount requests are made by an EE after consultation with Field Dosimetry. During incident response, the EE often gives sample kits directly to the worker. The Special measurement code is used while data are being collected for an evaluation. After a preliminary or final evaluation has been made, samples collected for long-term surveillance of the intake are scheduled as periodic samples.

6.3.3 Reporting Results from Indirect Measurements

Valid Results A result from a routinely processed sample is verbally reported or faxed to Internal Dosimetry by the Lab if the result exceeds the reporting level. Contractual reporting requirements for indirect bioassay measurements are included in Tables 6.1 through 6.4. For most indirect analyses, the reporting level is one-half the contractual detection level (CL), which is approximately equal to the decision level (L_c). The reporting level for uranium analyses are adjusted to reflect typical environmental contributions. All sample results are transferred electronically from the Lab to the REX database, as specified contractually, and listed in Tables 6.1 through 6.4.

Invalid or No Results There are a number of reasons that a sample may not be obtained or a result not be provided. When such circumstances occur, the Lab notifies Internal Dosimetry to take appropriate follow-up action. These circumstances and appropriate actions are discussed below.

6.3.3 Reporting Results from Indirect Measurements (contd)

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 notifies Internal Dosimetry by fax and writes a nonconforming data report to the contract administrator, with a copy to Internal Dosimetry. 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 Section 6.1), the sample is not analyzed and the IS code is noted in the REX database. 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.

Kit-Not-Out (KN) — If the kit was not out at the time of the scheduled pickup, a KN interim status code is assigned. The Lab will advise Internal Dosimetry of the attempted pickup and will make one more attempt to pick it up when notified of a revised pickup date. Samples not retrieved or scheduled for later retrieval within 10 days of the scheduled pickup are assigned a "lost kit" designation and should be rescheduled.

Lost Container (LC) — The LC code means that the Lab delivered a sample kit but was unsuccessful in retrieving it. The sample should be rescheduled.

Not Delivered (ND) — The ND code means that a scheduled sample kit was not delivered by the Lab. The sample should be rescheduled.

No Sample (NS) — The NS code 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 Internal Dosimetry of no samples. Internal Dosimetry then contacts Field Dosimetry. The worker should be contacted before pickup is rescheduled.

6.3.4 Scheduling In Vivo Bioassay Measurements

Summary

All in vivo measurements for baseline, end of assignment, termination, periodic, and contractor request reason codes are scheduled in a similar manner. The IVRRF has allocated to each contractor specific blocks of time for counting workers, and Field Dosimetry schedules their workers into those blocks. The REX and Hanford Health System (HHS) databases are used for scheduling most in vivo exams. Special in vivo measurements, performed in response to potential intakes, are scheduled directly with IVRRF staff and may take precedence over other scheduled measurements.

Typical Measurements

Field Dosimetry initiates the request for periodic in vivo measurements by completing the Employee and Dosimetry Changes form (Exhibit 6.1) and entering the information into the REX database and the HHS database.

The HHS identifies to Field Dosimetry workers who are specified for a periodic in vivo exam in the coming month. Whole body exams are then scheduled for individual workers directly by Field Dosimetry, using the contractor allocations of count times provided by IVRRF. Each night HHS sends an electronic file to IVRRF containing the names of workers scheduled for exams the next day.

Unscheduled workers will also be accepted, although some rescheduling might be required.

Recounts

Recounts are measurements performed the same day as a positive count to confirm the initial measurement. Measurements performed at a later date as follow-up or because a same-day recount could not be performed are assigned the "special" code.

Special

Special in vivo measurements are performed in response to identified potential intake or as follow-up to a periodic measurement which exceeds a screening level. These measurements may be requested by the Exposure Evaluator or the event contractor. Timely completion of special measurements is a high priority and may preempt a scheduled worker.

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 are shown in Appendix A. In addition, results from special 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 recommendations for follow-up, if necessary. All results are electronically transmitted weekly to the REX database.

No Results

Invalid results or no results may be obtained for an in vivo measurement for a variety of reasons, such as for a preliminary count that was followed by a record count on the same day, 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"

Whether or not a worker reported for an in vivo measurement can be determined from the Hanford Health System. Following each day's measurements, IVRRF staff send an electronic "show" file to HHS, listing workers who reported to IVRRF for exams, including unscheduled walk-ins. The actual measurement results are not part of this file.

The HHS generates a report upon user command by retrieving the "show" file and matching it with the day's schedule file. Matches and walk-ins appear as "shows." Workers scheduled but not listed in the "show" file are identified as "no-shows."

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.

6.4.1 Indirect Bioassay Measurements (contd)

≤ Screening Level — If the indirect bioassay measurement result is at or 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 6.2).

≥ 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 baseline or special measurement, any result above the reporting level is investigated. If the reason code is for a periodic, contractor request, end of assignment, 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 investigated. Otherwise, the letter shown in Exhibit 6.2 is sent to Field Dosimetry and no follow-up is performed by Internal Dosimetry.

Recounts — If a routine- or priority-processed urinalysis for alpha-emitting nuclides exceeds the screening level (usually equal to the L_c) but not the CL, Internal Dosimetry commonly requests recounts. This step reduces random false positive results that ensue from counting statistics alone. If both recounts are less than the screening level, then the letter shown in Exhibit 6.2 is sent to Field Dosimetry. If one recount is also at or above the screening level, then Internal Dosimetry notifies Field Dosimetry and initiates a formal assessment of possible internal dose. 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.

6.4.1 Indirect Bioassay Measurements (contd)

Reanalysis

If a result exceeds a screening level for an analysis for which only an aliquot of the original sample was required, Internal Dosimetry may request reanalysis of that sample, provided that sufficient sample remains. If two reanalyses are below the screening level, the initial result is considered unconfirmed. If one reanalysis is also at or above the screening level, then Internal Dosimetry notifies Field Dosimetry and initiates a formal assessment of possible internal dose. Details about the assessment of internal dose are discussed in Chapter 3.0.

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 decision levels L_c for the nuclides measured, except for naturally occurring ^{40}K. IVRRF staff attempt to recount all unexpected positive results on the same day, if possible. For whole body counts, IVRRF staff report the final (record) count to Internal Dosimetry; for all other count types, results of both initial and recount measurements are reported to Internal Dosimetry. Internal Dosimetry then reviews the reported results against the applicable screening levels (see Appendix A) before determining final disposition.

Preliminary Report

The worker receives a preliminary report on the results of in vivo measurements at the end of each visit to the IVRRF (see Exhibit 6.3). The preliminary report places the results of the measurements into one of four categories: 1) less than the screening level, 2) false-positive initial indication (for chest counts only), 3) not immediately available, e.g., final calculations by computer are delayed or calculation/evaluation by hand is required, and 4) equal to or exceeding the reporting level.

6.4.2 In Vivo Measurements (contd)

Final Report ≤ Screening Level

Where several screening levels may exist depending on whether the measurement is a baseline or routine periodic assay, Internal Dosimetry determines the applicable screening level for each case. When a result is finalized, and if the result is at or 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 but no evaluation is necessary, the letter shown in Exhibit 6.4 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 baseline or contractor-requested measurement, any result above the reporting level is investigated. If the reason code is for a periodic, contractor request, end of assignment, 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). 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 6.4 is sent to Field Dosimetry and no follow-up is performed by Internal Dosimetry.

6.5 RADIATION EXPOSURE (REX) DATABASE

The results of all bioassay measurements are permanently retained in the REX database. Field Dosimetry, Internal Dosimetry, IVRRF, and Lab staff all have access to only those parts of the REX database that are essential to their task responsibilities.

The REX database has superseded the Occupational Radiation Exposure (ORE) database. Information contained in ORE was incorporated into REX. Questions concerning the ORE database can be addressed to Internal Dosimetry or the HRRP.

Exhibit 6.1

Sample Form - Employee and Dosimetry Changes

Employer	Date	RADIATION PROTECTION RECORDS EMPLOYEE AND DOSIMETRY CHANGES	
Name (Last) (First) (Middle Initial)	Social Security No.	Payroll or Ident. No.	Org. Code

☐ Correct Social Security No. from _____ to _____

☐ Change Org. Code from _____ to _____ Effective Date _____

☐ Change Name from _____ Effective Date _____
(Last) (First) (Middle Initial)

☐ Change Employee Status:

☐ End of Employment ☐ Deceased Effective Date _____

External Dosimeter Requirement Effective Date of Change _____

☐ Assign Basic (Annual)

☐ Assign Multi-Purpose
☐ Annual ☐ Monthly ☐ Quarterly

☐ Change Basic to Multi-Purpose
☐ Annual ☐ Monthly ☐ Quarterly

☐ Change Multi-Purpose to:
☐ Basic Annual ☐ Multipurpose Annual ☐ Monthly ☐ Quarterly

☐ Discontinue Dosimeter (Not required)

Internal Dosimetry Requirements

Bioassay: (1) _____ (2) _____
Isotope Frequency Month Year Isotope Frequency Month Year

(3) _____ (4) _____
Isotope Frequency Month Year Isotope Frequency Month Year

☐ Discontinue All Bioassay

In Vivo: _____ ☐ Discontinue In Vivo
Type Frequency Year

See reverse for Bio Freq and In Vivo Types.

Remarks: _____

_____

_____

_____

_____

_____
Radiation Protection Concurrence

DISTRIBUTION: White - Personnel Dosimetry Services, PNL
Yellow - Contractor Radiation Protection Organization

54-3000-465 (8-85)

Exhibit 6.2

Sample Letter - Bioassay Urine Sample Results

DATE 07/30/92 PR# 99999

NAME AB TEST ORG CODE _____

URINALYSIS EXAMINATION REPORT

The analysis of your excreta examination on _____ has been completed. Results do not exceed the criteria for followup 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 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.

Exhibit 6.3

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.

__ Your first chest count indicated the possible presence of internal radioactivity; however, your second count, which was longer and more sensitive, did not detect radioactivity. Your first count is considered a false positive reading; due to the nature of radioactivity counting, false positive readings are expected to occur about 5% of the time.

__ 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 results reported above, 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 6.4

Sample Letter - In Vivo Measurement Results

STRICTLY PRIVATE

DATE 07/16/92 PR# 99999

NAME AB TEST ORG CODE _____

IN VIVO EXAMINATION REPORT

The analysis of your in vivo examination on _____ has been completed. Results do not exceed the criteria for followup 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 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.

7.0 INTERNAL EXPOSURE INCIDENT RESPONSE

This chapter provides guidance for recommended dosimetry response to potential internal exposure incidents. The roles of the contractor, Internal Dosimetry (the Exposure Evaluator, or EE), and other support groups in obtaining dosimetry data and in performing early assessments of internal exposure are discussed. Also addressed are some EE tasks that 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.

An internal contamination incident response plan has been developed and mutually approved by the Hanford contractor radiation protection managers. This plan addresses the responsibilities and actions of the various groups in responding to potential intakes. The plan is included as Appendix E to this manual.

7.1 INCIDENT RESPONSE OBJECTIVES OF THE HANFORD INTERNAL DOSIMETRY PROJECT

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 EE provides notification services for other types of incidents at Hanford.

7.2 INCIDENT RESPONSE SERVICES PROVIDED BY THE HANFORD INTERNAL DOSIMETRY PROJECT

The IDP provides incident response by means of its EE function. The EE is a sitewide 24-hour on-call contact for dosimetry and notification assistance.

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

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 and smears)
- arrangement with PNL Radiation Protection for Radiation Protection Technologist (RPT) support for IVRRF and the 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 PNL Hanford environmental monitoring teams
- 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 IVRRF.

7.3 DETERMINING 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:

- abnormal radioactivity detected on nasal smears
- suspected intake of radioactive material with the potential for a committed effective dose equivalent of 100 mrem
- extended or extensive personal skin contamination
- 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 that may have affected workers.

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 may make this notification. The EE may also informally notify HEHF if there seems to be a possibility that therapy may be warranted.

7.3.1 Notifications for Prompt Internal Exposure Evaluation and Dose Reduction Therapy

Notify Exposure Evaluator

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 indicators that committed effective dose equivalents (CEDEs) may exceed 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 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 checklist of information that may be useful to the EE for dosimetry evaluation. 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.

TABLE 7.1. Contamination Levels for Notifying Internal Dosimetry, dpm

Indicator	Alpha Emitters	Beta-/Gamma-Emitters
Nasal or mouth smears	Above background	Above background
Facial contamination	200	4,000
Skin breaks	Any skin break while handling alpha-emitters other than sealed sources	Any detectable activity around or on a skin break; or detectable activity on a blood smear
Head, neck contamination	2,000	40,000
Contamination inside respirator	Detectable activity inside respirator after use.	
Hands, forearms, clothing[a] Spotty, loose	10,000	200,000
Airborne contamination	Acute exposure equivalent to 40 DAC-hours[b] after incorporating respiratory protection factor	

(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 Notifying the Hanford Environmental Health Foundation, dpm

Indicator	Alpha Emitters	Beta-/Gamma-Emitters
Nasal or mouth smears	1,000	100,000
Facial contamination	25,000	500,000
Skin breaks	100	20,000

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

Radio Pager
Onsite 85-9901
Offsite 376-4190 (9901)

The on-call EE carries a pager that can be activated from a Hanford Site telephone by calling 85-9901. From an offsite phone, the pager can be activated by calling 376-4190, and entering "9901" at the tone. At the cue from the recorded message, enter the phone number for the EE to call. This method is particularly useful after hours if the EE is not at home to answer 376-2222. 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 Operations Center or the PNL Single Point Contact and request an alternate EE.

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 a radio pager and alternate contacts.

Cellular Phone (544-8067)

The cellular telephone is used at the discretion of the EE when responding to a radio page. The phone is not normally carried by the EE.

7.5 EXPOSURE EVALUATOR RESPONSE TO INCIDENTS

This section briefly describes the general EE response to an internal exposure incident. Further details are provided in the incident response plan (Appendix E).

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 possibly 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.

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 turnaround 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

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 h) (simulated 24 h) (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.

7.5.2 Scheduling and Performing Bioassay Measurements (contd)

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. Some example protocols are included in the Incident Response Plan (Appendix E).

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 a committed effective dose equivalent of 100 mrem for all radionuclides of concern at Hanford. However, 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 few days post-exposure. For most nuclides, if early data are obtained within the first few days following exposure, the dose assessment capability is 10 mrem or less. The Section 5 exhibits, the Technical Basis for Internal Dosimetry at Hanford (PNL-6866), and Appendix E provide more in-depth discussion of the capability of bioassay measurements with regard to dose assessment sensitivity.

7.5.3 Dose Assessment Capability (contd)

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 doses required to be reported to DOE. These dose assessments become part of the permanent REX 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 IVRRF, the EE, RPT, contractor, and IVRRF staff must determine the course of action. The IVRRF 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 IVRRF 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 or the responding paramedic team. 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 a first-aid station, 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, or diuretics) and surgical techniques (minor tissue excision, wound debridement). The EE advises HEHF of the potential effectiveness of various 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 IVRRF. 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 Project to provide this assistance.

7.6.6 Offsite Assistance Request

If the EE receives a request for 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 RL.

EXHIBIT 7.1

Checklist 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 _____

8.0 QUALITY ASSURANCE

The IDP has been designated as an Impact Level III Project in accordance with the PNL Quality Assurance (QA) manual.[a] By this designation, the project must comply with the Good Practices Standard (GPS), detailed in PNL's internal QA Manual, and is committed to meeting the mandatory good practices.

The QA and quality control (QC) features of the project 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 laboratory QC oversight program, and the IVRRF.

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.

(a) 1990 internal manual, PNL-MA-70, Pacific Northwest Laboratory, Richland, Washington.

8.1.1 Analytical Services Laboratory (contd)

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 ANSI N13.30-1989 on performance criteria for radiobioassay testing. 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 Oversight of the Lab's Quality Control Program

Internal Dosimetry conducts an independent oversight 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 (single blind audits), masked for analysis as authentic worker samples (double blind audits), or split with another laboratory for simultaneous analytical intercomparison (split samples). The results of the audit samples are used to track Lab performance relative to the contractual detection levels 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 ANSI N13.30-1989 recommendations and requirements of the contract.

The results of Internal Dosimetry's oversight 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 the Whole Body Counting Manual,[a] and in the QA Plan for Operation of the In Vivo Radioassay and Research Facility.[b] 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 phantoms. In addition, the IVRRF 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 REX database weekly. The QA data are kept in hard-copy form in the IVRRF library. Computer codes are validated and verified according to software test plans.

8.2 QUALITY ASSURANCE AND QUALITY CONTROL FOR DOSE ASSESSMENTS

The intention of the IDP is for internal dose assessments to meet the DOE requirements as stipulated in the Hanford Site Radiological Control Manual (RL 1992) and 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. Computer codes used for dose assessment are verified and validated according to code-specific software test plans.

(a) 1990 internal manual, PNL-MA-574, Pacific Northwest Laboratory, Richland Washington.

(b) Lynch, T. P., and L. J. Ethridge. 1993. QA Plan for Operation of the In Vivo Radioassay and Research Facility. QA Plan LSC-02.1, Pacific Northwest Laboratory, Richland, Washington.

8.2 QUALITY ASSURANCE AND QUALITY CONTROL FOR DOSE ASSESSMENTS (contd)

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 Project manager and the Personnel Dosimetry Section manager before they are issued.

The original evaluation and a copy of the summary letter are placed in the worker's radiation exposure file by Radiological Records staff. The original summary letter is sent to the designated contractor dosimetry representative.

IDP staff responsible for dose assessments have, either through education or training, basic knowledge of ionizing radiation and ICRP and NCRP guidance on internal dosimetry. In addition, they have been trained on methods described in this manual and on the specific computer codes germane to each dose assessment that they do. Each new dosimetrist undergoes a period of apprenticeship commensurate with his/her experience and education and is determined ready to perform dose assessments by the IDP manager.

8.3 INTERNAL DOSIMETRY PROJECT RECORDS

The records generated by the IDP are maintained in files within the Personnel Dosimetry Section of PNL. The IDP manager is responsible for the designation and maintenance of these records. Additional information is provided in 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: program and technical assessment. These types of documentation, as well as the documentation of changes, are briefly described in the following subsections.

9.1 PROJECT DOCUMENTATION

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

- The Technical Basis for Internal Dosimetry at Hanford (Sula, Carbaugh, and Bihl 1991), which includes technical methods, supporting evidence, and reference information used to provide the technical foundation for the IDP.
- The Hanford Internal Dosimetry Project Manual (i.e., this manual), which 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 Hanford Internal Dosimetry Procedures Manual[a], which includes procedures for the day-to-day operations of the Project, 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, measurement laboratory statements of work, and QA activities and are included in the summary list of documentation in Table 9.1.

(a) Internal manual, PNL-MA-565, Pacific Northwest Laboratory, Richland, Washington.

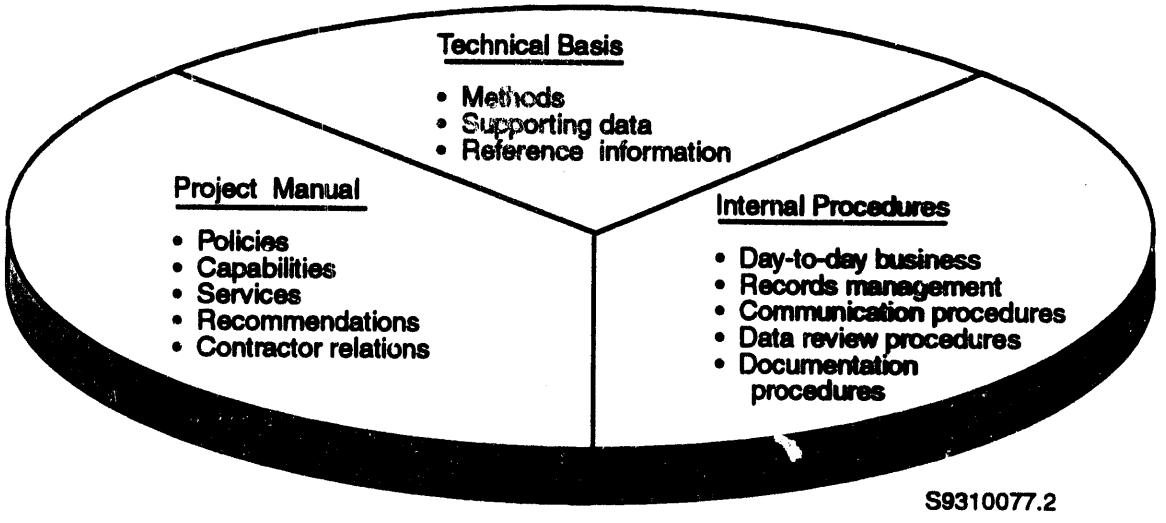

FIGURE 9.1. Documentation of the Hanford Internal Dosimetry Project

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 program 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 Program Documents for the Hanford Internal Dosimetry Project

Title or Subject	Content	Form[a]	Custodian	Storage	Disposition
Technical Basis for Internal Dosimetry at Hanford (PNL-6866, Sula, Carbaugh and Bihl 1991)	Technical support for program	1	IDP[b]	PNL[c]-controlled	Permanent
Hanford Internal Dosimetry Project Manual (PNL-MA-552; 1989)	Policies, services, capabilities, and recommendations	1	IDP	PNL-controlled	Permanent
Hanford Internal Dosimetry Procedures Manual (PNL-MA-565)	Daily operating procedures	1	IDP	PNL-controlled	Permanent
Whole Body Counting Manual	Technical support for the IVRRF including policies, services, and capabilities	1	IVRRF[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	HRRPL(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	1,2	HRRPL	Historical Files	Permanent
Program change record	Program change documentation and support	1,2	HRRPL	Historical Files	Permanent
Vendor Quality Assurance Manual	Vendor's quality assurance program	1,2	HRRPL	Historical Files	Permanent
Program computer codes	Design and user's guide to software implemented by the IDP. Also validation and verification results.	1,2	HRRPL	Historical Files	Permanent
Quality assurance audits	Audit of Internal Dosimetry Project	1,2	HRRPL	Historical Files	Permanent

(a) 1 = hardcopy report; 2 = microfilm
(b) IDP = Internal Dosimetry Project
(c) PNL = Pacific Northwest Laboratory
(d) IVRRF = In Vivo Radioassay and Research Facility
(e) HRRPL = Hanford Radiological Records Project Library
(f) Historical Files = Hanford Radiation Protection Historical Files

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

Title or Subject	Content	Form[a]	Custodian	Storage	Disposition
Internal dose assessments	Documentation of worker dose assessment	2	HRRPL[b]	Worker radiation exposure files	75 years
Bioassay data	Excreta and in vivo measurement results	3	HRRPL	REX personnel file	75 years
Excreta laboratory(ies) annual quality control for FY 19XX[c]	Annual letter report of excreta laboratory internal quality control samples	1,2	HRRPL	Historical Files[d]	Permanent
Results of the PNL QC oversight program for FY 19XX	Annual letter report of summary of IDP quality control audit sample program	1,2	HRRPL	Historical Files	Permanent
Vendor laboratory records	Records and documents supporting excreta sample analyses	1	Vendor, DOE	Temporary storage by vendor; permanent storage as raw records by DOE	75 years
Whole body counting records	Records and documents supporting in vivo measurements	1,2,3	IVRRF[e] HRRPL	Temporary storage by IVRRF; permanent storage by HRRPL as Historical Files	75 years

(a) 1 = hardcopy report
2 = microfilm and/or optical disk storage media
3 = magnetic storage media

(b) HRRPL = Hanford Radiological Records Project Library

(c) Not applicable June 1990 through November 1991. Seven laboratories were used during this period. Their QA sample results were summarized in the PNL audit program letter reports.

(d) Historical Files = Hanford Radiation Protection Historical Files

(e) IVRRF = In Vivo Radioassay and Research Facility

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 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 project files and by the HRRP in the Hanford Radiation Protection Historical Files 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

9.3.2 Revision/Update of Documents and Manuals (contd)

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 worker's radiation exposure file. The revised evaluation is identified using the Evaluation Number sequence described in Section 3.2.2.

- In Vivo Measurement – A notice of correction to an in vivo record is issued by the IVRRF staff in the form of a letter to HRRP. The correction letter describes the reason for the change and the new result. The original correction letter is filed in the worker's radiation exposure file.

- Excreta Measurement – A notice of correction to an excreta REX record is issued by the generating laboratory to Internal Dosimetry. The correction is reported verbally and in writing. Internal Dosimetry submits the correction to Dosimetry Records data processing personnel, and the original notice is filed in the worker's radiation exposure file.

Exhibit 9.1

Change Record Number: _____
Issue Date: _____

PROGRAM CHANGE RECORD
HANFORD INTERNAL DOSIMETRY PROJECT

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 any supporting information not referenced.)

(use attachments or additional pages if necessary)

Impact:

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

(Use attachments or additional pages if necessary.)

Supersedes (if manual, provide page and section):

Originated by: _____ Date: _____
Project Manager: _____
Technical Group Leader: _____

Notification (copies sent to):

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

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

10.0 REFERENCES

American National Standards Institute (ANSI). 1966. American National Standard Practice for Occupational Radiation Exposure Records Systems. ANSI N13.6-1966 (R 1972), New York.

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APPENDIX A

ORAL REPORTING AND SCREENING LEVELS FOR BIOASSAY MEASUREMENTS

This appendix lists the 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 oral reporting level. Results reported to Internal Dosimetry are compared with the screening levels in Tables A.1 through A.4 to determine if additional investigation or initiation of the dose assessment process is required.

Oral reporting levels are specified in the bioassay laboratory statements of work (SOWs). Excreta samples processed using routine processing codes have numerical values specified for the oral reporting level. All excreta samples processed using priority, expedite or emergency processing codes are verbally reported to Internal Dosimetry. The oral reporting level for any in vivo measurement is the detection of any radionuclide other than ^{40}K.

Screening levels for bioassay measurements are listed as follows:

Table A.1. Transuranics and ^{90}Sr Urinalysis
Table A.2. Tritium Urinalysis
Table A.3. Uranium Urinalysis
Table A.4. In Vivo Measurements

TABLE A.1. Transuranic and ^{90}Sr Urinalysis Oral Reporting and Screening Levels and Their Basis

Bioassay Measurement	Oral Reporting Level	Screening Level	Basis for Screening Level
Routine urine analyses results (per simulated 24-h sample unless noted)			
^{238}Pu (IPU)	0.01 dpm	>Lc	Detected activity[a]
$^{239+240}Pu$ (IPU)	0.01 dpm	>Lc	Detected activity[a]
$^{239+240}Pu$ (IPUL)	0.003 dpm	>Lc	Detected activity[a]
^{241}Am	0.01 dpm	>Lc	Detected activity[a]
^{242}Cm	0.01 dpm	>Lc	Detected activity[a]
$^{243+244}Cm$	0.01 dpm	>Lc	Detected activity[a]
^{90}Sr			
Baseline	5 dpm	>Lc	Detected activity[a]
Biennial	5 dpm	11 dpm	10 mrem/y (31 mrem CEDE)
Annual	5 dpm	26 dpm	10 mrem/y (68 mrem CEDE)

(a) Any result >Lc potentially indicates that a first-year effective dose equivalent could exceed 10 mrem.

TABLE A.2. Tritium Urinalysis Oral Reporting and Screening Levels and Their Basis[a]

Tritium Measurement	Oral Reporting Level	Screening Level	Basis for Screening Level
Baseline	10 dpm/mL	$>L_c$	Detected activity[b]
400 Area baseline	10 dpm/mL	40 dpm/mL	Elevated 400 Area background
Multiple acute scenario			
Biweekly routine	10 dpm/mL	110 dpm/mL	10 mrem/y[c]
Monthly routine	10 dpm/mL	80 dpm/mL	10 mrem/y[d]
Supplemental monthly	10 dpm/mL	800 dpm/mL	100 mrem/y[e]
Chronic equilibrium		310 dpm/mL	10 mrem/y
Single acute scenario			10 mrem/intake
Days post-intake			
1	10 dpm/mL	7,400 dpm/mL	
2	10 dpm/mL	6,900 dpm/mL	
3	10 dpm/mL	6,400 dpm/mL	
7	10 dpm/mL	4,900 dpm/mL	
14	10 dpm/mL	3,000 dpm/mL	
30	10 dpm/mL	990 dpm/mL	
Single acute, in addition to a 10-mrem chronic average			20 mrem total
Days post acute intake			
1	10 dpm/mL	7,700 dpm/mL	
2	10 dpm/mL	7,200 dpm/mL	
3	10 dpm/mL	6,700 dpm/mL	
7	10 dpm/mL	5,200 dpm/mL	
14	10 dpm/mL	3,300 dpm/mL	
30	10 dpm/mL	1,300 dpm/mL	

(a) Annual and committed effective doses are identical for tritium.
(b) Indicates past tritium exposure. The potential source and dose need to be considered for possible inclusion in lifetime dose estimate.
(c) Assumes 26 equally spaced intakes per year to give 10 mrem dose. No consideration given to buildup of tritium levels in urine.
(d) Assumes 12 equally spaced intakes per year to give 10 mrem dose. No consideration given to buildup of tritium levels in urine.
(e) First-year dose could potentially exceed 100 mrem; therefore, a change to biweekly sampling is recommended for closer monitoring until results fall below the biweekly screening level.

TABLE A.3. Uranium Urinalysis Oral Reporting and Screening Levels and Their Basis

Uranium Measurement	Oral Reporting Level	Screening Level	Basis for Screening Level
Isotopic uranium (IU), simulated 24-h sample			
^{238}U	0.15 dpm	0.15 dpm	Background level
$^{233+234}U$	0.15 dpm	0.15 dpm	Background level
^{235}U	0.01 dpm	>Lc	Detected activity[a]
Insoluble uranium			
Elemental mass analysis, (U)			
Simulated 24-h	0.2 μg	0.2 μg	Background level
Simulated 12-h	0.2 μg	0.2 μg	Oral reporting level[b]
Single void	Any result	0.14 μg/L[c]	Background level
Soluble uranium			
Chronic or multiple acute exposure, QUS analysis, simulated 12-h sample[d]			
Monthly	4 μg	4 μg	Chemical toxicity[e]
Biweekly	4 μg	11 μg	Chemical toxicity[e]
Annual Review	N/A[f]	1 μg[g]	10 mrem/y (CEDE)
Infrequent (single acute) exposure potential, simulated 24-h sample			
Quarterly	0.2 μg	0.5 μg	10 mrem CEDE
Quarterly Supplemental	0.2 μg	2.5 μg	Chemical toxicity[e]

(a) Any result >Lc potentially indicates a first-year effective dose equivalent could exceed 10 mrem.
(b) Oral reporting level is contractually the same as for simulated 24-hour samples. Screening level for 12-hour samples is numerically the same as for 24-hour samples, but extrapolation to a daily excretion implies a less sensitive daily screening level of 0.4 μg/day.
(c) Based on background level of 0.2 μg/day divided by reference man daily urine excretion rate of 1.4 L/day.
(d) Assumes 36 hours of absence from exposure potential prior to sampling.
(e) Levels shown indicate a potential acute intake at one-third of the assumed threshold for acute chemical toxicity.
(f) Not applicable.
(g) Geometric mean value for all routine samples related to chronic exposure in a year.

TABLE A.4. Oral Reporting and Screening Levels for Routine In Vivo Bioassay Measurements and Their Basis

Bioassay Measurement	Oral Reporting Level	Screening Level	Basis for Screening Level
Baseline whole body exam			
^{40}K	200 nCi	200 nCi	Environmental[a]
Other radionuclides	>Lc	>Lc	Unknown source
Annual whole body exam			
^{40}K	200 nCi	200 nCi	Environmental[a]
^{60}Co	>Lc	12 nCi	10 mrem/y[b] (28 mrem CEDE)
^{137}Cs (with ^{90}Sr)	>Lc	9 nCi	10 mrem/y[c] (42 mrem CEDE)
^{137}Cs (only)	>Lc	20 nCi	10 mrem/y (10 mrem CEDE)
^{154}Eu	>Lc	8 nCi	10 mrem/y[d] (35 mrem CEDE)
^{155}Eu	>Lc	4 nCi	10 mrem/y[d] (35 mrem CEDE)
Other radionuclides	>Lc	>Lc	Unknown source
Chest count			
^{154}Eu	>Lc	8 nCi	10 mrem/y[d] (35 mrem CEDE)
^{155}Eu	>Lc	4 nCi	10 mrem/y[d] (35 mrem CEDE)
Other radionuclides	>Lc	>Lc	Unknown source
Thyroid count (quarterly frequency using germanium detector)			
^{125}I	>Lc	4 nCi	10 mrem/y[e] (10 mrem CEDE)

(a) Potassium-40 in the general public ranges up to about 200 nCi.
(b) Assumes a class Y ^{60}Co intake.
(c) Assumes a class D intake mixture of equal activities of ^{137}Cs and ^{90}Sr. If the subject is on a routine monitoring program for ^{90}Sr, or is not subject to ^{90}Sr exposure, then the screening level for ^{137}Cs is more appropriate.
(d) Assumes an activity ratio of 2:1 for ^{154}Eu:^{155}Eu at intake.
(e) Based on potential exposure each quarter with a possible dose of 2.5 mrem each quarter.

APPENDIX B

KEY TO SELECTED FIELD CODES USED IN THE RADIATION EXPOSURE COMPUTER DATABASE (REX)

This appendix provides an explanation of selected data field codes used in the Radiation Exposure (REX) database that are pertinent to the Hanford Internal Dosimetry Project. The REX database includes online helps which provide an interpretive key to the fields. The listings in this appendix are not necessarily complete or current; they are provided as helps for use when computer access may not be readily available, such as when reviewing hardcopy printouts or reports. The most current listings can be obtained directly from REX, or by contacting the Hanford Radiological Records Project database administrator.

Information concerning codes used in the former Occupational Radiation Exposure (ORE) database system may be obtained from the Hanford Radiological Records Project.

TABLE B.1. Contractor Codes

Code	Contractor
AA	DuPont, General Electric, ITT Support Services
BB	Isochem, Atlantic Richfield, and Rockwell Hanford Operations
BC	BCS Richland, Inc.
CM	Environmental Management Operation (PNL)
CO	Corps of Engineers
DE	AEC, ERDA, DOE (Early service crew, FBI, Army, BPA, etc.)
FF	Computer Sciences Corporation
GT	General Telephone Company
HF	Hanford Environmental Health Foundation
HH	Douglas United Nuclear, United Nuclear Industries, UNC Nuclear Industries
KE	Kaiser Engineers Hanford
KK	AII-Vitro Engineering Division, Braun Hanford Company
PN	Battelle - PNL
PP	Washington Public Power Supply System (visiting UNC)
SS	Shippingport and Shippingport subcontractors
TT	JA Jones Construction, George A. Grant, Combustion Engineering, subcontractors
US	US West
VV	Westinghouse Hanford Company (WADCO/HEDL)
WC	Westinghouse Hanford Company

TABLE B.2. Sample Type Codes

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

TABLE B.3. Bioassay Reason Codes

Code	Name	Description
BL	Baseline	Measurement is performed to establish a reference level against which subsequent measurements will be compared. Generally, this may be for new employees, or for established employees, prior to commencing work with radioactive materials, beginning a specific type of radiation zone work, or making an offsite trip where potential internal exposure could occur.
PR	Periodic	Measurement is performed at a regularly scheduled interval.
EA	End of Assignment	Measurement is performed following completion of specific work assignment, but not end of employment.
SP	Special	Measurement is performed as part of a specific investigation of potential internal dose. May include response to off-normal work conditions, or follow-up of abnormal periodic measurements.
CR	Contractor Request	Measurement requested by employer for reasons other than periodic, baseline, end work, or special investigation.
RA	Reanalysis A	First reanalysis of sample by taking another aliquot and repeating the same radiochemical or chemical analysis.
RB	Reanalysis B	Second reanalysis of sample by taking another aliquot and repeating the same radiochemical or chemical analysis.
R1	Recount 1	First recount of original excreta sample or repeat in vivo exam.
R2	Recount 2	Second recount of original excreta sample or repeat in vivo exam.
QR	Quality and Research	Measurement performed as part of quality control, quality assurance, or research work.
TM	Termination	Final bioassay at termination of employment.
12	Contract Work	In vivo measurement performed under contract to customers rather than Hanford employees.
20	Source Count	In vivo source count made for system calibration or as a function check, usually using a known check source.
30	Background Count	In vivo system background measurement performed for system calibration or as a functional check.

TABLE B.4. Excreta Sample Kit Codes

Kit Code	Sample Medium	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	A 12-hour urine collection for termination sampling only. Collected at home overnight. Designated sample date is the date of scheduled kit pickup from the employee. Scheduled delivery is the day before the sample date.
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. Scheduled delivery is the day before the sample date.
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.
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.

Kit Code	Sample Medium	Sample Description
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.
A	Urine	Simulated 48-hour urine collection. Collected at home over a 4-day period (kit usually delivered Monday and picked up Friday). Used for large-volume, low-level isotopic plutonium analysis (IPUL). Designated sample date is the midpoint of the collection period (usually Wednesday).

TABLE B.5. Excreta Processing Codes and No-Sample Codes

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

No Sample Code	Description
NS	Kit retrieved but no sample provided by worker ("no sample")
LL	Sample lost during laboratory analyses ("lost-in-lab")
IS	Sample provided by worker but volume insufficient to meet contractual requirements ("insufficient volume")
LC	Sample kit not retrieved ("lost container")
CT	Sample lost due to bioassay analysis contract termination
C5	Sample/analysis cancelled
KN	Sample kit not out at time of scheduled pickup
ND	Sample scheduled but kit never delivered

TABLE B.6. Unit Codes

Computer Code	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
7	nCi (nanocuries)
8	µCi (microcuries)

TABLE B.7. Isotope Codes

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

TABLE B.8. Analysis Type and Multiple Result Codes for Excreta Samples

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, ^{241}Pu	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

TABLE B.8. (contd)

Description	Multiple Result Code	Computer Code	Results Reported
Th isotopic	T	OTH	^{228}Th, ^{230}Th, ^{232}Th
Ra isotopic	R	IRA	^{224}Ra, ^{225}Ra
Seq. Am and Cm isotopic		ACM	^{241}Am, ^{242}Cm, $^{243,244}Cm$
Seq. Am and Cm isotopic		ICA	^{241}Am, ^{242}Cm, $^{243,244}Cm$ (used from 6090 to 10-91)
Low-level isotopic Pu		IPUL	$^{234,240}Pu$

TABLE B.9. Bioassay Frequency Codes

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

TABLE B.10. In Vivo Body-Location Codes

Computer Code	Body Location
CH1	Chest result
CH2	Chest result corrected by ultrasound measurement of chest wall thickness
LG1	Lung result. (Chest result corrected for skeleton burden interference.)
LG2	Lung result. (Chest result corrected for skeleton and liver burden interference.)
ABD	Abdomen
KNE	Knee
TRT	Throat
HND	Hand
SPL	Special
THX	Thorax
SK1	Skeleton result based on a head count
SK2	Skeleton result based on something other than a head count
WBD	Whole body
WND	Wound

TABLE B.11. In Vivo Detector Codes[a]

Code	Type of Detector
New LC System Effective 1-1-92	
UA	One 4" x 11" and four 4" x 9" NaI detectors
VA	IG[b] lung count 6 PGTs 0.25 keV/ch Iron Room
VB	IG lung count 4 PGTs 0.25 keV/ch Iron Room
WA	IG lung count 6 CIs 0.25 keV/ch stainless
WB	IG lung count 4 CIs 0.25 keV/ch stainless
OA	One 4" x 4" x 8" and five 4" x 4" x 16" NaI detectors
IA	Four coaxial GE detector scan in Utah Room
JA	Single planar IG detector wound count
QA	Two planar IG detector head count
RA	Liver count using three planar IG detectors
JA	Thyroid count using two planar IG detectors
Codes Used Prior to 1-1-92	
U2	Stand-up whole body count keeping the spectra from the five detectors separate (four 4" x 9" and one 4" x 11")
V5	IG lung count 4 PGTs at 0.25 keV/ch
V6	IG lung count 6 PGTs at 0.25 keV/ch
V7	IG lung count 4 CIs at 0.25 keV/ch
I3	Three coaxial - 60%, 69%, 66.3% detector scan in Utah Room at 1.5 keV/ch
I4	Four coaxial - 59.4%, 69%, 66.3%, 77.1% detector WBC scan in Utah Room at 1.5 keV/ch
O2	Remote counter 4" x 4" x 16" and a 4" x 4" x 8" NaI
I4	Four coaxial - 59.4%, 69%, 66.3%, 77.1% stationary lung count in Utah Room at 1.5 keV/ch
O1	4" x 4" x 16" collimated scan 2" slit UTAH

TABLE B.11. (contd)

Code	Type of Detector
Codes Used Prior to 1-1-92 (contd)	
J2	Wound count using one IG detector at 0.25 keV/ch
I1	Wound count using one coaxial detector
Q1	Head count using two IGs on forehead at 0.25 keV/ch
J1	Wound count using one IG detector at 0.5 keV/ch
V4	IG lung count 6 PGTs at 0.25 keV/ch Pre 9/89 cal
S1	Shadow shield scan count 6" x 11" NaI
G2	Mobile shadow shield 4" x 11" NaI detector
S1	Shadow shield counter used as clothing counter 6" x 11"
I2	GeLi detectors 24% and 34% used for lung counting for high-energy emitters
V1	IG lung count 6 PGTs at 0.50 keV/ch
V2	IG lung count 6 PGTs at 0.25 keV/ch
E1	Phoswich thyroid count for I125
Q2	Thyroid count with two IGs at 0.25 keV/ch
J1	Thyroid count with one PGT IG (at Sequim) at 0.5 keV/ch
U1	Stand-up whole body count using sum of five detectors (four 4" x 9" and one 4" x 11")
O2	Head count using three IGs from one side
Q1	Head count using two IGs on forehead at 0.5 keV/ch
D1	Wound count using thin NaI detector

TABLE B.11. (contd)

Code	Type of Detector
Codes Used Prior to 1-1-92 (contd)	
J1	Lymph node count using one IG detector 0.5 keV/ch
J3	Lymph node count using one IG detector 0.5 keV/ch
R1	Liver count using three IG detectors 0.5 keV/ch
R3	Liver count using three PGT IG detectors 0.25 keV/ch
R2	Liver count using three CI IG detectors 0.25 keV/ch

(a) The current and historical listing of in vivo detector codes is maintained by the Hanford Whole Body Counting Project. The listing provided in this manual is not necessarily current or complete. For the most current information, contact the Whole Body Counting Project Manager.
(b) IG = intrinsic germanium.

TABLE B.12. In Vivo Schedule-Type Codes

Code	Type of Measurement
C	Chest count
C2	Extended chest count
HC	Head and chest count
HD	Head count
H2	Head and extended chest count
LC	Liver and chest count
LV	Liver count
LY	Lymph node count
TC	Thyroid count
TH	Thyroid
WB	Whole body count
WN	Wound count

TABLE B.13. In Vivo No-Result Codes

Code	Description
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 the location of activity and do not yield quantifiable estimates of activity.
M	Medically administered radioactivity interfered with measurement. Measurement invalid; no results obtained.
P	Preliminary count, when followed by a more quantitative record count. Used to indicate measurement taken, but not a record count.
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 REX 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.

TABLE B.14. INTERTRAC Mode-of-Intake Codes

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

TABLE B.15. INTERTRAC Evaluation Reason Codes

Code	Description
A	Annual chronic-intake evaluation
C	Contractor-requested evaluation
H	High routine-bioassay evaluation
I	Incident evaluation
N	New-hire measurement or previous employment record indicated exposure prior to Hanford employment
R	Reevaluation

TABLE B.16. INTERTRAC Source-of-Intake Codes

Code	Description
DHE	Intake at DOE site while employed at Hanford
Han	Intake at Hanford
NHE	Intake at non-DOE site while employed at Hanford
NOC	Nonoccupational intake
PTH	Intake occurred prior to Hanford employment

TABLE B.17. INTERTRAC Miscellaneous Codes

Intake Confirmed Code

Y - Yes
N - No

Nature of Intake Code

A - Acute
C - Chronic

Recorded Dose Code

Y - Yes
N - No
O - Yes, old evaluation
Z - Recorded dose is zero mrem

Source Known Code

Y - Yes
N - No

Type of Evaluation Code

P - Preliminary
F - Final

TABLE B.18. Person Codes

Code	Description
E	Employee
F	Fetus
N	Non-resident
S	Subcontractor
V	Visitor

TABLE B.19. Excreta Laboratory Codes

Code	Description
IT	IT Analytical Services - Richland
LA	Los Alamos National Laboratory
OR	Oak Ridge National Laboratory
PL	PNL Analytical Chemistry Laboratory
RE	REECO (Reynolds Electric Company, Nevada Test Site)
TA	TMA/Norcal, Richmond, California
WH	Westinghouse Hanford Company, 222-S Lab

APPENDIX C

ANALYTICAL PROCEDURES

This appendix summarizes the procedures that the Analytical Services Laboratory (Lab) uses to analyze indirect bioassay samples, and that the In Vivo Radiobioassay and Research Facility (IVRRF) uses to perform 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. A brief description of the procedure for each radionuclide follows.

C.1.1 Tritium in Urine

A 1-mL sample aliquot is mixed with scintillator solution and counted directly in a liquid scintillation spectrometer.

C.1.2 Urine – Emergency 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 then counted, using alpha spectrometry. Plutonium-241 activity is determined by dissolving the material from the planchet with nitric and hydrochloric acid and then counting the beta emissions in a liquid scintillation spectrometer.

C.1.2 Urine – Emergency and Expedite Processing (contd)

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 didentate organophosphorus solvent (DDCP), electrodeposited on a planchet, and counted using alpha spectrometry.

Uranium — A 10-mL aliquot of the sample is wet-ashed with acid and passed through an ion exchange column. The uranium is eluted with a weak acid and brought to a fixed volume with acid. The final sample is submitted for laser-induced phosphorescence uranium analysis.

C.1.3 Feces – Emergency 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. Enhanced oxidation steps using hydrofluoric acid and hydrogen peroxide can be requested. 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 Routine 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.

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

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 precipitations. This is followed by carbonate, nitrate, and a final carbonate precipitation. 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 Two methods are used to process plutonium. These methods are essentially the same as the procedure for emergency and expedite processing, except that counting times are increased to achieve the desired sensitivity.

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 acid, and precipitated with fuming nitric acid. The americium and curium are then concentrated with didentate 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 A 50-mL aliquot of the sample is wet-ashed with acid and passed through an ion exchange column. The uranium is eluted with a weak acid and brought to a fixed volume with acid. The final sample is submitted for laser-induced phosphorescence uranium analysis.

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
- 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.[(a)] 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 stand-up counter using five NaI detectors. The count time is typically 200 seconds. By identifying the detector with the most counts, radioactivity can be spatially identified as emanating from the general areas of the head, chest, abdomen, or 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.

(a) 1990 internal manual, PNL-MA-574, Pacific Northwest Laboratory, Richland, Washington.

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 routinely reports ^{241}Am, ^{235}U, and ^{234}Th (as an indicator of ^{238}U). A peak search program is used to identify the presence of other significant photon energies.

The chest counter is an array of up to six germanium planar detectors placed uniformly over both lungs. The person being counted is seated in a chair in a slightly reclined position. Typical counts are 1200 seconds long, but counts up to 4000 seconds can be arranged if higher sensitivity in required.

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-inch x 3-inch 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 and relative abundance of each plutonium isotope are known.

APPENDIX D

SAMPLE KIT INSTRUCTIONS

User instructions for each of the Analytical Services Laboratory's nine sampling kits are reproduced in this appendix. 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 title.

Instructions for Kit Code 1

(Orange)

Kit Code 1

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 IT ANALYTICAL SERVICES, Bioassay Section, of any errors by phoning (509) 375-3131, collect, between 7:30 A.M. and 5:00 P.M.

- Please collect **ALL** urine excreted within the periods one-half hour before retiring and one-half hour after rising for two consecutive days.

If kit was delivered on:	**Start col 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 3/4 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. It will be picked up on the pickup date indicated above.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 2

(Gold)

Kit Code 2

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 IT ANALYTICAL SERVICES, Bioassay Section, of any errors by phoning (509) 375-3131, 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 emloyer's termination procedure.

- 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 3/4 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.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 3

(Light Yellow)

Kit Code 3

FOR 24 HOUR TOTAL URINE SAMPLING
HOME FRACTION

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 IT ANALYTICAL SERVICES, Bioassay Section, of any errors by phoning (509) 375-3131, 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 it 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.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 4

(Dark Green)

Kit Code 4

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 IT ANALYTICAL SERVICES, Bioassay Section, of any errors by phoning (509) 375-3131, 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 it 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.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 5

(Blue)

Kit Code 5

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 IT Analytical, Bioassay Section, of any problems or discrepancies in the information on the label. Phone Richland (509) 375-3131, collect, between 7:30 A.M. and 5:00 P.M.
- Please collect a stool specimen (fecal sample) on the above date. If there is not voiding on the sample date, collect the next voiding and put the correct sample date on the label.
- Place the kit on your porch after sampling has been completed.
- Kit will be recovered on the pickup date indicated above.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

ADDITIONAL INSTRUCTIONS O BACK OF CARD

Kit 5 - Back of Card

(Blue)

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.

Instructions for Kit Code 6

(Red)

Kit Code 6

INSTRUCTIONS
FOR SINGLE-VOID URINE SAMPLING

PLEASE READ AND FOLLOW CAREFULLY

- Check the box 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 IT ANALYTICAL SERVICES, Bioassay Section, of any errors by phoning (509) 375-3131 collect, between 7 A.M. and 6 P.M.
- **UNLESS YOU HAVE BEEN INSTRUCTED OTHERWISE,** please collect **ALL** urine passed starting one-half hour before retiring on the above sample date and ending one-half hour after 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 3/4 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 indicted above.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 7

(Light Green)

Kit Code 7

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 IT ANALYTICAL, Bioassay Section, of any errors by phoning (509) 375-3131, 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 3/4 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.

IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

Instructions for Kit Code 8

(Turquoise)

Kit Code 8

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 IT ANALYTICAL SERVICES, Bioassay Section, of any problems or discrepancies in the information on the container. Phone Richland (509) 375-3131, collect, between 7:30 A.M. and 5:00 P.M.
- Please collect specimen (fecal sample), following the instructions given below.
- Place the kit on your porch after final sampling has been completed.
- Kit will be recovered on the pickup date.

CHECK TIME OUT OF ZONE:

- O Less than 1 day
- O 1-3 days
- O More than 3 days

ADDITIONAL INSTRUCTIONS ON BACK OF CARD

Kit 8 - Back of Card

(Turquoise)

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.

Instructions for Kit Code 9

(Pink)

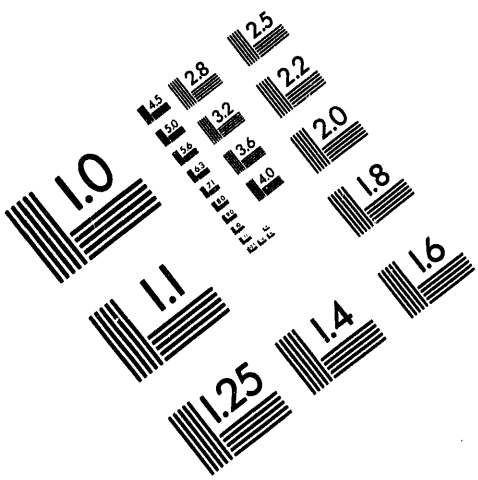
Kit Code 9

INSTRUCTIONS
FOR COLLECTING A URINE SAMPLE FOR MAILING

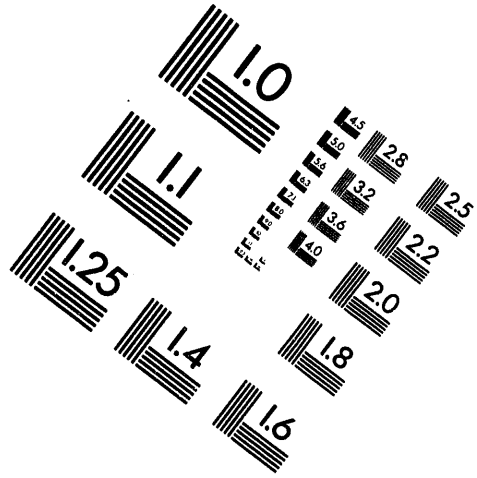
PLEASE READ AND FOLLOW CAREFULLY

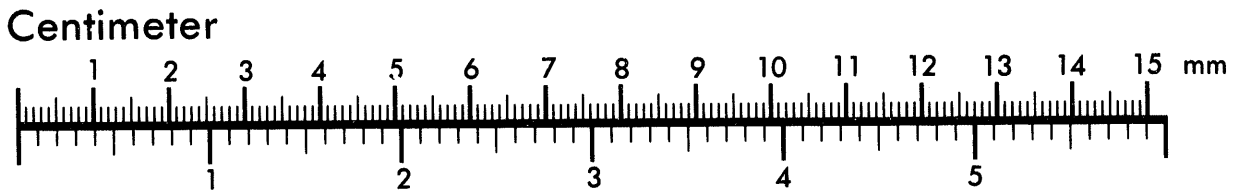
1. Discard the outer box. Write the start date here:_____.
2. Please collect ALL urine while at home until all bottles are used.
3. Three bottles are provided in the kit. Begin with any bottle and fill each bottle at least to the fill line but not higher than the bottle neck.
4. Keep the bottles capped 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 card. Seal the box by moistening the gummed surface of the tape provided and centering over the box closure.
6. Return the package to IT ANALYTICAL SERVICES by calling
7. If you have any questions please call IT ANALYTICAL SERVICES, Bioassay Section, at (509) 375-3131, collect, between 7:30 A.M. and 5:00 P.M.

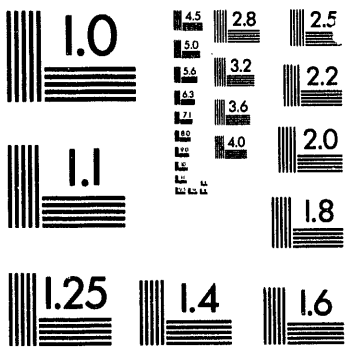
IT ANALYTICAL SERVICES
BIOASSAY SECTION
2800 George Washington Way
Richland, Washington 99352

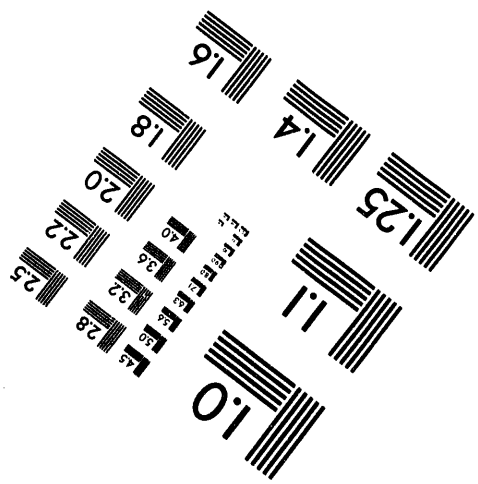


Association for Information and Image Management
1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202









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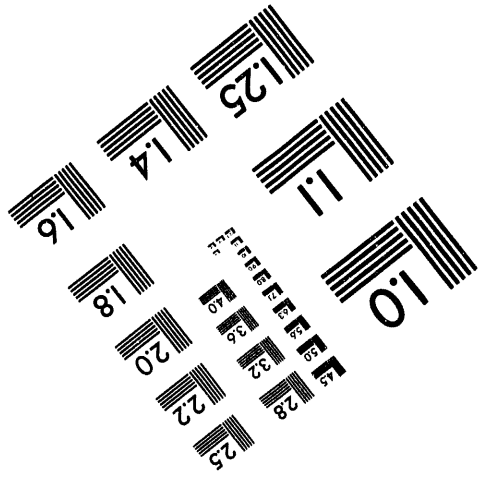

3 of 3

APPENDIX E

HANFORD INTERNAL CONTAMINATION

INCIDENT RESPONSE PLAN

HANFORD INTERNAL CONTAMINATION INCIDENT RESPONSE PLAN

P. C. Olsen
D. E. Bihl

December 1993

Work supported by
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Pacific Northwest Laboratory
Richland, Washington 99352

HANFORD INTERNAL CONTAMINATION INCIDENT RESPONSE PLAN DECEMBER 1993

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ACRONYM LIST

ALI	annual limit on intake
CAM	continuous air monitor
CEC	Commission of the European Communities
CEDE	committed effective dose equivalent
classes D, W, Y	ICRP 30 inhalation classes categorizing the quickness by which various elemental materials are removed from the lung
CP	Cutie-pie (ionization chamber)
DAC	derived air concentration
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DTPA	diethylene triamine penta acetate; used to bind and remove plutonium and americium from the blood.
EDF	Emergency Decontamination Facility
GI	gastrointestinal
GM	Geiger-Müller radiation chamber
HEHF	Hanford Environmental Health Foundation
ICRP	International Commission on Radiological Protection
IPA	isotopic plutonium and ^{241}Am via alpha spectrometry
IVRRF	In Vivo Radioassay & Research Facility
KEH	Kaiser Engineering Hanford Company
LEPD	Code for lab analysis, referring to non-destructive low-energy photon spectrometry; measures x-rays from ^{241}Am.
MDA	minimum detectable activity or, for uranium, minimum detectable amount
MDD	minimum detectable dose
NCRP	National Council on Radiation Protection

PNL	Pacific Northwest Laboratory
REAC/TS	Radiation Emergency Assistance Center/ Training Site
RCT	radiological control technician
RL	U.S. Department of Energy, Richland Operations Office
WHC	Westinghouse Hanford Company

1.0 INTRODUCTION

This document discusses actions taken by various groups at the Hanford Site in response to an incident with potential for an intake of radioactive material. The scope of such an incident can range from something requiring special bioassay samples taken within a few days of the incident to something requiring immediate medical treatment. The document discusses response at the fullest level to ensure that all responses are covered, but the extent of any given response is tailored according to the suspected severity and the time lag between time of the incident and the recognition that an intake may have occurred.

Because Hanford is a multi-contractor site managed by the U.S. Department of Energy (DOE) and because response to a suspected intake involves various contractors and groups within contractor organizations, specifics of implementation at the contractor level are usually contained in various contractor manuals. This document provides an overview of how response at Hanford works and guides the reader to the appropriate contractor manuals for specifics.

This document does not address accidents with potential for abnormal external radiation exposure, criticality, or skin contamination (except when the circumstances of the skin contamination imply a potential for an intake).

2.0 CONTRACTOR RESPONSIBILITIES AT HANFORD

Proper response to an incident with potential for an intake of radioactive material at Hanford involves coordinated action by many contractors and subgroups within the contractor organizations. This section lists the responsibilities of these groups for identification, response, and management of a worker or workers who may have recently incurred an unexpected intake.

2.1 FACILITY RADIATION MONITORING AND SURVEYING

The facility radiological control organization is responsible for monitoring radiological conditions of the workplace and for surveying personnel and equipment within and upon leaving radiological controlled areas. This function is performed by

- Westinghouse Hanford Company (WHC) Health Physics Support for facilities and outdoor areas within its control
- Pacific Northwest Laboratory (PNL) Laboratory Safety for facilities and areas within its control.

Duties include air monitoring, surface contamination surveying, personnel surveying, obtaining and counting nasal and mouth swabs, personnel decontamination (except for serious wounds that require prompt medical attention), and initial notifications of a potential intake. The radiological control organization is also responsible for collecting special samples that may provide information about the source of an intake, such as smears of the contamination at the source, or smears from the worker's clothing, equipment, or person. Depending on the nature of the sample or the counting equipment available, the radiological control organization may count these special samples or may make arrangements for having the samples counted at a laboratory.

The facility radiological control organization is also responsible for ensuring that workers with contamination on their skin, hair, or clothing are decontaminated before leaving the facility. In the event that a worker has to be transported to the Emergency Decontamination Facility (EDF) or to the hospital for decontamination and/or medical treatment, the facility radiological control organization (with the concurrence of the Hanford Fire Department) is responsible for preparing the contaminated worker and/or appropriate ambulance areas for transportation to minimize contamination spread. They are also responsible for accompanying the contaminated worker to the EDF and surveying the ambulance and potentially contaminated areas outside of the EDF after the worker has been safely brought inside.

2.2 CONTRACTOR DOSIMETRY

Each contractor and U.S. Department of Energy, Richland Operations Office (RL) has a representative or organization that specializes in dosimetry issues. Subcontractors of these are covered through the principal contractor organization. Within WHC, that organization is Health Physics/Dosimetry, and within PNL the representative is designated staff within the Laboratory Safety Department. The dosimetry organization or representative is the contact for the worker concerning his/her internal dose evaluation and dose management. The contractor dosimetry representative usually accompanies the worker during the first in vivo counts or first stages of treatment. The contractor dosimetry organization has overall responsibility for intake case management and interface with the worker.

The contractor dosimetry organization is responsible for:

- obtaining worker identification and information about particulars of the intake from the monitoring organization
- recommending additional workplace measurements, such as time-delayed counts on nasal swabs, counts of smears of the contamination, blood smears, clothing, and air samples
- notifying the PNL exposure evaluator and the RL radiation protection programs monitor that an potential intake has occurred and providing information about the intake scenario as it becomes available
- notifying other organizations if necessary, such as the Hanford Environmental Health Foundation (HEHF) nurse, and assisting with recommendations for treatment, especially with the decision to administer diethylene triamine penta-acetate (DTPA)
- representing the company in discussions with the worker about various issues resulting from the intake, such as bioassay measurements or sampling, nature of treatment, estimates of intake or dose, and work restrictions
- serving as the contact for the exposure evaluator for arranging bioassay samples, and obtaining source term information via analysis of workplace samples or interviewing knowledgeable staff
- establishing work restrictions for workers with suspected or confirmed intakes while the intake is being investigated.

2.3 PACIFIC NORTHWEST LABORATORY WHOLE BODY COUNTING AND INTERNAL DOSIMETRY

Pacific Northwest Laboratory is chartered through the Hanford Site Services Handbook (RL 1991) to provide in vivo radiological measurements, provide for excreta bioassay measurements, and perform and document internal exposure evaluations. These functions are provided as services to the contractor dosimetry organizations who retain the overall responsibility for the worker's radiation protection and dose management. The functions are performed through the Whole Body Counting and Internal Dosimetry Programs.

2.3.1 Pacific Northwest Laboratory Whole Body Counting Project

The Whole Body Counting Project located at the In Vivo Radioassay and Research Facility (IVRRF) is responsible for providing in vivo counts appropriate for the type of radioactive material involved in the intake. This includes the capability to quantify high-energy gamma-emitters in the whole body and low-energy gamma- or x-ray-emitters in lungs, wounds, and excised tissue at EDF. Measurements of beta-emitters such as ^{90}Sr can also be made through associated radiations emitted from the skull.

The project is capable of performing immediate measurements of radionuclides after an accidental intake and is usually the first indication of the extent and quantity of the intake. This service works with the Internal Dosimetry Program for the early evaluation of worker intakes.

2.3.2 Pacific Northwest Laboratory Internal Dosimetry Project

The Internal Dosimetry Project is responsible for providing a 24-hour single point-of-contact for response to a potential intake. The staff member on call is referred to as the exposure evaluator. The exposure evaluator is responsible for:

- notifying the HEHF physician-on-call, the PNL radiation control technician, the Whole Body Counter staff, the excreta laboratory, and, if necessary, the contractor dosimetry representative
- meeting the worker when he/she arrives at the EDF or IVRRF and discussing with the worker what in vivo measurements and excreta sampling will be conducted;
- interpreting the results of in vivo measurements, making initial assessment of the potential severity of the intake based on the data at hand, and discussing implications of the results of the in vivo measurements with the worker, the HEHF doctor (if one is involved), and the contractor dosimetry representative
- recommending the type, frequency, and analysis priority for bioassay samples and/or additional in vivo measurements, as well as indicating the consequences of missed samples or samples analyzed at other-than-recommended priorities for the accuracy or responsiveness of dose assessment

- advising the HEHF physician concerning the need for treatment
- arranging for excreta sampling according to agreement with the contractor dosimetry representative and worker
- identifying supplemental measurements and samples to aid in the dose assessment (e.g., measurement of air filters, smears, etc.)
- providing radiation monitoring support at EDF if a contaminated worker arrives at EDF before a PNL radiological control technician arrives.

2.4 HANFORD ENVIRONMENTAL HEALTH FOUNDATION

Hanford Environmental Health Foundation provides periodic health evaluations, health information, primary care for acute injuries and illnesses, and follow-up care for injuries (RL 1991). In the event of a potential intake not involving life-threatening trauma or serious injury, HEHF is responsible for directing treatment with respect to the internal deposition (Good 1992). In the event of serious injuries or trauma, HEHF cooperates with the Hanford Fire Department Emergency Paramedic organization for appropriate remediation of any internal deposition of radioactive material. The HEHF maintains a physician-on-call at all times, and at least one nursing station is staffed at all times.

Hanford Environmental Health Foundation is responsible for

- deciding when to treat and how to treat workers to ameliorate the effects of intakes
- maintaining medical supplies appropriate for treating workers for intakes of radionuclides applicable at the Hanford Site
- obtaining worker consent for administering DTPA
- administering appropriate pharmaceuticals or medicines for treatment of intakes
- notifying the exposure evaluator if the contractor has not already done so
- arranging for medical specialists, as appropriate.

If the potential intake involves a contaminated wound, HEHF is responsible for

- deciding when to activate the EDF and being in charge of operations when the EDF has been activated

- providing nursing assistance at or near the workplace, unless the injury is severe, in which case, the Hanford Fire Department paramedics are responsible for first-response medical assistance

- maintaining contact with the Kadlec Medical Center and notifying the exposure evaluator if the decision is made to transport the worker to Kadlec.

2.5 PNL LABORATORY SAFETY RADIOLOGICAL PROTECTION TECHNICIANS

In addition to providing workplace monitoring for facilities within its jurisdiction, PNL provides radiation monitoring support for activities conducted at EDF. In this regard, PNL Laboratory Safety is responsible for

- establishing potential contamination areas and step-off pads within EDF

- assisting the medical staff with locating and surveying external contamination on the injured worker

- monitoring the radiation field resulting from the injured worker and advising the medical staff and the exposure evaluator of the strength of the field (**Note**: The physician-in-charge may overrule normal radiation protection exposure guidelines if deemed necessary to protect the health of the injured worker.)

- surveying all personnel and equipment leaving the contamination area

- operating the air sampling system

- surveying the contamination areas and other areas with potential for contamination spread at the end of the work and removing the contamination area designation as soon as applicable

- ensuring that all the radioactive waste is placed in proper receptacles and arranging for disposal.

If the potentially exposed worker is taken to IVRRF instead of EDF, PNL Laboratory Safety Department is also responsible for monitoring the worker for surface contamination before the worker is allowed into the counting area.

2.6 HANFORD FIRE DEPARTMENT

The Hanford Fire Department provides ambulance response for the Hanford Site (RL 1991) through the Emergency Medical Services Program. The program maintains registered and certified paramedics who provide on-the-scene emergency medical treatment and transportation to the hospital or EDF. During a medical emergency, paramedics (or emergency medical technicians) take direction from the Medical Program Director of the Mid-Columbia Emergency Medical Service. If known or suspected internal radionuclide deposition is

involved and injury is not life-threatening, then HEHF is responsible for directing treatment. Otherwise, the paramedics or emergency medical technicians will manage the immediate medical care under direction of the Kadlec emergency room physician (Good 1992) although an HEHF doctor may take charge of medical care if the doctor is present with the patient. In such a situation, the HEHF doctor will inform the Kadlec emergency room physician of the intent to take over medical care so that clear responsibility for patient care is established and so that clear direction is given to the paramedics and emergency medical technicians.

With known or suspected radiological intakes, the Hanford Fire Department dispatcher is responsible for promptly notifying the nearest Health Service Center and the HEHF physician-on-call. If EDF is activated, the Hanford Fire Department dispatcher is responsible for contacting the bus dispatcher to request that the emergency generator be put in place at EDF (Good 1992).

The ambulance will either pick up the HEHF nurse while responding to the scene or bring the patient to the nearest available Health Service Center as determined by the medical and logistical requirements of the incident. Patients may be released from the HEHF nurse to a paramedic for transportation to EDF or Kadlec (Good 1992).

2.7 DEPARTMENT OF ENERGY, RICHLAND OPERATIONS OFFICE

The U.S. Department of Energy, Richland Operations Office, Health Physics staff monitor the status of an incident with potential for intake. One of the staff is contacted by the worker's dosimetry organization. The staff at RL in turn keeps the RL Office of the Manager and Office of Communications informed of the status of the incident, if warranted. In the event that the Unified Dose Assessment Center, the Emergency Action Coordinating Team, and the EDF are all activated because of the same event, RL provides a liaison between the EDF and the Emergency Action Coordinating Team.

3.0 INITIATION AND WORKPLACE ACTIONS

The initiation of response to an incident with potential for an intake of radioactive materials requires prompt actions in several areas. As discussed in the previous section, coordination between the various Hanford contractors and response personnel has to occur, and prompt estimates of intake and the proper level of response must be determined. This section discusses the various immediate actions that should be taken in the event of a suspected or known intake of radionuclides at the job site.

3.1 EVACUATION AND SAFETY OF PERSONNEL

The initiation of response to a suspected intake may occur from one of many indicators. Continuous air monitor (CAM) alarms, unexpectedly high monitoring survey results, loss of containment, or other serious accident conditions such as fire or explosion may occur. Prompt response for an incident/event condition is paramount, and should be in direct relation to the incident conditions. Both WHC and PNL have documented instructions on accident/emergency response and potential internal radioactive material intakes. The Hanford Fire Department Emergency Medical Services Program Plan, WHC-EP-0575 (Good 1992), details accident responses by paramedics and ambulance services. The Westinghouse Hanford Emergency Plan, WHC-CM-4-1, describes the contractor interface and response during Hanford emergencies and other incidents (WHC 1990).

At Hanford intakes of radioactive material most often occur without a formal activation of the site emergency preparedness response function. If contaminated wounds or intakes occur as part of a larger event requiring activation of the site emergency preparedness functions, the response to the intakes would proceed simultaneously and mostly independently of the response to the site emergency.

Generally, the following steps should be considered in the initial actions for a suspected intake or contamination event; the steps are listed in their order of priority:

1. Provide for emergency medical care immediately for serious injuries, if safe to do so. The Hanford Site RadCon Manual (RL 1992) lists dose limits for lifesaving as 25 rem where a lower dose limit is not practicable and allows for >25 rem only on a voluntary basis.

   Alert medical personnel (Hanford Fire Department paramedic team and HEHF physician-on-call) for injuries requiring immediate attention.

2. Remove injured/contaminated individuals first, then all individuals from contaminated radiation areas. Control/segregate a) the injured, b) the contaminated, and c) the suspected internally contaminated.

3. Survey worker(s) for contamination, include (where feasible) nasal swabs, nose blows, sputum samples, blood smears, and mouth and facial surveys as well as general contamination levels. Section 3.4.1 of Management of Persons Accidentally Contaminated with Radionuclides, NCRP 65 (NCRP 1980) contains detailed information on special surveys for initial radionuclide intake estimates.

   Recount samples with detectable alpha contamination at a later time to account for radon progeny interference.

4. If intakes of radionuclides are suspected or confirmed, make notifications according to the notification levels (Table 1 of this document or tables in WHC-CM-4-16).

5. Remove contaminated clothing, provide clean replacement coveralls, and perform minor decontaminations of skin and outer surfaces of the body.

   Control and separate personal dosimetry for evaluation of radiation dose.

6. If a decision has been made to administer DTPA, ensure that the nurse has proper information for prompt arrival at the designated location, i.e., exact room in the facility.

   Provide radiation monitoring support to the worker and nurse.

7. If the contaminated worker is to be transported via ambulance, prepare the ambulance for control of contamination and provide radiation monitoring support for the ambulance and for staff in the ambulance.

8. Assist in identifying radionuclides involved in the exposure, their chemical form, particle size information, and solubility by obtaining workplace samples and/or communicating knowledge about the nature of the contamination.

3.2 WESTINGHOUSE HANFORD COMPANY ACTIONS

These WHC manuals specify steps to be taken for suspected intakes of radioactive materials:

- Dosimetry and Medical Services Manual, WHC-CM-4-16
- Health Physics Practices Manual, WHC-CM-4-12
- Health Physics Procedures, WHC-IP-0718.

Care of injured or contaminated personnel is the first priority, and notification of the PNL exposure evaluator will occur after initial medical response steps have been initiated. Initial response is handled by WHC radiological control technicians (RCTs) and their supervisors upon discovery

of a potential intake of radioactive materials. The WHC Internal Dosimetry Advisor is notified, who in turn coordinates the appropriate technical support contacts. If notification levels of contamination are exceeded, as specified in WHC-CM-4-16, then WHC will notify the exposure evaluator to be prepared for bioassay monitoring and additional recovery efforts.

If decontamination of individuals is required, then a Westinghouse RCT will perform initial decontamination in the field, by procedure WHC-IP-0718, Section ER-03. If field indicators for radioactive contamination exceed stated levels in WHC-IP-0718, then the RCT or supervisor notifies HEHF Health Services Center for consideration of administration of DTPA or other appropriate medical intervention. Upon completion of decontamination, the individual is transported to the IVRRF for monitoring. If decontamination is not successful the individual is transported to the EDF for further decontamination (with the concurrence of the HEHF physician-on-call). Subcontractors to WHC follow the WHC procedures discussed above.

3.3 PACIFIC NORTHWEST LABORATORY ACTIONS

Policy and Procedures for Radiation Protection Technician Supervisors, PNL-MA-506, Sections 4 ("Off-Normal Events") and 8 ("Air Sampling Program") contain PNL procedures for determining that intakes have occurred from air sampling or other survey results and procedures for operating the EDF. Procedures for Radiation Protection Technicians, PNL-MA-507, Vol. 2, also addresses initial response to potential intakes in Procedure RP 3.4.01, "Job Coverage."

In the event of an incident in which a suspected internal deposition of radioactive material may have occurred, the radiation protection technician (RPT) supervisor will take the following actions (see PNL-MA-6 Radiation Protection, Article 543):

1. Identify personnel potentially exposed.

2. Obtain nasal, sputum, blood, or surface contamination surveys where appropriate, for the qualitative characterization of the intake.

3. Obtain air samples or CAM monitoring results to determine the airborne concentration and integrated exposure where appropriate.

   Note any use of respiratory protection, and whether or not it was compromised in any fashion.

4. Determine the duration of the exposure.

5. Notify the PNL exposure evaluator and provide the above information.

6. Assist in other notifications, such as the HEHF Health Service Center or the physician-on-call.

7. Obtain special bioassay samples as requested by the exposure evaluator or HEHF physician-on-call.

Subcontractors performing work under the direction or by subcontract to PNL follow PNL procedures as described above, using the radiation protection organization of PNL.

4.0 NOTIFICATION OF AUTHORITIES

4.1 ONSITE NOTIFICATIONS

Some requirements for prompt investigation of a possible intake are provided in the Hanford Site RadCon Manual (RL 1992), Article 522.5. A set of procedures for prompt notification of the PNL exposure evaluator and the HEHF physician-on-call are found in the Hanford Internal Dosimetry Program Manual, Section 7.

Notification levels based on workplace indicators are shown in Tables 4.1 and 4.2. These are considered general guidance to the contractors who incorporate the guidance in their internal manuals or procedures governing the actions of radiation control technicians and dosimetry staff. Generally, the intake of alpha-emitters such as plutonium or americium cause the most dose commitment for the activity ingested. For this reason, and because of the detection difficulties in measuring quantities of alpha-emitters internally or with bioassay procedures, the action levels for these are the most restrictive. Fission or activation product radionuclides, beta-gamma emitters, and pure beta-emitters are less difficult to detect, and usually have a lower committed effective dose equivalent (CEDE) per unit of intake.

4.1.1 Westinghouse Hanford Company Notifications

The WHC Internal Dosimetry Emergency Procedure, WHC-CM-4-16, Section 5.1, contains a flow chart for the initial notifications to be made for a potential intake. The notifications include WHC Health Physics/Dosimetry, the HEHF physician-on-call, line management, the exposure evaluator, and the RL health physics representative. Criteria for making the decision to notify these persons are based on the level of contamination found at the scene, the airborne radiological conditions, or suspected contaminated wounds. Tables 5.1.1 and 5.1.2 of WHC-CM-4-16, section 5.1, contain these criteria levels. They are also found in "Personnel Decontamination," Section ER-03 of WHC-IP-0718.

4.1.2 Pacific Northwest Laboratory Notifications

The PNL Laboratory Safety dosimetry representative is notified whenever an acute intake of >40 DAC-hours is suspected. The Laboratory Safety dosimetry representative, in turn, notifies the exposure evaluator and the RL health physics representative. More restrictive reportable limits on single air contamination results of 3.3E-12 μCi/mL gross alpha or 6.0E-10 μCi/mL β,γ (corrected for radon and background) on a 24-hour sample are found in Policy and Procedures for RPT Supervisors (PNL MA-506). This level requires an investigation report to be completed and the dosimetry engineer to be informed. Normally, the PNL counting room technician will report the result to a radiation monitoring supervisor. Radiation Protection, PNL-MA-6, states that persons currently participating in the broad scope bioassay program shall participate in special bioassay monitoring whenever their routine bioassay

TABLE 4.1. Contamination Levels for Exposure Evaluator Notification

Indicator	Alpha-emitters	β or β,γ Emitters
Nasal or mouth smears	Detectable activity	Detectable activity
Facial contamination (direct measurement)	200 dpm	4,000 dpm
Skin breaks or blood smears	Any skin break while handling alpha-emitters other than sealed sources	Any detectable activity around or on skin break, or detectable activity on blood smear
Head, neck contamination	2,000 dpm	40,000 dpm
Contamination in respirator	Detectable activity inside respirator after use	
Hands, forearms, clothing[a]	10,000 dpm	200,000 dpm (10 mrad/h β,γ w/CP)[b]
Airborne radioactivity	Acute intake equivalent to 40 DAC-hours after accounting for respiratory protection factor[c]	

(a) Clothing contamination levels apply to exposure without respiratory protection, such as on inner coveralls or personal clothing.

(b) If the Geiger-Müller (GM) detector approaches operational limits, use Cutie-Pie (CP) meter and exposure rate as guideline. This value is based on 10% operational efficiency and a conversion factor of 2000 cpm/mrad/h.

(c)
$$\text{DAC-hours} = \frac{\text{airborne concentration}}{\text{DAC}} \times \text{hours of intake}$$

TABLE 4.2. Contamination Levels for Notification of HEHF Physician-On-Call

Indicator	Alpha-emitters	β or β, γ Emitters
Nasal or mouth smears	1,000 dpm	100,000 dpm
Facial contamination	25,000 dpm	500,000 dpm
Skin breaks or wounds	100 dpm	20,000 dpm

monitoring results indicate an unexpected intake of radioactive material resulting in a CEDE of 100 mrem or more.

When so indicated, the notification of the HEHF physician-on-call can be accomplished by either the radiation monitoring supervisor, the Laboratory Safety dosimetry engineer, or the exposure evaluator.

4.1.3 Other Hanford Site Notifications

The activation of the EDF, for contaminated wounds not severe enough to require hospitalization or decontamination not readily performed in the workplace, is accomplished by decision of the HEHF physician-on-call. The physician arranges for medical staff as necessary. The exposure evaluator arranges for the in vivo counting staff and PNL radiation monitoring support.

When a determination has been made that same-day in vivo counts are necessary, the exposure evaluator notifies the in vivo counting staff and, for incidents not occurring in PNL facilities, notifies PNL radiation monitoring.

4.2 OFFSITE NOTIFICATIONS

The notification of offsite personnel or agencies is usually restricted to major contamination events or if additional medical assistance is required in the event of injuries or severe contamination. **Note:** An exception to this is that RL shall be notified in accordance with the following section on occurrence reporting.

4.2.1 Medical Support

In the event that an internal contamination event requires additional medical treatment beyond that of the HEHF staff, the physician-on-call can arrange for medical specialists at one of several Tri-City hospitals. Treatment can be either at the EDF or at one of the local hospitals, at the discretion of the HEHF physician. Notification of the hospital should be completed by medical personnel, who are familiar with the medical aspects of the case.

When necessary, medical care takes precedence over treatment for an intake. Usually, the paramedics are in charge; however, an HEHF doctor may take charge of medical care if the doctor is present with the patient. The paramedics are in contact with and take direction from a doctor associated with the Mid-Columbia Emergency Medical Service. Most likely the worker will be transported to Kadlec Medical Center. At that point, involvement of Hanford dosimetry or radiation monitoring personnel is determined by discussion between the HEHF physician-on-call and the Kadlec doctor. If such support were requested, HEHF would notify the exposure evaluator, who would in turn arrange for in vivo counting staff or radiation monitoring staff as necessary.

Additional medical intervention support for serious accidents or intakes with high dose consequence can be obtained through consultation with the Radiation Emergency Assistance Center/Training Site (REAC/TS) operated through DOE by

the Oak Ridge Institute for Science and Education. A 24-hour emergency assistance number is (615) 481-1000.

4.2.2 Occurrence Reporting

Notification of RL by the occurrence facility is required during the course of a suspected intake of radioactive materials. Notification to the Hanford Facility Manager at RL shall be undertaken according to the "Categorization of Reportable Occurrences" found in Attachment 1 of DOE Order 5000.3B (DOE 1993). Confirmation of an uptake of radioactive material for compliance with DOE Order 5000.3B requires that the assessed dose be quantified. For the purpose of formal reporting, an intake of radioactive material is confirmed once there is a final dose assessment.

Briefly, the categories of reportable occurrences are as follows:

- **Emergency**
  - Any confirmed intake of radioactive material by a worker, student, or minor (onsite), or member of the public (onsite), which in conjunction with any external exposures, results in a dose in excess of five times the DOE annual limits specified in Table 2-1 of the DOE RadCon Manual; or for members of the public (offsite) in excess of Paragraph 1 of DOE Order 5400.5, Chapter II (DOE 1990).
- **Unusual Occurrence**
  - Any confirmed intake of radioactive material by a worker, student, minor, or member of the public, which in conjunction with any external exposures results in a dose in excess of the DOE annual limits as specified in Table 2-1 of the DOE RadCon Manual; or for members of the public (off-site) in excess of Paragraph 1 of DOE Order 5400.5, Chapter II.
  - Any occurrence requiring offsite medical assistance for contaminated personnel.
- **Off-Normal Occurrence**
  - Any confirmed intake of radioactive material by a worker that would result in a committed effective dose equivalent from all intakes equal to or greater than 0.1 rem.
  - Any confirmed intake of radioactive material by a minor or student (onsite) or member of the public that would result in a committed effective dose equivalent equal to or greater than 10 percent of the annual limit specified in Table 2-1 of the DOE RadCon Manual.

5.0 ASSESSMENT OF DOSE FROM INTAKE OR DEPOSITION

Early estimates of the severity of an intake are provided by the PNL exposure evaluator based on results of bioassay measurements. The documentation of the biokinetic models and dose conversion factors used to determine the intake, deposition, or dose is contained in The Technical Basis for Internal Dosimetry at Hanford, PNL-6866.R1 (Sula et al. 1991). Generally, the models used are from International Commission on Radiological Protection (ICRP) Publications 30 (ICRP 1979) or 48 (ICRP 1986). The Jones urinary excretion model is used for transuranics (Jones 1985).

The initial priority of the exposure evaluator is

- to obtain the identification of the workers and the circumstances surrounding the exposure
- to determine the appropriate type of bioassay measurements
- to arrange for the measurements
- to provide information and guidance to the physician concerning the need for or effectiveness of treatment (for more severe intakes)
- to make an early estimate of dose (or of the minimum detectable dose if bioassay measurements do not detect contamination).

There is a large range of bioassay measurements and usually a choice of three laboratory analysis times available for each excreta measurement. The exposure evaluator recommends to the worker's dosimetry representative the mix of bioassay measurements and analysis times based on the type of intake, radionuclides involved, probable severity of intake, and information needs of the physician and the worker's management. Bioassay measurements available include:

- whole body counts for high-energy gamma-emitters (such as ^{137}Cs)
- chest counts, head counts, wound counts, other organ counts for low-energy gamma- or x-ray-emitters (such as ^{241}Am)
- single voiding, overnight, and 24-hour urine samples
- fecal samples.

The excreta samples can be analyzed for all radionuclides of interest at Hanford. Three laboratory analysis times are available for excreta samples: emergency (analysis times of a few hours), expedite (about 2 days), and priority (1 to 2 weeks). (The much slower routine analysis option is also available, but it is not recommended for incident investigation.)

Note: All parties have to recognize that there is a trade-off between the promptness by which estimates of intake or dose can be made and the accuracy of those estimates.

Response protocols vary according to the radionuclides likely involved in the potential intake and the likely severity of the intake, as indicated by results from workplace monitoring of the individual and the environment. Specific responses for most probable radionuclides and scenarios at Hanford follow. The discussion also provides estimates of minimum detectable intakes (in terms of the resulting CEDE) that can be determined at various stages of response.

5.1 TRITIUM EXPOSURE ASSESSMENT

Single-void urine sampling is the recommended bioassay method for an unplanned intake of tritium. The first sample should be obtained about 2 hours after the intake and should be the second voiding after the intake. It is unlikely that an intake of tritium could occur at Hanford that would require emergency processing of urine samples for purposes of treatment, but emergency processing might be important for reporting purposes. Priority processing (3-day analysis time) is usually adequate. This decision can best be made at the time the sample is collected.

Following the first spot sample, an overnight sample or next-morning spot sample should also be collected. Usually, dose assessment can be made based on just these two samples, with a minimum detectable dose of about 1 mrem. However, if the dose estimated at that time is greater than 100-mrem CEDE, then additional samples collected over the next 2 weeks should be collected to improve the precision of the dose assessment.

5.2 MIXED FISSION AND ACTIVATION PRODUCT EXPOSURE ASSESSMENT

Mixed fission and activation products emitting gamma-rays with energies >300 keV are easily measured by whole body counting. A whole body, wound, or thyroid count (if radioiodine is suspected) within the first week after intake is sufficiently sensitive to confirm an intake resulting in a few mrem CEDE. Counts taken on the same day as the intake should generally not be used for dose assessment because of the possible interference from external contamination and because of the rapidly changing biokinetics of the material. If a same-day count results in an estimated dose >10-mrem CEDE, then an additional count should be obtained during the next 7 days. If the estimated dose is >100 mrem, several more counts should be obtained over a period approximately the same as the effective retention half-time in the body (or 6 months, whichever is shorter) to quantify the dose.

Within this category, excluding special research projects, only ^{137}Cs, ^{60}Co, and $^{154/155}Eu$ are of concern now at the Hanford Site. Other mixed fission or activation products have either decayed away or are mixed with and produce much less dose than the three principal radionuclides.

If ^{137}Cs is detected and the estimated dose from the ^{137}Cs is >10-mrem CEDE, then a urine sample should be analyzed for ^{90}Sr.

5.3 STRONTIUM-90 EXPOSURE ASSESSMENT

There are some places onsite where workers may be exposed to ^{90}Sr without accompanying ^{137}Cs or other gamma-emitting radionuclides. Generally, a 12-hour urine sample analyzed by expedite processing is sufficient to give a prompt indication of the severity of the intake down to a few mrem. Actual dose assessment should be based on at least one 24-hour (or 24-hour simulated) urine sample taken a few days after the intake and analyzed by priority processing. If the preliminary dose estimate is >100 mrem, then several urine samples should be obtained during the next couple of months.

If workplace monitoring indicates a potential for a very large intake, then same-day and next-day in vivo counts should be made and a second-void urine sample should be obtained and analyzed by emergency processing. In vivo counting should be able to detect an intake down to 1-rem CEDE within a few hours after intake, and the urine sample should be able to detect an intake around 10-mrem CEDE within 12 to 24 hours after intake. Therefore, a decision to begin or end treatment can easily be made within a few hours after intake.

5.4 URANIUM EXPOSURE ASSESSMENT, SOLUBLE FORMS

Because uranium at Hanford is natural, depleted, or just slightly enriched (up to 1.2% ^{235}U), soluble forms of uranium (e.g. UO_3 and uranylnitrate) pose a chemical as opposed to a radiological hazard. If a major intake is suspected, early response is focussed on the kidney burden relative to the threshold for toxicity (Sula et al. 1991). A same-day chest count should be made as quickly as possible, and a second-void urine sample should be obtained and analyzed by emergency processing. The second-void urine sample should be followed by an overnight or 12-hour sample. Twenty-four-hour samples would follow if the worker was being treated. The chest count should be able to detect an intake of about 14-21 mg depending on how soon after intake the measurement is made, and the spot urine sample should be able to detect an intake of about 1 mg. If anything is detected in a chest count, or if the spot urine and 12-hour urine samples exceed 0.1 mg or 0.5 mg, respectively, then HEHF should be notified. Monitoring of kidney function is recommended.

If workplace monitoring or prompt urine results indicate that the threshold for toxicity was not approached, then actual dose assessment should be based on at least one 24-hour (or 24-hour simulated) urine sample taken at least 3 days after the intake and analyzed by priority processing. The 3-day delay allows for elimination from the body of the unabsorbed fraction of the intake, which can introduce a large error in the dose calculation. Doses down to fractions of a mrem can be detected at that time.

5.5 URANIUM EXPOSURE ASSESSMENT, INSOLUBLE FORMS

Uranium that is more slowly transferred from the lung or wound site can also be encountered at the 303-M, 333, and 306-W Buildings and may possibly be contained in liquid effluent pipes or disposal sites associated with the buildings.

An inhalation of uranium associated with the 303-M building is considered the most difficult to detect because it is mostly class Y material, specifically 10% class D and 90% class Y. Consequently, the dose calculations were based on 303-M uranium as a worse case. Details of the response protocol are given in Table 5.1. Because of the 10% class D component, early urine samples provide adequate sensitivity to an intake. But the urine samples should not be relied on entirely; for potentially large intakes, early fecal samples are essential. This is because virtually all of the dose is contributed by the class Y component, and fecal samples give the best estimate of the quantity of class Y material in the intake. If dose calculations are based on urine samples alone, a small uncertainty in the percentage of class D material present in an intake could lead to a large miscalculation of the dose.

If activity in urine remains above normal after the first couple of days, then additional urine samples should be obtained at about 5, 10 and 30 days after intake.

If there is only normal activity in urine but the activity is >100 times the minimum detectable amount (MDA) in feces, then as a minimum an additional fecal sample should be obtained at about 20 days after intake. Two samples, at 10 and at 20 to 30 days, are preferred.

Fecal samples are not required for intakes of insoluble uranium by wounds because there is no transfer of systemic uranium to the gastrointestinal tract. However, for a very significant intake of uranium via a wound, a couple of fecal samples should be obtained to provide proof of this assumption.

Because of the lower specific activity of uranium relative to plutonium, workplace monitoring is a more reliable indicator of the severity of a uranium intake. For instance, the intake resulting in a 500-mrem CEDE is about 5 mg, which should be readily detectable in the workplace. Consequently, the bioassay protocol is less automatic than for plutonium and can be tailored to reflect the seriousness of the intake as indicated by workplace monitoring. The decision to perform emergency processing of a spot urine sample on one extreme versus priority processing of a 24-hour sample on the other is more subjective. When workplace monitoring implies that the intake is likely to be <100 mrem, then fecal sampling can be skipped.

TABLE 5.1. Inhalation of Recycled Uranium from 303M, No Treatment

Days Post-Intake	Measurements	When Results are Known	What Can Be Said at That Point	Problems or Comments
Same day	3000-s chest count	Same day	Can say if CEDE is < or > 5 rem	If ^{235}U or ^{234}Th detected, advise HEHF for treatment decision.
Same day	2nd voiding spot urine, emergency processing.	Same day or first thing next morning	Can say if CEDE is < or > 1 rem	If spot urine >60 μg, advise HEHF for treatment.
1	If chest count detects activity, then collect a 12-h urine, emergency processing, and a second chest count.	End of second day	No real change in detectable dose, but second chest count will help determine split between class D and class Y, and 12-h urine will improve accuracy of dose estimate and efficacy of treatment.	
1	If first chest count did not detect activity, then collect 24-h total urine and expedite processing.	Morning of the fifth day	If nothing in sample, then dose is 0 to 10 mrem.	If nothing in 24-h sample, collect at least one more and analyze priority processing.
1-3	Total fecal excretion for first 3 days; priority processing.	12 to 14 days after intake		Used to determine class Y component of intake

5.6 PLUTONIUM EXPOSURE ASSESSMENT

Plutonium of concern at Hanford tends to be a mixture characterized by about 6% ^{240}Pu by weight. The time since the plutonium was purified varies from a few years to many years so that there has been ample time for ^{241}Am to grow into the mixture from ^{241}Pu. This material is referred to as "aged 6% plutonium mixture."

The response protocol listed in Tables 5.2 to 5.4 considers both inhalation classes W and Y, although work by Stradling and Stather (1989) has indicated that class W plutonium becomes more and more like class Y as it ages, i.e., as it oxidizes at normal room temperature and humidity.

Details of the bioassay protocol and minimum detectable doses at various stages after an inhalation intake are provided in Tables 4 and 5. Basically, the bioassay protocol consists of a same-day chest count, a second-voiding urine sample

- a 12-hour urine sample collected after the second voiding
- a 24-hour urine sample collected immediately after the 12-hour sample
- all of the fecal excretion for the first 3 days after the incident.

The fecal samples are essential if sensitivity at a few-hundred-mrem CEDE is to be obtained for class Y plutonium. If activity has been detected in urine during the early sampling listed in Tables 5.2 and 5.3, then additional urine samples should be obtained at about 5, 10, and 30 days after intake. If there has been no activity in urine but activity was >100 times the MDA in feces, then as a minimum an additional fecal sample is obtained at about 20 days after intake. Two samples are preferred, at 10 days and at 20 to 30 days.

Details of the bioassay protocol for a plutonium-contaminated wound are provided in Table 5.4. Basically, the protocol consists of same-day wound counts and at least one urine sample. The decision on the type of urine sample (e.g., spot or 12-hour) and processing time will depend not only on what the wound count indicates but also on other contamination data (e.g., the results of the blood sample or the level of contamination on the wound source or on skin around the wound). Fecal samples are desirable for large intakes but are not essential.

For wounds, the issue is not so much the sensitivity of early bioassay measurements, especially for shallow wounds, but the time involved to determine the biological behavior of the material. For instance, it may take months to determine the transfer rate of plutonium from the wound to blood and the quantity of plutonium transferred to the lymph system instead of to blood. Prolonged DTPA treatment will also prolong the time until the CEDE can be quantified.

TABLE 5.2. Inhalation of Aged 6% Pu Mixture, No DTPA Given at Worksite

Days Post-Intake	Measurements	When Results are Known	What Can be Said at What Point	Problems or Comments
Same day	3000-s chest count; second voiding spot urine; emergency processing	Same day or first thing next morning	Can say if CEDE is < or > 12 rem	If anything detected, should administer DTPA.
1	12-h urine, emergency processing; second chest count if first result detected activity	End of second day	If nothing in urine or chest, then intake is class W <5 rem, class Y <10 rem	If nothing in urine or chest, then DTPA is not needed. If Pu alpha in urine >2 dpm, then consider initiating DTPA.
2	24-h total urine, expedite processing	Morning of fifth day	If nothing in sample (and previous chest counts), then CEDE class W <500 mrem, class Y <5 rem	From bioassay data, still won't know inhalation class of material
1-3	Total fecal excretion for first 3 days after intake[a] Two processings by lab: 1) LEPD expedited processing, 2) IPA priority processing	LEPD results: 6-7 days after intake IPA priority: 16-17 days after intake	If nothing in LEPD analysis, then CEDE <500 mrem If nothing in IPA, then CEDE <100 mrem	

(a) If more than one sample is produced in a day, the samples should be composited into a single sample before analysis.

TABLE 5.3. Inhalation, Aged 6% Pu Mixture, DTPA Promptly Administered Based on Workplace Data

Days Post Intake	Measurements	When Results are Known	What Can be Said at What Point	Problems or Comments
Same day	3000-s chest count; second voiding spot urine, emergency processing.	Same day or first thing next morning	If CEDE is < or > 12 rem. Much lower dose if sure material is class W.	Consider second DTPA shot if anything detected in spot urine.
1	12-h urine, emergency processing; second chest count if 1st detected activity.	End of second day	If nothing in urine or chest, then intake is class W <2 rem, class Y <10 rem.	If nothing in urine or chest, then DTPA can be discontinued. If Pu alpha in urine is >2 dpm, then consider continuing DTPA.
2	24-h total urine, expedite processing.	Morning of 5th day.	If nothing in sample (and previous chest counts), then CEDE class W <200 rem, class Y <4 rem.	From bioassay data, still won't know inhalation class of material.
1-3	Total fecal excretion for first 3 days post intake.[a] Two lab processings: 1) LEPD expedited, 2) IPA priority processing (or routine processing if cost is a factor)	LEPD results: 6-7 days after intake; IPA priority: 17-18 days after intake; IPA routine: about 6 weeks after intake	If nothing in LEPD analysis, then CEDE <500 mrem. If nothing in IPA, then CEDE <100 mrem.	

(a) If more than one sample is produced in a day, the samples should be composited into a single sample before analysis.

TABLE 5.4. Wound contamination by Aged 6% Pu Mixture, No DTPA Given at Worksite

Days Post Intake	Measurements	When results are Known	What Can be Said at What Point	Problems or Comments
Same day	One or more wound counts; second voiding spot urine; emergency processing.	Same day or first thing next morning.	Can say if CEDE is < or > 3 rem.	If anything detected in wound or urine, should administer DTPA. If activity in wound is >0.5 nCi, excision should be considered.
1	12-h urine, emergency processing; second wound count if first detected activity	End of second day	Minimum detectable dose somewhat <3 rem, but cannot say exactly due to uncertainty in transfer rate from wound.	If nothing in urine or wound, then DTPA is not needed. If Pu alpha in urine >2 dpm, then consider initiating DTPA.
2	If nothing was detected in previous samples, then one additional urine sample (24-h-simulated) is collected; priority processing.	11 days	If nothing in sample, then CEDE <100 mrem	
2	If activity was detected in previous samples, then additional wound, urine, and possibly fecal samples will be needed. Processing will depend on the activity in the samples.			

The dose estimates in the tables assume that ^{241}Am has had about 5 years to build into the mixture. Longer ingrowth times will improve the chest and low-energy photon (LEPD) fecal detection capabilities somewhat, but never by more than a factor of 3. However, shorter ingrowth times drastically reduce the sensitivity of chest and LEPD fecal counting. Intakes of freshly separated plutonium or pure isotopes of plutonium, are especially difficult to detect via bioassay. A special bioassay program is needed for work with such material; Internal Dosimetry should be consulted before work is begun.

6.0 GUIDES FOR IMMEDIATE CARE

6.1 ACTION OR INTERVENTION LEVELS

Notification levels based on workplace indicators for reacting to a potential intake were provided in Section 4.1 (Table 4.1). The intent of these notification levels is to provide guidance for field response to any potential intake of radioactive material with a potential for a dose commitment that is >100-mrem CEDE. Table 4.2 provided notification levels to the HEHF physician-on-call, for possible early medical intervention in an internal contamination event. These tables are based on general considerations and significant experience with past intakes of radioactive material and, because they are based on field measurements, do not correspond with any exact dose commitment to the worker.

Separate action levels are developed, based on bioassay results, which will occur at a time later in the incident recovery process. These action levels have a strong correlation with the dose commitment received by the worker for different intake situations, although the degree of uncertainty is high - especially in early bioassay sample results. Thus, the following action levels are conservative, and are to be used to assist in the medical decision to treat the intake.

The decision to administer treatment and the treatment protocol are solely the responsibilities of the physician in charge. The basic principle is that the proposed intervention should do more good than harm (Gerber and Thomas 1992). Guidelines for the medical intervention of a radionuclide intake can be found in several publications. NCRP Report No. 65 (NCRP 1980) and the joint publication of the Commission on European Communities (CEC) and the DOE Guidebook for the Treatment of Accidental Internal Radionuclide Contamination of Workers (Gerber and Thomas 1992) both contain detailed guidance in intervention and medical procedures useful in mitigating radiation overexposures. The CEC/DOE Guidebook has been based on the annual limit on intake (ALI) for action levels, rather than on CEDE, to overcome the problem of uncertainties in dose per unit intake. The ICRP has recommended in Publication 60 (1991a) a 2-rem y^{-1} (20 mSv y^{-1}) limit on effective dose. Thus, the ALIs found in ICRP Publication 61 (1991b) and used in the CEC/DOE Guidebook noted above are those which would provide a 2-rem y^{-1}CEDE instead of current U.S. regulations of 5-rem y^{-1} CEDE. Guidance in the CEC/DOE Guidebook can be summarized as follows:

- When the estimated intake is below one ALI, treatment should not be considered.

- When the estimated intake is between 1 and 10 times the ALI, treatment should be considered. Under these situations, short-term administration will usually be appropriate, except for intake of materials poorly transported from the lung (class Y).

- When the estimated intake exceeds 10 times the ALI, then extended or protracted treatment should be implemented, except for materials poorly transported from the lung.

- For poorly transported material in the lung, lung lavage is the only recommended treatment, and it is only a consideration for intakes exceeding 100 times the ALI.

Because the dose associated with the ALI in the CEC/DOE Guidebook is 2-rem CEDE and because the upper administrative level allowed by the DOE RadCon Manual is 2 rem, the Hanford Site generally uses 2 rem and 20 rem as intervention level guidance in the manner presented in the CEC/DOE Guidebook:

- When the estimated intake is below 2-rem CEDE, treatment is not generally recommended.

- When the estimated intake is between 2-rem and 20-rem CEDE, treatment should be considered. Under these situations, short-term administration will usually be appropriate.

- When the estimated intake exceeds 20-rem CEDE, then extended or protracted treatment is strongly recommended, except for poorly transported material in the lung.

6.2 SPECIFIC BIOASSAY INTERVENTION LEVELS

General guidelines for when treatment may be considered reasonable, based on specific bioassay results, are presented below for radionuclides common at Hanford (see Table 6.1). Except for plutonium and insoluble uranium, they have been developed using internal dosimetry models to derive intakes that result in a CEDE of 2 rem and 20 rem, corresponding to the intervention-level guidance discussed above.

6.2.1 Tritium

Tritium cannot be measured by in vivo bioassay because it emits only a low-energy beta. The most sensitive method for bioassay measurement is the amount of tritium in urine, used to estimate the total tritium in body water.

Treatment (2 rem and 20 rem). If the results of either a single-void urine sample taken 3 to 4 hours after exposure (to ensure equilibrium of tritium in body water) or a following overnight sample exceeds 10^6 dpm/mL, HEHF should be notified (implying an intake resulting in a CEDE of about 2 rem). If the urine content exceeds 10^7 dpm/mL, treatment is strongly indicated (implying an untreated CEDE of 10 to 20 rem).

TABLE 6.1. General Guidelines for When Treatment May be Considered Reasonable, for Radionuclides Common at Hanford

Isotope	Measurement	Result	Action	Possible Treatment
Tritium				
2 rem	Single-void urine 3-4 h after exposure	10^6 dpm/mL	Notify HEHF	Fluids, diuretics
20 rem	Same	10^7 dpm/mL	Strongly recommend treatment	Fluids, diuretics
Mixed Fission Products				
2 rem (assumes 2:1 Sr/Cs ratio)	Whole body count, or urine/fecal for severe intakes	>2500 nCi uptake, or >40,000 nCi if no Sr present	Notify HEHF	Prussian blue Ca,(Sr), ammonium phosphate, others
20 rem (assumes 2:1 Sr/Cs ratio	Same	>25,000 nCi uptake, or >400,000 nCi if no Sr present	Treatment strongly recommended	Same
^{90}Sr				
2 rem	Second-void spot urine or in vivo detection	>200,000 dpm in spot urine, or >MDA in vivo	Notify HEHF	Alginate, Ca gluconate, Sr lactate, others
20 rem	Same	>2,000,000 dpm in spot urine, or >50 μCi in vivo	Treatment strongly recommended	Same
Uranium, Soluble				
Potential kidney toxicity	Chest count Second-void urine sample 12-hour urine sample	>MDA (14-21 mg) >0.1 mg >0.5 mg	Notify HEHF	Na or Ca bicarbonate; intestinal adsorbants

TABLE 6.1. (continued)

Isotope	Measurement	Result	Action	Possible Treatment
Uranium Insoluble[a]				
2 rem	Chest count	>MDA for ^{235}U or ^{234}Th	Notify HEHF	None recommended
200 rem	Same	100 x ALI	Treatment strongly recommended	Lung lavage
Plutonium				
	For plutonium intakes, refer to Tables 5.4 and 5.5.			
[a] If soluble component is present, then urine sampling is appropriate. Use same action levels as above for soluble uranium.				

6.2.2 Mixed Fission Products

Mixed fission products can be detected easily by whole body counting. Minimum detectable doses for the major radionuclides encountered at Hanford are on the order of a few mrem CEDE. In severe intakes, other bioassays such as urine or fecal sampling can be implemented to provide a complete picture of the modes of clearance and retention of fission products. Cesium-137 and ^{90}Sr are the most prevalent fission products left at the Hanford Site.

Treatment (2 rem and 20 rem). For ^{137}Cs at 1-day post-intake, if the whole body content exceeds 2,500 nCi, HEHF should be notified and a spot urine sample should be analyzed for radiostrontium by emergency processing. If the whole body content exceeds 25,000 nCi, treatment is strongly indicated and a spot urine sample should be analyzed for radiostrontium by emergency processing. Both of these levels assume a 2:1 ratio for ^{90}Sr to ^{137}Cs for conservativeness. If it is likely that no ^{90}Sr is present, then the whole body content treatment quantities become 40,000 nCi and 400,000 nCi, respectively.

For ^{60}Co at 1-day post-intake (assuming class Y), if the whole body content exceeds 5,000 nCi, HEHF should be notified. If the whole body content exceeds 50,000 nCi, treatment is strongly indicated.

6.2.3 Strontium-90

Strontium is normally associated with mixed fission products at Hanford although there are some locations where it can be found without this association. Although urine sampling is most sensitive, for larger intakes

measurements of the skull or whole body can be undertaken to detect the bremsstrallung radiations from the beta emissions.

Treatment (2 rem and 20 rem). If a second-void spot urine sample exceeds 200,000 dpm or if anything is detected in vivo, HEHF should be notified. If the second-void spot urine sample exceeds 2,000,000 dpm, treatment is strongly indicated.

6.2.4 Uranium, Soluble Forms

Soluble uranium materials at Hanford pose a problem from chemical toxicity rather than from radiological toxicity due to the low enrichment found on the site (<1.2% ^{235}U.) A major intake of uranium should focus on kidney content and potential nephrotoxicity.

Treatment (nephrotoxicity). An inhalation intake of 8 to 15 mg should be considered potentially large enough to produce a kidney burden at or near the threshold for transient toxicity, and treatment (or at least monitoring of kidney function) should be considered (Sula et al. 1991).[a] A same-day chest count should be made, and a second-void urine sample should be obtained and analyzed by emergency processing. If anything is detected in a chest count, or if the spot urine and 12-hour urine samples exceed 0.1 mg or 0.5 mg, respectively, then HEHF should be notified. Usually, the treatment for intervention is sodium or calcium bicarbonate. Monitoring of kidney function is recommended.

For wounds, excision by surgery is not usually recommended, due to the high transportability of the material. A wound with 4 to 8 mg or urine samples containing uranium at 0.1 mg (for spot urine samples) or 0.5 mg (for 12-hour samples) should involve notification of HEHF and kidney function monitoring.

6.2.5 Uranium, Insoluble Forms

Uranium found in buildings 303-M, 333, and 306-W contain a much higher proportion of slower-clearance class Y material. Both 3000-second same-day chest counts and second-void spot urine samples are used for rapid estimation of the intake.

Treatment. There is no simple treatment for class Y components of the intake retained in the lung. If anything is detected in a chest count (implying a potential CEDE of 2 rem), then HEHF should be notified, although it is doubtful that any treatment will be appropriate. Lung lavage should be considered only for extremely large intakes. If the chest burden exceeds 200 nCi (600 mg) ^{238}U or 10 nCi (5 mg) ^{235}U then treatment for removal of

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(a) McGuire, S. A. 1990. "Chemical Toxicity of Uranium Hexafloride Related to Radiation Doses." NUREG-1391, draft report for comment. U.S. Nuclear Regulatory Commission, Washington D.C.

activity in the lung should be discussed. These burdens imply a potential CEDE of 200 rem or approximately 1700-rem committed dose equivalent (CDE) to the lung.

Because there is some soluble material associated with the intake, nephrotoxicity can still be of concern for large intakes. If the second-void urine sample or the 12-hour urine sample exceeds 0.1 mg or 0.5 mg, respectively, then HEHF should be notified. (This excretion would imply an intake of about 40 mg.) Monitoring of kidney function is recommended.

Wounds that contain uranium metal exhibit a serious surface dose consequence to surrounding tissue due to beta particles (>200 mrad/h). Excision should be considered in these cases if the wound contains > 20 mg. Based on the 2-rem CEDE criterion, treatment should be considered for wounds containing about 170 nCi of ^{238}U and/or about 8 nCi of ^{235}U (in oxide form). At the same time, the urinary excretion should be watched closely because, if the material leaves the wound quickly, nephrotoxicity may be of concern.

6.2.6 Plutonium

Treatment. Plutonium is treated by removal from blood and systemic organs using DTPA chelation via injection (by HEHF). This means that treatment does not affect activity in the lung to any appreciable extent, so treatment based on dose per unit intake (which is influenced by lung dose, especially for class Y material) is not as reliable an indicator of benefit. On the other hand, there is a direct correlation between DTPA, urinary excretion, and dose averted because of plutonium excreted. The CEDE dose averted per dpm excreted in urine is about 2 mrem, and the excretion enhancement factor using DTPA can vary from about 10 to 50. So if DTPA is administered when untreated excretion is 2 dpm/day, excretion should increase to 20 to 100 dpm for a dose savings of 40 to 200-mrem/day CEDE. It is probable that the efficacy of treatment will decrease with continued administration as plutonium is removed from the liver and the rate of transfer from lung to blood decreases. Ceasing DTPA treatment when excretion drops to below 2 dpm/day probably sacrifices less than 40 mrem/day.

For wounds refer to Table 5.4 above. Generally, any detectable plutonium in the wound or in spot urine samples should warrant considering administration of DTPA. If the activity in the wound is >5 nCi, excision of tissue should also be considered.

6.2.7 Ingestion of Radioactive Materials

Similar considerations for treatment or intervention levels apply to ingestion of radioactive materials as to inhalation. Exposure of the lower large intestine for poorly transported chemical species can be considerable in large intakes, but rapid clearance through the gastrointestinal (GI) tract to feces occurs. If an intake could potentially result in dose to an organ in the GI tract exceeding 50 rem, treatment should be considered.

6.3 WORK RESTRICTIONS

Under any of the above intake circumstances, a work restriction should be imposed to prohibit the worker from receiving further occupational radiation dose until an estimate of his/her dose is completed.

6.4 METHODS OF TREATMENT FOR INTAKES

Many forms of treatment exist for the reduction in dose equivalent to patients or workers after an accidental intake of radioactive materials; this document will not attempt to distinguish all the potential treatment regimes that may be decided upon by the physician.

Several recent guidance texts are available and should be consulted for exact treatment agents for most radionuclides. The CEC/DOE Guidebook provides the most recent guidance by the radiation protection community on chemical blocking agents, chelation treatments, dilution treatments, and many other forms of non-surgical intervention. It includes a quick reference table (Table 6.1) that lists important radionuclide and treatment data for most radionuclides encountered in radiation protection. In addition, NCRP Publication 65 (1990), though not as recent, includes extensive information of the operations during response and recovery to an accidental contamination. A quick-reference chapter (Chapter 2) is especially valuable for the early stages of incidence response and identification of potential intake victims. It also includes a reference table for administration of treatment agents.

The most commonly encountered treatments for accidental inhalation intakes at Hanford include chelation therapy by CaDTPA or ZnDTPA for plutonium/americium intakes, sodium bicarbonate or other bicarbonates for uranium intakes, fluids or diuretics for tritium uptakes, and prussian blue for ^{137}Cs intakes. Many other agents are available at the discretion of the treating physician. For treatment of ingestion intakes, stomach lavage, the use of laxatives and purgatives, and the administration of blocking agents may all be considered in the event of large ingestion of radioactive materials. Wounds are often treated with excision of tissue, depending on the measured activity found in the wound and the subsequent dose received by the patient if the excision is not performed. These are all medical procedures and will be determined as appropriate only by the physician treating the patient. Advice on the dose consequences of performing or not performing a treatment will be provided to the medical staff by the exposure evaluator and associated professional staff.

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ACRONYMS AND ABBREVIATIONS

AMAD	activity median aerodynamic diameter
ANSI	American National Standards Institute
ALI	annual limit on intake
BCSR	Boeing Computer Services - Richland
CEDE	committed effective dose equivalent
CL	contractual detection level
CNO	container-not-out
DAC	derived air concentration
DAC-hours	time-integrated exposure to airborne contamination
DEMS	Dose Evaluation Management System
DOE	U.S. Department of Energy
DPI	days post-intake
DTPA	diethylenetriamine pentaacetic acid
EDE	effective dose equivalent
EDF	Emergency Decontamination Facility
EE	Exposure Evaluator
EPA	U.S. Environmental Protection Agency
ER	environmental restoration and remediation
GI	gastrointestinal
GPS	Good Practices Standard
HEHF	Hanford Environmental Health Foundation
HHS	Hanford Health System (database)
Historical Files	Hanford Radiation Protection Historical Files
HMS	Hanford Medical Scheduling
HRRP	Hanford Radiological Records Project
HRRPL	Hanford Radiological Records Project Library
HSRCM	Hanford Site Radiological Control Manual
ICRP	International Commission on Radiological Protection

IDP	(Hanford) Internal Dosimetry Project
INTERTRAC	Internal Dose Tracking System
IS	insufficient volume sample
ITAS	IT Analytical Services (Inc.)
IVRRF	In Vivo Radioassay and Research Facility
KN	kit not out
Lab	Analytical Services Laboratory
LC	lost container
LL	lost in lab
MDA	minimum detectable activity/amount
NCRP	National Council on Radiation Protection and Measurements
ND	not delivered
NIST	National Institute of Standards and Technology
NS	no sample
ORE	Occupational Radiation Exposure (System)
PNL	Pacific Northwest Laboratory
POC	Patrol Operations Center
QA	quality assurance
QC	quality control
RCM	DOE Radiological Control Manual
REIRS	Radiation Exposure Information Reporting System
REX	Radiation Exposure (System)
RL	DOE Richland Operations Office
RPT	Radiation Protection Technologist
SOW	statement of work
TEDE	total effective dose equivalent
WB	whole body
WBC	whole body count
WBCP	Whole Body Counting Project
WHC	Westinghouse Hanford Company

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 internal dose actually received in, or assigned to, a particular calendar year.
annual limit on intake (ALI)	The quantity of a single radionuclide which, if inhaled or ingested in a working year, would irradiate a person represented by ICRP Reference Man, to the limiting value for control of occupational exposure.
bioassay	Measurement of the 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 ANSI Standard N13.30-1989).
chest measurement	Direct measurement of radioactivity deposited in the chest region. The chest measurement includes contributions from activity in the lungs and skeleton.
committed dose equivalent	The dose equivalent to an organ or tissue committed over a total 50-year period following an acute intake, or onset of chronic intake, of radioactivity.
committed effective dose equivalent (CEDE)	The sum of the products of the weighting factors applicable to each of the irradiated body organs or tissues and the committed dose equivalent to those organs or tissues.
container-not-out (CNO)	A term denoting that the worker took the sample kit inside his/her residence but did not put it out on collection day.
contractual detection level (CL)	The required minimum detection level which is equivalent to the highest acceptable MDA. The CL applies to the overall process and not to individual samples.
DAC-hours	The time and concentration integrated exposure to airborne radioactivity. Exposure to 1 DAC-hour implies one hour equivalent exposure to air at the DAC value. *See also* derived air concentration (DAC).
decision level (L_c)	The quantity of radioactivity (or mass for uranium analyses) above which there is at least 95% confidence that the sample is not a blank.

derived air concentration (DAC)	The concentration of a radionuclide in air which, if breathed over a working year, would irradiate a person represented by ICRP Reference Man, to the limiting value for control of occupational exposure. *See also* DAC-hours.
dose assessment	The evaluation and assignment of a specific dose associated with a specific intake. The dose assessment is documented using 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 radiation exposure file.
Exposure Evaluator (EE)	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 and personal contamination surveys.
head measurement	Direct bioassay measurement of the radioactive content of the head. This measurement is used to estimate the total skeleton content, and to correct a chest count to provide an estimate of lung content.
insufficient volume	A urine sample below the minimum contractual volume for routine analysis. This sample will not be analyzed; 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.
Internal Dosimetry	The staff within the Pacific Northwest Laboratory's Personnel Dosimetry Section who are assigned to the Hanford Internal Dosimetry Project.
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 container (or lost kit)	A sample kit that was not retrievable by the Analytical Services Laboratory. A "container-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 (MDA)	An estimate of the smallest quantity that can be measured in a sample such that the risk for false detection and false nondetection are each 5%.
non-stochastic effects	Effects for which the severity increases with dose, and for which there may be a threshold dose below which the effect does not occur. (*Same as* deterministic effects.)
no sample (NS)	A kit that was not used and remained outside the residence on collection day. The Analytical Services Laboratory notifies Internal Dosimetry of a "no sample" within one day so that rescheduling can 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. (See Section 6, Tables 6.1 through 6.5.)
Radiological Records	The sitewide support program, operated by the Pacific Northwest Laboratory, that maintains occupational radiation records for the Hanford Site.

reason code	A computer code used to describe the reason that 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 or electronic notification to Internal Dosimetry.
screening level	The minimum level of a bioassay measurement at which some further review or action is advantageous to determine whether follow-up measurements or dose assessment is needed.
sequential analyses	More than one radiochemical analysis performed on a single sample. For example, IPS is the analysis code for an IPU analysis and a ^{90}Sr analysis performed on the same sample.
statement of work (SOW)	The technical and administrative specification of work to be performed under contract by the Analytical Services Laboratory.
stochastic effects	Effects for which the probability of an effect occurring, rather than its severity, is a function of dose, without threshold.
total effective dose equivalent (TEDE)	The sum of the deep-dose equivalent (for external exposures) and the committed effective dose equivalent (for internal exposures).
whole body measurement	Direct bioassay measurement to determine the amount of high-energy, gamma-emitting radionuclides in the total body.

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(Note: Referenced numbers refer to manual sections, not pages.)

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