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Hanford Radiological Protection Support Services Annual Report for 1989

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July 1990

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

**Pacific Northwest Laboratory
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PACIFIC NORTHWEST LABORATORY
operated by
BATTELLE MEMORIAL INSTITUTE
for the
UNITED STATES DEPARTMENT OF ENERGY
under Contract DE-AC06-76RLO 1830

Printed in the United States of America

Available to DOE and DOE contractors from the
Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831;
prices available from (615) 576-8401. FTS 626-8401.

Available to the public from the National Technical Information Service,
U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

NTIS Price Codes, Microfiche A01

Printed Copy

Price Code	Page Range	Price Code	Page Range
A02	1- 10	A15	326-350
A03	11- 50	A16	351-375
A04	51- 75	A17	376-400
A05	76-100	A18	401-425
A06	101-125	A19	426-450
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A12	251-275	A25	576-600
A13	276-300	A99	601-Up
A14	301-325		

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Pacific Northwest Laboratory
Richland, Washington 99352

ABSTRACT

Certain sitewide radiation protection services operated by Pacific Northwest Laboratory for the U.S. Department of Energy-Richland Operations Office and Hanford contractors are documented in this annual report on these services provided during calendar year 1989. These activities include internal dosimetry, in vivo measurements, external dosimetry, instrument calibration and evaluation, radiation source calibration, and radiological records keeping. In each case the routine program, program changes, associated tasks, investigations, and studies, as well as related publications, presentations, and other professional activities are discussed as applicable.

SUMMARY

This report documents the performance of certain radiological protection site-wide services during calendar year (CY) 1989 by the Pacific Northwest Laboratory in support of the U.S. Department of Energy-Richland Operations Office (DOE-RL) and contractor activities on the Hanford Site. The routine program for each service is discussed along with any significant program changes and tasks, investigations, and studies performed in support of each program. Other related activities such as publications, presentations, and memberships on standards or industry committees are also listed. The programs covered provide services in the areas of 1) internal dosimetry, 2) in vivo measurements, 3) external dosimetry, 4) instrument calibration and evaluation, 5) calibration of radiation sources traceable to the National Institute of Standards and Technology, and 6) radiological records.

The Hanford Internal Dosimetry Program provides for bioassay monitoring and associated evaluation and documentation of assessments of internal exposure and dose to Hanford personnel and site visitors. During 1989 the Internal Dosimetry Program performed 15,794 bioassay measurements. Two hundred eighty-four assessments of potential new intakes along with seven reassessments of prior exposures were performed. Of the measurements, 98.6% were classified as routine and 1.1% were due to intake follow-up and 0.3% were classified as special purpose measurements. Quality control monitoring of the bioassay analytical services laboratory continued to show generally satisfactory performance. Supporting tasks that were performed included conversion of the pilot fecal sampling project to a routine program, a self-appraisal of internal dosimetry record-keeping practices, and development of a tritium bioassay program for the Fast Flux Test Facility (FFTF).

As an integral part of personnel dosimetry at Hanford, the Hanford In Vivo Measurement Program provides for the detection of any radioactive materials deposited in Hanford employees and visitors. The In Vivo Measurement Program provided 11,072 measurements during CY 1989. Changes to facilities and equipment included the completion of the two new shielded rooms and a new mobile counter unit. Special studies conducted and other changes incorporated into the program included the measurement of ^{241}Am in four

retired Hanford workers, comparison of head counts and actual skeletal content for ^{241}Am in bone, ^{92m}Nb studies for improving calibration factors for measuring ^{239}Pu in the lung, postmortem measurements of a thorotrast patient, reduction of radon daughter background in the Utah Room, additions to the calibration phantom library, and the development of in-house maintenance capabilities for germanium planar detectors.

The Hanford External Dosimetry Program administers the distribution and processing of all dosimeters issued to Hanford personnel and visitors to measure any external radiation doses received while onsite. The External Dosimetry Program processed approximately 225,000 dosimeters during CY 1989. The program formally participated in the DOE Laboratory Accreditation Program and successfully passed all requested categories for the basic, beta/photon, and multipurpose dosimeters. Special projects that were conducted during the year included the microVAX memory upgrade, characterization of the high dose response of the Hanford dosimeter reader systems, participation in an extremity dosimeter comparison study, and testing to determine dosimeter response to 100°C and 80°C oven anneals. During 1989 seven external dosimetry issues were submitted to and formally reviewed by the Hanford Personnel Dosimetry Advisory Committee. These issues involved sigma pile audit dosimeters, the Hanford convention for rounding dosimeter results, note code 50 dosimeter results, use of a simplified fast neutron dose algorithm (which included the formation of an ad hoc committee to examine fast neutron dose results), reporting of neutron results as total neutrons, the new DOE security credential, and a Hanford practice for calculating doses from skin and clothing contaminations.

The Instrument Calibration and Evaluation Program provides complete and reliable radiation protection instrument services to help ensure personnel safety in the Hanford workplace. Specific tasks performed under this program during 1989 included the conduct of the routine instrument pool, the Hanford Instrument Evaluation Program, deployment of High-Range Cutie Pies, the instrument manual update, the documentation of the history of Hanford instruments, and the calibration of Westinghouse Hanford Company 200 Area alpha constant air monitors. Tasks performed during the year that supported the routine program included the redesign of the beta source holder to allow for a

higher activity source and ensure proper personnel protection and the calibration and acceptance testing of a number of alarming pocket dosimeters.

The Radiation Standards and Calibration Project maintains radiological calibration standards, special instrument and dosimeter response-characterizing equipment, and calibration data handling equipment at Hanford. The project is divided into two major functions: 1) maintenance of calibration standards and capabilities and 2) maintenance of the instrument calibration and repair data management system. Improvements to the project during 1989 included the placement of a new ^{252}Cf source into the Room 106 Rabbit System, receipt of a new ^{241}Am irradiator, upgrade of the HP-9000 computer to a Model 825, several modifications of program software, and the creation of a database for tracking pencil dosimeters. Supporting studies included measurement quality assurance for photon beams, measurement quality assurance for beta irradiations, and further evaluation of instrument bar code labels.

The Hanford Radiological Records Program preserves and administers all records of personnel radiological exposure, Hanford historical radiation protection practices, and Hanford radiological incidents since the inception of Hanford in the early 1940s. During 1989 the Radiological Records Program operated the occupational radiation exposure (ORE) system, and maintained the Hanford Radiation Protection Historical Files and the Hanford Radiological Incident File in support of the DOE-RL and Hanford contractor radiological protection and dosimetry programs. The program produced reports for DOE-RL, DOE Headquarters, site contractors, and individuals and assisted personnel researching historical and incident data. Changes to these systems included a number of changes required by the new DOE 5480.11, Radiation Protection for Occupational Workers, which was published in December 1988 and which included the summation of internal and external effective dose equivalents, initiation of a termination exposure letter, changes to the annual employee exposure report card, and changes to the Radiological Exposure Information Reporting System report format. Other changes included the addition of a second address field, inclusion of invalid in vivo counts into the database, and the issuance of a program manual. The redevelopment of the ORE system, which is expected to take over 2 years to complete, was funded and initiated during CY 1989.

ACRONYMS

ANS	American Nuclear Society
ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
BCSR	BCS-Richland
BOMAB	bottle manikin adsorption (phantom)
CAM	continuous air monitor
CAR	computer-assisted retrieval (system)
CP	Cutie Pie (instrument)
CY	calendar year
DOE	U.S. Department of Energy
DOELAP	Department of Energy Laboratory Accreditation Program
DOE-RL	U.S. Department of Energy-Richland Operations Office
EDF	Emergency Decontamination Facility
EPA	U.S. Environmental Protection Agency
FFTF	Fast Flux Test Facility
FY	fiscal year
GI	gastrointestinal
HBPD	Hanford beta/photon dosimeter
HEHF	Hanford Environmental Health Foundation
HIEC	Hanford Instrument Evaluation Committee
HMPD	Hanford multipurpose dosimeter
HPDAC	Hanford Personnel Dosimetry Advisory Commission
HPSSC	Health Physics Society Standards Committee
HRCF	High-Range Cutie Pie (instrument)
IARC	International Agency for Research on Cancer
ICRP	International Commission on Radiological Protection
I&ED	Instrumentation and External Dosimetry (section)
KEH	Kaiser Engineers Hanford Company
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MDA	minimum detectable activity
MQA	measurement quality assurance
NAVLAP	National Voluntary Laboratory Accreditation Program

NCRP	National Council on Radiation Protection and Measurements
NIST	National Institute of Standards and Technology
ORE	occupational radiation exposure
ORNL	Oak Ridge National Laboratory
PC	personal computer
PNAD	personal neutron accident dosimeter
PNL	Pacific Northwest Laboratory
QA	quality assurance
QC	quality control
QUS	quick uranium soluble (a rapid analysis for soluble uranium)
REIRS	Radiological Exposure Information Reporting System
RPS	radiation protection standard
SEE	specific effective energy
SOW	statement of work
TGLD	Task Group on Lung Dynamics
TLD	thermoluminescent dosimeter
TRU	transuranic (elements)
UST	United States Testing Company, Inc.
USRT	United States Transuranium Registry
WBC	whole body counter
WHC	Westinghouse Hanford Company

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INTRODUCTION

This annual report documents the calendar year (CY) 1989 activities of certain radiation protection sitewide services operated by Pacific Northwest Laboratory (PNL)^(a) for the U.S. Department of Energy-Richland Operations Office (DOE-RL) and the Hanford contractors. The programs covered provide services in the areas of 1) internal dosimetry, 2) in vivo measurements, 3) external dosimetry, 4) instrument calibration and evaluation, 5) calibration of radiation sources traceable to the National Institute of Science and Technology (NIST), and 6) radiological records. All of these services fall within the purview of PNL's Health Physics Department.

While some of the programs discussed in this report are involved in activities funded by other sources, such as supplying in vivo measurement and instrument calibration services to private nuclear companies and site environmental dose measurements, only those activities funded by DOE-RL, DOE Headquarters, and the Hanford contractors are addressed herein. It should be noted that 1) the services provided to non-DOE-RL activities are performed only to the extent that they do not affect services to DOE and its contractors, and 2) these services provide funds that support the program and reduce the costs to DOE and the Hanford contractors (i.e., BCS-Richland [BCSR], the Hanford Environmental Health Foundation [HEHF], Kaiser Engineers Hanford Company [KEH], PNL, and Westinghouse Hanford Company [WHC]).

Each Hanford program listed above is presented in a separate section of the report. Each major section discusses the routine program, including any significant changes and improvements; investigations, studies, and tasks performed in support of the routine program; and other program-related activities such as publications, presentations, professional memberships, and external professional activities, if applicable. Figure 1 is an organizational chart showing the PNL and DOE management structure and communication interfaces for each PNL-operated program and the DOE Safety and Environment Division, which is responsible for PNL's services in this area.

(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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FIGURE 1. Management Structure and Major Communication Interfaces for Hanford Radiological Support Services Between PNL and DOE-RL and Within PNL

HANFORD INTERNAL DOSIMETRY PROGRAM

The Hanford Internal Dosimetry Program was initiated in late 1944 to provide for the assessment and documentation of occupational doses from intakes of radionuclides at Hanford. The program is administered in support of Hanford radiation protection programs as required by DOE 5480.11 (DOE 1988a) and the Hanford Site Services Handbook (RL 1983). The routine program provides the following internal dosimetry services:

- administration of a routine bioassay monitoring program
- investigation and assessment of potential internal exposures
- monitoring of bioassay lab performance
- selection and application of models, procedures, and practices for evaluating internal exposures
- technical support to DOE-RL and site contractors.

The impact of implementing DOE 5480.11 and the 1989 routine bioassay monitoring and other program services and highlights are discussed in the following sections.

IMPLEMENTATION OF DOE ORDER 5480.11

DOE 5480.11 (DOE 1988b) was issued in December 1988 for compliance beginning on January 1, 1989. The new order imposed requirements that were extensively different from previous requirements related to internal dosimetry methodology and record keeping. Briefly, the new order mandated conversion to the methodology presented in Publications 26 and 30 of the International Commission on Radiological Protection (ICRP 1977; 1979), involving the calculation of an effective dose equivalent as the sum of organ dose equivalents, each weighted by a stochastic risk factor. The Hanford Internal Dosimetry Program had been preparing for the change for about 3 years, as discussed by Lyon et al. (1989), and was able to perform the change on January 1 as required.

Primary changes made because of the new order are highlighted below:

- Determination of the maximum permissible body burden was eliminated.

- Instead, doses to risk organs are calculated as a function of the magnitude of the intake, the location of the intake, and the distribution and retention of the radionuclides within the body.
- An effective dose equivalent is calculated as the sum of the organ dose equivalents, each weighted by a risk factor specified in the order.
- Organ and effective dose equivalents are calculated for each calendar year after intake for 50 years. The annual organ and effective dose equivalents are used to determine compliance with the radiation protection dose standards in the order. (An exception to the calculation of annual doses exists for cases where the 50-year committed effective dose equivalent is less than 100 mrem, in which case the 50-year committed effective dose equivalent is assigned to the year of intake).

ROUTINE PROGRAM

Bioassay monitoring is performed on a regular frequency for workers that could incur intakes of radionuclides in their jobs. Measurement types and frequencies are based on the radionuclides of concern, and their anticipated physical and chemical form. Minimum detectable activities (MDAs) and follow-up levels for excreta and in vivo bioassay measurements are shown in Tables 1 and 2.

Intakes of radionuclides are generally prevented by containment or other protective measures. Internal exposures principally (and infrequently) occur as a result of the failure of a protective system. Exceptions to this are low-level chronic exposure conditions that exist for depleted and low-enrichment uranium in the 306-W Specialty Machine Shop, the Uranium Oxide Plant, and the N Reactor Fuel Production Facility; and for tritium in several laboratories. In these facilities, internal exposures are controlled through engineered and administrative measures; however, because complete containment is not provided, chronic exposures are assumed to occur. As a result of a routine fecal sampling program started in 1988, frequent low-level intakes of plutonium were also discovered at the Plutonium Finishing Plant. Unlike the uranium facilities, the Plutonium Finishing Plant is designed for containment of the plutonium; however, residual levels of airborne plutonium on the order of a few percent of the derived air concentration were measured in 1988 (Lyon et al. 1989).

TABLE 1. Specified Minimum Detectable Activities and Follow-Up Levels for Routine Urinalyses During 1989

<u>Radionuclide</u>	<u>MDA(a)</u>	<u>Follow-Up Level Sampling Frequency(b)</u>
^3H	10 dpm/ml	80 dpm/ml (M)
^{90}Sr	2.0 dpm/sample	26 dpm/sample (A)
^{90}Sr	2.0 dpm/sample	11 dpm/sample (BE)
^{238}Pu	0.02 dpm/sample	0.01 dpm/sample (A)
^{239}Pu	0.02 dpm/sample	0.01 dpm/sample (A)
^{239}Pu (in feces)	0.20 dpm/sample	2.0 dpm/sample
^{241}Am	0.02 dpm/sample	>MDA (A)
U-natural(d)	0.5 $\mu\text{g}/\text{sample}$	11 $\mu\text{g}/\text{sample}$ (BW)
U-natural	0.05 $\mu\text{g}/\text{sample}$	0.2 $\mu\text{g}/\text{day}$ (Q,A)(c)

- (a) Specified MDA based on Type I and Type II errors of 5% as described in the "1989 Statement of Work for the First Operational Year of Analytical Services of Sub-contract 005145-A-M1." (A copy of the SOW is available in the Hanford Radiation Protection Historical Files.)
- (b) Investigation of a potential internal exposure is performed whenever these values are exceeded. Routine bioassay monitoring frequency: A-annual, BE-biennial, BW-biweekly, M-monthly, Q-quarterly.
- (c) Upper level of expected environmentally derived uranium in urine for the Hanford region.
- (d) Rapid analysis procedure (quick uranium soluble [QUS]).

Assessments of internal dose are performed for intakes according to practices established in PNL-MA-552, Hanford Internal Dosimetry Program Manual. To summarize, assessment of potential internal exposure is conducted for:

- any potential occupational intake reported to Internal Dosimetry by site radiation protection organizations
- any "new hire" or "beginning work" bioassay measurement that indicates any detectable intake not previously evaluated

TABLE 2. Minimum Detectable Activities and Follow-Up Levels for Routine In Vivo Measurements During 1989

<u>Measurement/Radionuclide^(a)</u>	<u>MDA, nCi</u>	<u>Follow-Up Level</u>
Whole body count		
²² Na	1.5	Any detected
⁵⁴ Mn	3	Any detected
⁵⁹ Fe	6	Any detected
⁶⁰ Co	3	8 nCi
¹⁵⁴ Eu	4.5	8 nCi
¹³⁷ Cs	3	9 nCi
Lung count		
¹⁴⁴ Ce	0.4	Any detected
¹⁵⁴ Eu	0.05	8 nCi
²³² Th	0.4	Any detected
²³⁵ U	0.08	Any detected
²³⁸ U(²³⁴ Th)	1.2	Any detected
²⁴¹ Am	0.12	Any detected

(a) For selected radionuclides. If radionuclides not listed here are detected, a follow-up measurement is taken.

- any routine bioassay measurement that indicates a potential occupational internal exposure, not previously evaluated, resulting in an annual internal effective dose equivalent greater than 10 mrem
- any employee, hired by DOE-RL or a Hanford Site contractor, who has incurred an occupational internal exposure. (If information about the intake received from the employer at intake meets the recording and reporting requirements of DOE 5480.11, then that information may be accepted in lieu of a local assessment.)

Internal dose assessments are performed using biokinetic models to interpret bioassay measurements. The standardized biokinetic models that are used are listed in Table 3, and the models and other technical bases for assessments are documented in the Technical Basis for Internal Dosimetry at Hanford (Sula et al. 1989). Dose conversion factors are consistent with the specific

TABLE 3. Models Used to Interpret Bioassay Data During 1989

System	Model
Respiratory tract	TGLD ^(a) Model (ICRP 1979)
GI ^(b) tract	ICRP GI Tract Model (ICRP 1979)
Pu urine excretion	Jones' Function (Jones 1985)
Sr urine excretion	ICRP Alkaline Earth Model (ICRP 1973, 1979)
Other metabolic models	ICRP 30 (1979)

(a) TGLD = Task Group on Lung Dynamics.

(b) GI = gastrointestinal.

effective energy (SEE) values in ICRP 30 (1979). The biokinetic models are implemented using the computer codes GENMOD Version 3.0 (Johnson and Carver 1981) and PUCALC Version 2.2.^{(a)(b)}

Bioassay measurement results are maintained in the occupational radiation exposure (ORE) database, and laboratory analytical procedures are documented via PNL-MA-574, Whole Body Counting Manual and in the Procedures for Contract 005145-A-M1^(c) of the United States Testing Company, Inc. (UST). Individual assessments of internal dose are documented in each individual's file in the Hanford Radiological Records Program microfilm files.

Technical Basis for Internal Dosimetry at Hanford

Two major tasks conducted as part of an objective to achieve complete documentation of the Hanford Internal Dosimetry Program were completed in 1989. The first was the issuance in April of the document, Technical Basis for Internal Dosimetry at Hanford (Technical Basis) (Sula et al. 1989). The Technical Basis details the models, methods, and assumptions used to assess

- (a) May, R. A. 1986. Plutonium Deposition Calculation from Urine Samples, Version 2.0. Copy available in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.
- (b) May, R. A. 1988. "Update of PuCalc from 2.1 to 2.2." Letter to Distribution, dated June 16, 1988. Copy available in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.
- (c) United States Testing Company, Inc. 1989. Procedures for Contract 005145-A-M1. Richland, Washington.

internal dose and design bioassay programs at Hanford. The document was approximately 3 years in development and was part of the Hanford implementation of DOE 5480.11 (DOE 1988a). Chapters are devoted to the appropriate radionuclides of the following elements or groups: tritium, corrosion products (^{58}Co , ^{60}Co , ^{54}Mn , ^{59}Fe), strontium, cesium, iodine, europium, uranium, and plutonium and americium. For each of these radionuclides, the sources and characteristics of material expected at Hanford, dosimetry, bioassay measurements and monitoring, dose assessment, dose reduction therapy, and bioassay follow-up are discussed. Appendixes address the computer codes, general models, and statistical methods used in the document.

The purposes of the Technical Basis are to:

- provide assurance that the Hanford Internal Dosimetry Program derives from a sound technical base
- promote the consistency and continuity of routine program activities
- provide a historical record
- serve as a technical reference for radiation protection personnel
- aid in identifying and planning for future needs.

The document has been highly praised by other DOE sites and is being used as a template for development of similar documents by others.

Hanford Internal Dosimetry Program Manual

The second documentation task accomplished was completion of a companion document, PNL-MA-552, The Hanford Internal Dosimetry Program Manual. The following subjects are included in the manual:

- practices of the program, including interpreting applicable DOE orders, regulations, and guidance into criteria for assessment, documentation, and reporting of doses
- assessment of internal dose, including a summary explaining when and how assessments are performed
- recording and reporting practices for internal dose
- selection of workers for bioassay monitoring and establishing type and frequency of bioassay measurements

- capability and scheduling of bioassay monitoring services
- recommended dosimetry response to potential internal exposure incidents
- quality control (QC) and quality assurance (QA) provisions of the program
- screening and follow-up levels used for bioassay measurements
- keys to the various ORE computer system submenus and screens
- capsule summaries of bioassay analytical procedures
- copies of the bioassay sampling kit instructions.

The Hanford Internal Dosimetry Program Manual was issued in two forms. The controlled manual version (PNL-MA-552) was issued in July 1989 to Hanford Site personnel who routinely use the program services. The controlled manual is updated as needed. In response to a large number of onsite and offsite requests, an uncontrolled document version (PNL-7001) was issued in October 1989 for distribution to interested personnel not routinely using the program services (Carbaugh, Sula, and Bihl 1989). This document is not updated.

THE INTERTRAC COMPUTER CODE

As part of the preparation for operation under DOE 5480.11 (DOE 1988b) requirements, a computer code for storing and reporting internal doses, as determined from dose assessments, was developed. The first version of the code, titled INTERTRAC, was written in 1988 for personal computers (PC) using DBASE III software; but it was designed to be temporary, with the intent of being converted to the UNIVAC for incorporation into the ORE system. However, a decision to phase out use of the UNIVAC and to redesign the ORE system precluded incorporation of INTERTRAC into the ORE database during the next several years. The first version of INTERTRAC was cumbersome to use and lacked some needed capabilities, so in 1989 INTERTRAC II was developed. INTERTRAC II is also designed for PCs using PARADOX 3.0 software. INTERTRAC II provides 1) annual effective and organ dose equivalents for each year for 50 years after an intake, 2) the 50-year effective dose equivalent for each intake, and 3) effective and organ dose equivalents summed for all intakes and cumulated to age 75.

Change in Decision Level for Plutonium in Urine

Effective April 1989, Internal Dosimetry initiated a policy to follow up on urinary plutonium results above a decision level of 0.01 dpm/sample but below the contractual detection level of 0.02 dpm/sample. This change was implemented in response to recommendations in the American National Standards Institute's Draft American National Standard for Performance Criteria for Radiobioassay, ANSI N13.30, (ANSI 1989). As part of that practice, measurements in this range are first verified by recounting the planchet. If a recount also results in a dose determination above 0.01 dpm, the worker is put on dose evaluation. If two recounts do not confirm the initial measurement, the first result is designated as a false positive.

MONITORING AND ASSESSMENT ACTIVITIES

During 1989, 15,794 bioassay measurements were scheduled in support of Hanford activities. Of these, nearly 99% were classified as routine (including measurements on visitors), with 1.1% due to intake follow-up measurements and only 0.3% classified as special purpose measurements. (Not included in the numbers were 236 excreta sample requests made in 1989 for which analyses were not completed by mid-February.) The types and numbers of urine and fecal bioassays are summarized in Table 4, while the in vivo bioassays recorded in the ORE database for 1989 are summarized in Table 5. Routine urine measurements have been increasing over the past few years (see Figure 2), with an increase of 15% from 1988 without the outstanding analyses or 20% if outstanding analyses are included. Routine in vivo measurements show renewed increase, following a decrease in 1988 (see Figure 3); these measurements were up 23% over 1988 and up 15% over 1987.

Investigations of possible internal exposure to radionuclides are performed following an indication from a routinely scheduled bioassay measurement of a possible intake that could result in an internal first-year effective dose equivalent exceeding 10 mrem, or for any workplace potential exposure incidents. Potential exposure incidents are identified by workplace indicators such as air sampling, contamination surveys, nasal smears, or smears

from potentially contaminated wounds. Special requests for bioassay measurements are also performed at the request of workers through the contractor dosimetry group.

During 1989, 22 potential internal exposure incidents involving 33 workers were identified through workplace monitoring. Of these workers, 13 were potentially exposed to radiostrontium and/or radiocesium, 3 to radiocobalt, 5 to uranium, 4 to tritium, and 8 to transuranic (TRU) elements. Of these workers, 15 received no internal dose; 17 received 50-year committed effective dose equivalents of less than 100 mrem; 1 received a 50-year committed effective dose equivalent greater than 100 mrem. Table 6 shows the incident breakdown by contractor and area. Annual trends for the last 4 years are included in Table 7.

Internal dose assessments were also performed because of 1) bioassay measurement results not associated with incidents but above the criteria for follow-up, 2) bioassay results indicating that a revision to a previously assessed dose is needed, or 3) known chronic intakes. Excluding chronic intakes, there were 54 new non-incident potential intake evaluations in 1989, involving the following radionuclides or groups (and number of cases): TRU elements (32), ^{137}Cs and/or ^{90}Sr (7), europium (1), uranium (11), tritium (1), activation productions (2). Of these cases, 38 received no internal dose; 7 received 50-year committed effective dose equivalents less than 100 mrem; and 9 received 50-year committed effective dose equivalents greater than 100 mrem. Potential chronic intake cases involved tritium, uranium, and TRU elements. Nineteen of these were assessed as having no intake; the rest received 50-year committed effective dose equivalents of less than 100 mrem. Annual trends for the last 4 years are included in Table 7.

The internal dose status of the Hanford workforce at the end of 1989 is summarized in Table 8. All past exposures received by current workers are included. The number of cases had decreased from 98 in 1987 to 72 in 1988, but increased to 275 in 1989, largely due to a policy change lowering the screening level for initiation of evaluations and to the inclusion of chronic exposure cases involving minor doses. If only those cases exceeding 1% of the DOE Radiation Protection Standard (DOE 1988a) are considered (as was used in

TABLE 4. Excreta Measurements for Samples Requested During CY 1989 and Recorded in the ORE Database^(a)

Type/Reason	DOE	KEH	PNL	WHC	TOTAL
³ H-urine					
Routine schedule	0	0	56	121	177
Special request	0	0	0	1	1
Intake follow-up	0	0	0	6	6
⁹⁰ Sr-urine					
Routine schedule	4	274	20	1083	1381
Special request	0	0	0	1	1
Intake follow-up	0	3	0	12	15
Uranium-urine					
Routine schedule	0	0	180 ^(b)	566	746
Special request	0	0	0	1	1
Intake follow-up	0	0	7	6	13
Plutonium-urine					
Routine schedule	5	288	205	1658	2156
Special request	2	11	0	6	19
Intake follow-up	0	0	14 ^(c)	37	51
Plutonium-fecal					
Routine schedule	0	0	9	250	259
Special request	1	0	2	0	3
Intake follow-up	0	0	13	0	13
Other TRU ^(c) -urine					
Routine schedule	0	1	3	8	12
Special request	0	0	0	1	1
Intake follow-up	0	4	8	3	15
Other-fecal					
Routine schedule	0	0	0	1	1
Special request	0	0	0	0	0
Intake follow-up	0	0	6	0	6
ANALYSES TOTALS	12	587	531	3802	4877
Recounts					
Plutonium - urine	0	6	8	41	55
³ H - urine	0	0	0	2	2
Measurements outstanding ^(d)					
IPS ^(e) , routine	0	13	0	104	117
IPS, follow-up	0	0	0	1	1

(a) Figures do not include samples for which no result was obtained.

(b) Includes four samples for isotopic uranium.

(c) Two analyses were for isotopic plutonium including ²⁴¹Pu.

(c) Other TRU elements include ²⁴¹Am, ²⁴²Cm, ²⁴⁴Cm, and ²³⁷Np.

(d) Measurement results not recorded in ORE database as of the data compilation date (2/12/90) for this report.

(e) IPS - sequential strontium and isotopic plutonium analysis.

TABLE 5. In Vivo Measurements Performed During CY 1989 and Recorded in the ORE Database^(a)

<u>Type/Reason</u>	<u>DOE</u>	<u>KEH</u>	<u>PNL</u>	<u>WHC</u>	<u>TOTAL</u>
Whole body count					
Routine schedule	63	1060	1271	6275	8669
Special request	0	0	2	9	11
Intake follow-up	0	3	10	11	24
Visitors	15	0	112	162	289
Total	78	1063	1395	6457	8993
Chest count					
Routine schedule	1	289	303	1301	1894
Special request	0	0	0	5	5
Intake follow-up	0	2	4	18	24
Visitors	0	0	0	1	1
Total	1	291	307	1325	1924
Special counts					
Wound	0	1	0	7	8
Head	1	0	9	16	26
Other ^(b)	0	0	0	5	5
Total	1	1	9	28	39

(a) Figures do not include invalid counts.

(b) Other counts would include any special organ count such as liver, kidney, or thyroid.

S9004068.4

FIGURE 2. Routine Urine Analyses

S9004068.5

FIGURE 3. Routine In Vivo Measurements

TABLE 6. Summary of Potential Exposure Incidents During 1989

Area	Number of Incidents (individuals involved) (a)				
	DOE	KEH	PNL	WHC	Total
100-N	0	0	0	4(5)	4(5)
200-E	0	0(2)	0	5(3)	5(5)
200-W	0	0	0	5(7)	5(7)
300	0	0	6(12)	1(0)	7(12)
400	0	0	0	1(4)	1(4)
Total	0	0(2)	6(12)	16(19)	22(33)

(a) Number of incidents occurring in facilities under custodianship of the listed contractor. Number of workers is by worker employer. The employees listed are not necessarily involved in the incidents in that employer's facilities.

TABLE 7. Comparison of Internal Exposure Incidents and Internal Exposure Dose Assessments from 1986 to 1989

	1989	1988	1987	1986
Number of incidents	22	12	14	44
Number of workers	33	25	20	63
Evaluations	297(a)	83	135	196
Re-evaluations	7	8	16	47
New cases	284	72	157	149
Incidents	33	26	75	70
Special requests	3	8	31	4
High routines	51	38	51	75
Chronic exposures	203			
No dose(b)	77	22	147	143

- (a) Total includes all evaluations issued with an 1989 identifier plus re-evaluations indexed to the original evaluation numbers.
- (b) For 1986 to 1988, the cutoff for dose assessment was 1% of the DOE radiation protection standard or of the maximum permissible body burden. For 1989, the criteria for dose assessment changed (see text) such that smaller intakes were assessed than in previous years.

TABLE 8. Internal Dose Status of Hanford Work Force at 1989 Yearend

Percent RPS ^(b)	Number of Workers ^(a)				Total
	<u>DOE</u>	<u>KEH</u>	<u>PNL</u>	<u>WHC</u>	
Acute Intake					
<1	1	1	12(2)	27(1)	41(3)
1 - <5 ^(c)	1(1)	2	13(1)	19(2)	35(4)
5 - <10	0	1	2	7(1)	10(1)
10 - <50	0	1	6(1)	9	16(1)
50 - <100	1(1)	0	0	1	2(1)
>100	0	0	0	0	0
Chronic Intake					
<1	0	0	7	172	173
1 - <5 ^(c)	0	0	2	0	2
≥5	0	0	0	0	0
Total	3(2)	5	42(3)	235(4)	285(10)

- (a) Numbers in parentheses refer to assessed doses due to offsite exposures.
- (b) Percent of the DOE RPS annual effective equivalent dose limit of 5 rem/yr.
- (c) This table reflects the doses assigned to 1989. Current policy dictates that any 50-year effective equivalent dose of less than 100 mrem be attributed to the year of intake. For assessed doses in excess of 100 mrem the dose table reflects the annual doses assigned to 1989.

previous years), the 1989 total would be 64. Many workers who had long-term internal depositions dating from the 1950s and 1960s retired in 1989.

BIOASSAY ANALYTICAL SERVICES

Bioassay analytical services include excreta sample analysis provided by UST through a subcontract managed by PNL and in vivo measurements performed by PNL. The following subsection discusses the bioassay analytical services provided by UST. The in vivo measurement services provided by PNL in 1989 are reviewed in a separate section of this annual report.

Laboratory Operational Requirements

The Statement of Work^(a) (SOW) for the first operational year of the contract with UST was applicable for the first 9 months of 1989 and a similar SOW (for the second operational year) was applicable for the rest of the calendar year. The most important change in the SOW for 1989 was a requirement to subtract the reagent blank value from gross sample results to produce net sample results. This procedure was actually implemented for samples received by the analytical services lab beginning September 30, 1988.

Laboratory Quality Control

The internal QC program operated by UST provides for monitoring and documenting laboratory performance. The results of internal QC samples are issued in an annual letter report.^(b) The report covering QC samples analyzed in fiscal year (FY) 1989 showed performance to be satisfactory with respect to contractual requirements except that 11% of the yields of all samples were below the minimum for the plutonium in urine using the plutonium-strontium sequential procedure.

In addition to the QC program operated internally by UST, the Hanford Internal Dosimetry Program submits samples containing known quantities of radionuclides in urine. Some of the samples are submitted blind; that is, they are made to appear to be normal urine samples from Hanford workers, and some are submitted openly as audit samples. This external audit sample program provides a check on UST's own internal QC program. Analyses for ⁹⁰Sr, ²³⁸Pu, ²³⁹Pu, ²⁴¹Am, and elemental uranium via two different methods were

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- (a) United States Testing Company, Inc. 1989. Statement of Work for the First Operational Year of Subcontract 005145-A-M1 (1989). Maintained in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.
 - (b) Bruce, P. H. 1989. Bioassay Annual Quality Control Report for Fiscal Year 1989. Letter report to Don Bihl, dated November 10, 1989. United States Testing Company, Inc., Richland, Washington. Copy available in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

tested during FY 1989 and the results were documented in an annual letter report.(a)

The results of the external audit program were generally the same as for UST's internal QC program, although the PNL data indicated a possible problem with the precision of the ^{241}Am analysis at spike levels near the contractual detection level. However, because ^{241}Am analyses were infrequent, the number of QC samples for both UST and PNL were low; hence, the capability to judge the precision was low. Quality control of this analysis will continue to receive attention in FY 1990.

Other highlights worth noting were:

- Revised procedures for ^{90}Sr and ^{241}Am were implemented in January 1989.
- A contamination spread in the counting room caused a suspension in alpha spectrometry for about 1 month beginning March 16. High QC samples led to a suspension of ^{241}Am analyses for about 1 month in August. Also high QC and worker samples lead to a suspension of plutonium analyses in the priority laboratory for a short time in December.
- An incident involving ^{237}Np caused UST to do extensive pretesting and reworking of an old procedure that had not been used for many years for ^{237}Np in urine and feces.

SUPPORTING INVESTIGATIONS AND STUDIES

Supporting work conducted during 1989 included the issuance of three letter reports dealing with 1) routine fecal sampling, 2) record keeping, and 3) tritium bioassay at the Fast Flux Test Facility (FFTF).

Routine Fecal Sampling Program

The pilot fecal sampling program, described in Lyon et al. (1988), evolved into a routine program. In April, after 12 months as a pilot quarterly sampling program, the sampling frequency was changed to annual, with the

(a) Bihl, D. E. 1990. Results of the Bioassay Audit Program for Fiscal Year 1989. Letter report, dated February 16, 1990, Pacific Northwest Laboratory, Richland, Washington. Copy available in the Hanford Radiation Protection Historical Files. Pacific Northwest Laboratory, Richland, Washington.

provision that approximately an equal number of samples are obtained each quarter. As an aid to calculated doses, a computer code, GENCOMP, was written to calculate fecal excretion from a cycling intake pattern of X days of intake followed by Y days of no intake. The committed effective dose equivalent from a year of low-level intake of plutonium was slightly less in 1989 than 1988.

The results of the first 12 months of sampling were analyzed and reported in a letter report to WHC,^(a) and a presentation on the results and recommendations was made at the 35th Annual Conference of Bioassay, Environmental, and Analytical Radiochemistry (Bihl 1989).

Status of Record-Keeping Practices

Internal dosimetry-related programs generate data regarding the internal dose status of workers and visitors at Hanford including results of bioassay measurements, assessments of internal exposure, and evaluation of internal dose equivalents. These programs include the Whole Body Counting Program, the Bioassay Analytical Support Services Program, and the Internal Dosimetry Program. Long-term maintenance of occupational dosimetry records is provided by the Hanford Radiological Records Program.

Requirements for the generation and maintenance of internal dosimetry records are contained in DOE 5480.11 (DOE 1988a). The order also references ANSI N13.6 (ANSI 1972), Practice for Occupational Radiation Exposure Records Systems, for additional guidance. Additional guidance is expected to be issued soon as part of a DOE performance standard for internal dosimetry program. Finally, Hanford internal dosimetry-related programs have been defined as a QA Impact Level 3 and must therefore meet the recording/documentation requirements identified in PNL's internal quality assurance guidelines. These requirements are in addition to the DOE-related documentation requirements.

A self-appraisal of the status of all internal dosimetry-related records relative to the requirements and guidance provided in the above-

(a) Bihl, D. E. 1989. "Results of Pilot Fecal Sampling Program for March 1988 through February 1989." Letter to W. A. Decker, Jr., WHC, dated August 23, 1989. Copy available in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

listed documents was conducted in 1989. Record-keeping requirements from these documents were organized into checklists for each of the three analytical functions: whole body counting, excreta analysis, and dose assessment. The purpose of this review was to identify the existence and ultimate disposition of such records. Only a cursory review was conducted for computer code documentation.

The self-appraisal, issued as a letter report on October 30, 1989, (a) found that record keeping and documentation of the internal dosimetry programs were generally in good shape; however, some additional improvements were recommended:

- formalization of record-keeping systems and practices by the Whole Body Counter Program
- additional, more comprehensive, review and evaluation of computer code documentation for all three functions
- formalization of procedures and schedules for transferring records from the site of origin to the Hanford Radiological Records Program for long-term maintenance
- improved documentation of special in vivo measurements and deviations from documented procedures.

All involved programs began work on corrective action immediately.

Tritium Bioassay Program for Fast Flux Test Facility

A tritium bioassay program was developed for FFTF as a consequence of the tritium production associated with the irradiation of a fusion materials test assembly. The program required consideration of the possible existence of chronic low-level environmental tritium contamination in drinking water to ensure that any assessed doses would be based on actual occupational intake rather than on environmental exposure.

The drinking water at FFTF is obtained from groundwater wells that contain trace levels of tritium from past 200 Area liquid waste disposal

(a) Sula, M. J., and K. M. McFadden. 1989. "Status of Record-Keeping Practices - Hanford Internal Dosimetry." Letter to D. E. Bihl, dated October 30, 1989. Copy available in the Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

practices. The tritium concentration in FFTF drinking water has consistently been below the U.S. Environmental Protection Agency drinking water standard of 20,000 pCi/L for at least 3 years (EPA 1978); however, the sensitive urinalysis procedure used by UST was noted as potentially being able to detect the existing levels.

To determine the background levels that might be expected in FFTF workers, 47 beginning work urine samples were collected between February and July 1989, before any potential tritium production or handling occurred at FFTF. The results were analyzed using probability analysis techniques, and the data were found to fit a log-probability distribution. Based on this analysis, a screening level for tritium in FFTF worker urine samples was set at 40 dpm/mL, corresponding to the 99.9 percentile for environmental exposure. This concentration is about 10% lower than the EPA Drinking Water Standard (EPA 1978). The screening level is used to initiate the dose assessment process for FFTF workers based on routine bioassay measurements. The study was documented in a letter report to the Hanford Radiation Protection Historical Files.^(a)

PRESENTATIONS

Hanford Internal Dosimetry Program staff made the following presentations during 1989:

1. Aldridge, T. L., and R. A. May II. 1989. "Internal Dosimetry Computer Tracking System." Presented at Computer Applications in Health Physics: 1989 Update, Western Regional Symposium of the Health Physics Society, March 16-17, 1989, Richland, Washington.
2. Aldridge, T. L., and R. A. May. 1989. "The Hanford Internal Dose Accounting and Reporting System." Paper presented at Computer Applications in Health Physics: 1989 Update, Western Regional Symposium of the Health Physics Society, March 16-17, 1989, Richland, Washington.
3. Bihl, D. E. 1989. "Results of a Pilot Fecal Sampling Program for Plutonium Workers." Presented at the 35th Annual Conference on Bioassay, Environmental, and Analytical Radiochemistry. October 30-November 2, 1989, Charleston, South Carolina.

(a) Carbaugh, E. H. 1989. "Tritium Bioassay for FFTF Workers." Letter to the Hanford Radiation Protection Historical Files, dated August 2, 1989. Pacific Northwest Laboratory, Richland, Washington.

4. Bihl, D. E. and M. J. Sula. 1989. "Hanford Internal Dosimetry Program, Implementation of DOE Order 5480.11." Presented at a workshop on internal dosimetry aspects of 5480.11, May 3, 1989, DOE Headquarters, Germantown, Maryland; and presented again at a TRADE conference, May 16, 1989, Chicago, Illinois.
5. Carbaugh, E. H. 1989. "Medical and Health Physics Plans for Contaminated Injuries." Presented at the Hanford Technical Exchange, December 8, 1989, Richland, Washington.

PUBLICATIONS

Program staff prepared or contributed to the following publications during 1989:

1. Carbaugh, E. H., M. J. Sula, and D. E. Bihl. 1989. Hanford Internal Dosimetry Program Manual. PNL-7001, Pacific Northwest Laboratory, Richland, Washington.
2. Sula, M. J., E. H. Carbaugh, and D. E. Bihl. 1989. Technical Basis for Internal Dosimetry at Hanford. PNL-6866, Pacific Northwest Laboratory, Richland, Washington.
3. Carbaugh, E. H., W. A. Decker, and M. J. Swint. 1989. "Medical and Health Physics Management of a Plutonium Wound." Radiation Protection Dosimetry, 26(1/4):345-349.
4. Johnson, J. R., E. H. Carbaugh, and R. J. Traub. 1989. "A Review of the State of Tritium Dosimetry." In proceedings of the Third Japan-US Workshop on Tritium Radiobiological and Health Physics," IPPJ-REV3, pp. 293.

PROGRAM-RELATED PROFESSIONAL ACTIVITIES

1. Sula, M. J. and D. E. Bihl--Members of DOE Expert Group on Internal Dosimetry (Bihl replaced Sula in May 1989.)
2. Carbaugh, E. H.--Member of the Health Physics Society N13.14-1983, "Standard for Dosimetry-Internal Dosimetry Programs for Tritium Exposure-Minimum Requirements."

4. Bird, D. E. and M. J. Sule, 1989. "Human-Internal Dosimetry Program: Implementation of DOE Order 5400.11." Presented at a workshop on internal dosimetry aspects of 5400.11, May 3, 1989, DOE Headquarters, Germantown, Maryland; and presented again at a DOE conference, May 16, 1989, Chicago, Illinois.

5. Carbaugh, E. H., 1989. "Medical and Health Physics Plans for Contaminated Injuries." Presented at the Human Technical Exchange, December 6, 1989, Richmond, Washington.

PUBLICATIONS

Program staff prepared or contributed to the following publications during 1989:

1. Carbaugh, E. H., M. J. Sule, and D. E. Bird, 1989. Human Internal Dosimetry Program Manual: PNL-7001, Pacific Northwest Laboratory, Richland, Washington.

2. Sule, M. J., E. H. Carbaugh, and D. E. Bird, 1989. Technical Guide for Internal Dosimetry at PNL-7001, PNL-8555, Pacific Northwest Laboratory, Richland, Washington.

3. Carbaugh, E. H., V. A. Jackson, and M. J. Sule, 1989. Medical and Health Physics: Management of a Radiation Wound. Radiation Protection Dosimetry, 26(1-4):145-149.

4. Johnson, J. R., E. H. Carbaugh, and R. J. French, 1989. "A Review of the State of Tritium Dosimetry." In Proceedings of the Third Annual-12 Workshop on Tritium Radiological and Health Physics, 1989-89-12, pp. 203.

PROGRAM-RELATED PROFESSIONAL ACTIVITIES

1. Sule, M. J. and D. E. Bird, members of DOE Expert Group on Internal Dosimetry (EGID) (April 1989 to May 1989).

2. Carbaugh, E. H., member of the Health Physics Society HPS 1A-1989, "Standards for Emergency-Internal Dosimetry Program for Tritium Exposure-Mitigation Requirements."

HANFORD IN VIVO MEASUREMENT PROGRAM

The In Vivo Measurement Program has been an integral part of personnel dosimetry at Hanford since 1959 to assist in detecting the deposition of radioactive materials in Hanford employees. Program requirements are outlined in the Hanford Site Services Handbook (RL 1983). The In Vivo Measurement Program provides for the management, operation, and maintenance of the in vivo counting facilities and equipment located in the 747-A Building, the 747-A Trailer, a mobile in vivo counting facility, and the Emergency Decontamination Facility (EDF). Operating hours are from 8:00 a.m. to 4:30 p.m. on weekdays. The facilities and equipment are also available during off-hours on an on-call basis. Results of measurements are transmitted electronically to the ORE database for permanent record. Daily operational and functional checks are performed on all routinely used counting systems, which are also periodically fully calibrated to ensure their accuracy. The staff participate in inter-comparison programs to further improve the accuracy of operations. The activities of this program, including special studies and development work carried on during 1989, are described in the following subsections.

ROUTINE PROGRAM

Several types of routine in vivo measurements are made on personnel. The type of measurement made on each person is determined by the type of radioactivity to which he is potentially exposed. Generally, if an employee does not work with TRU radionuclides, only a whole body count is performed to detect the higher energy of gamma rays from fission or activated corrosion products. If the work involves TRU radionuclides, lung and whole body counts are done. If radioactivity is detected by either of these measurements, several other types of counts may be done to identify and quantify the activity in the body.

The number and types of measurements made on personnel during 1989 are listed in Table 9. During 1989, 11,075 measurements were made for DOE-RL and the Hanford contractors. This number is 24% higher than the number for 1988. Figure 4 graphically depicts the in vivo measurements made at the Whole Body Counting Facility for the past 5 years. The 1989 total of 9081 whole body and

TABLE 9. Measurements Made on Hanford Personnel During 1989(a)

Contractor	Whole Body Counts	Lung Counts	Other	Total
BCS	112	0	0	112
DOE	85	1	1	87
WHC	6,555	1,344	24	7,923
HEHF	28	0	0	28
KEH	1,072	297	1	1,370
PNL	1,229	312	11	1,552
Total	9,081	1,954	37	11,072

(a) Includes routine and special counts.

FIGURE 4. In Vivo Measurements Made at the Whole Body Counting Facility from 1985 Through 1989

other miscellaneous counts (other than lung counts) is 26% higher than the same total counted in 1988. Lung counts for 1989 totaled 1954 (18% higher than in 1988).

ADDITIONS OR CHANGES TO EQUIPMENT AND FACILITIES IN 1989

Three major facility additions were completed during 1989, which significantly enhanced the capability and capacity of the whole body counting operations. Two new shielded rooms were brought into full use, and the construction and equipment installation on a new mobile whole body counter (WBC) was completed. This completes a major upgrade of both the shielded rooms and detector systems that have been planned and developed over the past 8 years. This has resulted in a whole body counting facility that is very adequate for the needs of the Hanford project. However the sensitivity for measuring pure ^{239}Pu is inadequate, despite the fact that the equipment for measuring ^{239}Pu is state of the art. Plans remain for establishing a remotely operated WBC in FY 1991, but there are no planned major facility additions in the 747-A Building for the next few years.

Two New Shielded Rooms

Lyon et al. (1989) described the size, source of materials, and the construction of the two shielded rooms that were being built during 1988. After a delay of a few months due to cost overruns for construction, the construction was completed and the rooms were put into routine use starting July 1, 1989. The entrances to the rooms are shown in Figure 5 along with the entrance to the original steel room that was built in 1959.

The middle room is used for a second lung counting system (see Figure 6). This increased capacity for lung counts allowed the counting time to be increased from 1000 to 2000 seconds, which increased the sensitivity for measuring low-energy x- and gamma-ray emitters in the lung by 40%. The counter normally uses six germanium planar detectors that are cooled with liquid nitrogen, but in case of detector failure it can also be operated with four detectors using a 3000-second count time, which provides slightly better sensitivity than using the six detectors for 2000 seconds. The door of the middle room is moved by an air cylinder, which operates very smoothly and

FIGURE 5. Entrances to the Three Shielded Rooms at the Whole Body Counting Facility

quietly from a compressed air supply piped over from the HEHF laboratories adjacent to the 747-A Building. An emergency supply of compressed air is maintained in two cylinders located behind the steel room. The air cylinder's closing mechanism is designed so that in the event of a failure in air pressure or electricity, the door is automatically opened by a counter weight. The graded shield of this room is made from low-background lead, tin, and stainless steel rather than the lead, cadmium, and copper that is normally used. Tin is less expensive than cadmium and the stainless steel does not tarnish or scratch as easily as copper. Both types of graded shield are equally good in reducing the low-energy background of the rooms.

The other new steel room is commonly called the Utah Room because it was obtained from the University of Utah after a DOE-sponsored radiobiology

FIGURE 6. The Second Lung Counter (six germanium planar detectors in place on a measurement subject)

program was terminated. This room (shown in Figure 7) is used to shield an array of four, large-volume, coaxial germanium detectors that is used for whole body counting of the higher energy gamma rays associated with mixed fission and activation products. The room is made of battleship armor plate

FIGURE 7. Taking a Whole Body Count of a Subject in the Utah Room

that is 12 in. thick. The inside graded shielding is composed of lead, cadmium, and copper. The average counting efficiency of the four detectors relative to a 3-x-3-in. NaI(Tl) detector is 68%, which makes the total efficiency almost the same as three 3-x-3-in. NaI(Tl) detectors. This array (shown in Figure 8) is used to quantify all positive body burdens of radionuclides except for naturally occurring ^{40}K and lung and skeleton burdens of low-energy x- and gamma-ray emitters. This can be accomplished completely by computer analysis, even on complex mixtures of radionuclides, because of the excellent energy resolution of the detectors.

New Mobile Whole Body Counter

A new trailer was obtained through the Fleet Management Section of the WHC Operations Support Services Department as a replacement for the old

FIGURE 8. The Array of Four Large-Volume Coaxial Germanium Detectors in the Utah Room

trailer that was 45 years old. The trailer was delivered to the Patillo Construction Company of Kennewick, Washington, in February where paneling, insulation, lighting, carpeting, heating and cooling equipment, a storage room, cabinets, change rooms and lockers, benches, desk, entrance steps, and outside storage boxes were installed. The trailer, shown in Figure 9, was delivered to PNL in April and the shadow shield WBC was transferred from the old trailer to the new trailer. As part of the transfer, the counter was raised 1 ft off the floor for easier entrance and exit from the counter. A picture of the shadow shield counter in the new trailer is shown in Figure 10.

An additional counting facility was added to the trailer to allow for measurements of the head, thyroid, and lungs using planar germanium detectors. The limited shielding of 4 in. of lead on the bottom and 2 in. of lead on

FIGURE 9. The New Mobile Whole Body Counter Trailer

three sides (see Figure 11) provides an 80% reduction in the background for detectors. The background is low enough to make adequate measurements of ^{131}I in the thyroid and other radionuclides in the lung or skeleton using germanium planar detectors, but is not low enough for measuring ^{239}Pu , ^{241}Am , or uranium.

Remotely Operated Whole Body Counter

Lyon et al. (1989) described a feasibility study of the remote operation of a WBC. The study and a test of the proposed methods showed that there are no major obstacles to overcome and that a remotely operated WBC for the radionuclides having gamma-ray energies above 100 keV is technically feasible. DOE-RL approved the construction of the counter and directed that it be built into the new mobile unit that can then be located at the HS-1 Building or

FIGURE 10. The Shadow Shield Counter in the Mobile Whole Body Counter Trailer

FIGURE 11. The Additional Planar Germanium Detector Array in the Mobile Whole Body Counter Trailer (used for head, thyroid, and lung counts)

other locations, which will make whole body counting more convenient for Hanford employees. The concentrated weight of the previous counter exceeds the load limits of the new mobile unit, so a counter design was developed that minimized the weight of the counter. By using this design and placing the counter over an area in the forward section of the trailer that had an extra "I" beam substructure, the load limit of the trailer will not be exceeded.

SPECIAL STUDIES

Seven special studies conducted in 1989 are discussed in the following subsections.

Measurement of ^{241}Am in Retired Hanford Workers

Four retired Hanford workers with measurable burdens of ^{241}Am were measured as part of a program by PNL and HEHF to provide them with a free medical examination and in vivo measurement every 2 years. The main purpose of this study was to obtain a measurement on them within a year or two of their death. Since they have all volunteered as tissue donors for the U.S. Transuranium Registry (USTR), the whole body counting results can be more closely correlated with the ^{241}Am content of autopsy samples that will become available in the future. The ^{241}Am in the workers is that associated with ^{239}Pu , but the ^{239}Pu cannot be measured because it is masked by the ^{241}Am activity. The same four workers were measured in 1987 and the results of the counts are shown in Table 10. The amount of activity has not changed significantly over the 2-year period, as expected for long established bone burdens. For worker A the lung burden may have decreased with a corresponding increase in the skeletal content. For worker B there appears to be a decrease in the bone burden with a corresponding increase in the liver burden. The workers will be measured again in 1991.

Comparison of Head Counts and Total Skeletal Analysis for ^{241}Am in Bone

Over the past few years, postmortem measurements of ^{241}Am have been made on the skull of several USTR whole body donations. In three of the cases the total skeletal content of ^{241}Am has been determined by radiochemical analysis at Los Alamos National Laboratory (LANL). This allows for a comparison of the actual skeletal content with the estimate obtained from counting the skull. In the past, the fraction of activity in the skull has been assumed to be 15% based on studies by Cohen, Spitz, and Wrenn (1977). More recently, Lynch, Kathren, and McInroy (1988) have studied the radiochemical analysis data from skeletons of several total body donations (Kathren, McInroy, and Swint 1987; McInroy, Kathren, and Swint 1989). Lynch, Kathren, and McInroy (1988) determined that 13% is a more appropriate fraction of ^{241}Am in the skull when it is

TABLE 10. Americium-241 Measurements on Retired Hanford Workers

Worker	Skeletal Content, nCi		Lung Count, nCi		Liver Content, nCi	
	1987	1989	1987	1989	1987	1989
A	2.0	2.3	1.2	1.0	---	---
B	10.0	7.9	0.14	0.06	0.65	2.1
C	1.4	1.4	0.68	0.51	<.14	---
D	.38	.34	<.12	<.12	<.09	---

TABLE 11. Comparison of Skeletal Deposition Estimates of ^{241}Am by Skull Counting and Postmortem Radiochemical Analysis

Case Number	Estimated Skeletal Deposition		
	Postmortem Radio-Chemical Analysis	Skull Counting (13% in skull) (a)	Skull Counting (15% in skull) (b)
USTR 102	4.40 kBq	4.27 ± 0.24 kBq	3.70 ± 0.21 kBq
USTR 208	3.27 Bq	2.56 ± 0.56 Bq	2.22 ± 0.48 Bq
USTR 213	12.5 Bq	12.4 ± 2.0 Bq	10.7 ± 1.7 Bq

(a) Assuming 13% of total skeletal deposition in skull according to Lynch, Kathren, and McInroy (1988).

(b) Using skull deposition of 15% as suggested by Cohen, Spitz, and Wrenn (1977).

associated with ^{239}Pu . Table 11 shows a comparison of skeletal deposition estimates of ^{241}Am by skull counting and postmortem radiochemical analysis. Future estimates of the skeletal content of ^{241}Am using skull counts at PNL will use 13% as the fraction in the skull.

Niobium-92m Studies for Improving Calibration Factors for Measuring ^{239}Pu in the Lung

Four more male subjects from England, containing known quantities of $^{92\text{m}}\text{Nb}$ in the lung, were measured and studied during the year. This makes a total of seven subjects who had inhaled the activity on 1- μm particles. In a previous series of measurements conducted a few years ago, the subjects inhaled the $^{92\text{m}}\text{Nb}$ attached to 5- μm particles. Four of the subjects measured this year were the same people who participated in the study using the 5- μm

particle size. The PNL results on the four people who participated in both studies indicated that the counting efficiency of the inhaled activity on 1- μ m particles averaged 44% higher than when it was inhaled on 5- μ m particles. When the average counting efficiency of all the participants of the two groups was compared, the counting efficiency of the activity on 1- μ m particles averaged 64% more than when the activity was on 5- μ m particles.

The other laboratories participating in the study, Argonne National Laboratory, Lawrence Livermore National Laboratory (LLNL), and Harwell Laboratory in England, all reported similar results. The real magnitude of the difference in counting efficiency between inhaling ^{92m}Nb on 1- and 5- μ m particles is uncertain because of poor agreement between measured chest wall thickness among the participating laboratories and because of those individuals participating in both experiments, only one had maintained the same weight. Despite these uncertainties it appears that activity associated with smaller particle size gives a distribution in the lung that is measured with a higher sensitivity. These results agree with the results of an inhalation case of ^{238}Pu at Hanford several years ago where the inhaled activity was a very fine particle size and appeared to be measured with about twice the expected efficiency for 17-keV x-rays.

Postmortem Measurements of a Thorotrast Patient

Postmortem measurements were made on the body of a thorotrast patient that had been donated to the USTR. Measurements were made on the total body and various parts of the body with an array of three, large-volume, germanium coaxial detectors, and a linear scan over the length of the body was made with a collimated NaI(Tl) detector that was 16 in. long and had a cross section of 4 x 4 in. The estimate of the ^{232}Th in the body was 153 nCi. The linear scan of the activity in the body (see Figure 12) shows the activity to be distributed in the red bone marrow as expected when the colloidal ThO_2 is injected, and the scanned activity correlates well with the red bone marrow distribution in Reference Man given in ICRP 23 (1974). Figure 12 also shows a comparison of the distribution of the ^{232}Th activity in this thorotrast case with a skeletal distribution of ^{241}Am . Obviously the thorotrast case is of no practical use at this time in calibrating detector systems for measuring

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FIGURE 12. Comparison of the Distribution in the Body of ^{241}Am and ^{232}Th Administered as Thorotrast

burdens of radioactivity deposited in the bone mineral of the skeleton. More detailed results of these measurements will be published as part of a special future issue of the Health Physics Journal.

Reduction of Radon Daughter Background in the Utah Room

Measurements taken in the new Utah Room during FY 1989 indicated that its radon daughter background appeared to be significantly higher in comparison with the background levels in other shielded rooms. A search for the source of the background revealed that at least 65% of it was coming from the molecular sieve material in the cryostats of the four germanium detectors. The configuration of the detectors allowed this source of activity to be readily shielded and eliminated without interfering with the counting

geometry. The remainder of the background has not been clearly identified yet. It does not seem to be associated with the air circulating in the room because shutting off the fan does not cause the background level to increase as would be expected from the growth of radon daughters in the well-filtered air. Further studies of the background will be done during the coming year to identify the source of the radon daughter activity and hopefully eliminate or significantly reduce it.

Additions to the Calibration Phantom Library

The close association between the WBC operations and the USTR has provided unique opportunities to develop calibration phantoms from total body donations. These opportunities will continue in the future. The development of these phantoms has been funded by DOE Headquarters Laboratory Accreditation Support and is very beneficial to the PNL whole body counting program, because it enables PNL to develop a library of calibration phantoms for short-term loan to other whole body counting laboratories that need phantoms for calibration purposes. The first phantom developed under this program contained the entire half of a skeleton containing ^{241}Am for which the other half had been analyzed by radiochemical analysis. During this past year, four bottle manikin adsorption (BOMAB) phantoms were purchased for the purpose of filling three of them with standard amounts of radioactivity mixed uniformly with solid polyurethane. One phantom will contain ^{137}Cs , another ^{40}K , and the third will contain a mixed standard of long-lived radionuclides with energies extending from 86 keV to 1596 keV. During 1989 the ^{137}Cs phantom was constructed; the other two should be completed in early 1990. In addition to these phantoms, LLNL transferred several tissue-equivalent torso phantoms to PNL along with several sets of lung and liver organs containing known amounts of radioactivity. The original molds for all the phantom parts were also included in the transferred items. Several of these calibration phantoms were on loan at the end of 1989.

Maintenance of the Germanium Planar Detectors

The second lung counter that was placed into routine use in 1989 has been operating with only four detectors because of many problems with the organ pipe design detectors. In the past, the repair of these detectors has

always been done by the manufacturer; however the time required for these repairs is not acceptable for PNL WBC operations. The manufacturer quotes a repair time of 6 weeks, but in practice it usually takes 6 to 12 months. Because of this long repair time at the manufacturing facility, a decision was made to try to repair the detector at PNL. Canberra Industries, Inc., agreed to provide the WBC maintenance technician with 3 days of instruction on methods and techniques for keeping planar detectors in good operating condition. Necessary spare parts and materials were ordered to facilitate these repairs. A few of the detectors have been repaired and are operating. Part of the cause of detector malfunction was water condensing on the cold tube connections at the top of the detector and running down into the preamplifier causing corrosion on the printed circuit board. This problem was solved by using fill tubing of surgical rubber surrounded by foam tube insulation. Most of the other problems with the detectors are associated with the cooled field emission transistor in the preamplifier.

PUBLICATIONS

Program staff contributed to the following publications during 1989:

1. Palmer, H. E., and M. C. Rhoads. 1989. "The Measurement of Pu-239 to Am-241 Ratio in Wounds by Measuring the L x rays with a Si(Li) Detector." Health Physics 56:249-252.
2. Breitenstein, B. D., and H. E. Palmer. 1989. "Lifetime Followup of the 1976 Americium Accident Victim." Radiation Protection Dosimetry 26:317-322.
3. Palmer, H. E., G. A. Rieksts, S. J. Jefferies, and K. J. Gunston. 1989. "Improved Counting Efficiencies for Measuring Pu-239 in the Lung in the Sitting Position." Health Physics 57:747-752.

HANFORD EXTERNAL DOSIMETRY PROGRAM

The Hanford External Dosimetry Program is a multifaceted effort involving all Hanford contractors. Dose-of-record information from external radiation for Hanford personnel is provided by this program in compliance with the requirements of DOE 5480.15 (DOE 1987) and DOE 5480.11 (DOE 1988a). Program dosimeter results provide the means used by contractor personnel to project, control, and measure radiation doses received by personnel. Program staff also provide site-wide nuclear accident dosimetry in compliance with DOE 5480.11 requirements.

ROUTINE PROGRAM

PNL processed approximately 225,000 dosimeters during 1989. This total includes processing all Hanford personnel dosimeters as well as updating chip sensitivity factors for both even and odd monthly and quarterly issued dosimeters as well as annually issued dosimeters for 1990. Each year numerous control and audit dosimeters are processed to ensure the integrity of the dosimeter processing. During 1989, 3267 audit dosimeters were processed. A breakdown of the audit dosimeters is shown in Table 12.

TABLE 12. Audit Dosimeters Processed During 1989

Dosimeter	Dose Category ^(a)				
	Shallow	Deep	Fast Neutron	Slow Neutron	Blank
Basic	NA	400	NA	NA	180
Beta/photon	130	65	NA	NA	NA
Multipurpose	419	498	549	418	268
Rings	NA	280	NA	NA	Controls
Two-element	60	NA	NA	NA	Controls

(a) NA = Not Applicable

Control charts are used to evaluate the results for each of the audit dosimeter categories. Charts are prepared for each dosimeter and radiation type for each of the 17 dosimeter processings (monthly, quarterly, and annual) that are conducted each year. A QC report is prepared for each processing. Copies of the QC report are distributed to all Hanford contractor radiation protection organizations as well as to the Hanford Radiation Protection Historical Files (Historical Files). Copies of the control charts are also provided to the Historical Files.

DOE LABORATORY ACCREDITATION PROGRAM

During 1989 the Hanford External Dosimetry Program formally participated in the DOE Laboratory Accreditation Program (DOELAP) in personnel dosimetry, as required by DOE 5480.15 (DOE 1987). Hanford successfully passed all requested categories for Hanford basic, beta/photon, and multipurpose dosimeters. The results are summarized in Table 13. Performance testing covered a period of nearly 6 months and involved approximately 350 dose evaluations for a variety of single and mixed exposure conditions. Exposures included personnel and accident level doses (the latter as high as 500 rem).

An onsite technical program appraisal was conducted on December 12 and 13 to examine program documentation and practices relative to the requirements of the DOELAP Handbook (DOE 1986). The appraisers noted 16 concerns and 10 observations, which are summarized in Tables 14 and 15, respectively. A formal response was submitted to DOE-RL on December 20, describing program response to and time required to resolve each of the concerns shown in Table 14. It should be noted that none of the concerns questions the quality of Hanford personnel dose estimates, but are directed at improving documentation, training, and security of the Hanford External Dosimetry system. Efforts to respond to each of the concerns are scheduled for completion within the next year. Although not required, each of the observations in Table 15 will be similarly resolved. Hanford is scheduled to receive formal program accreditation during the spring of 1990 based on passing the performance testing in all requested categories and demonstrating program integrity during the onsite technical appraisal.

TABLE 13. DOELAP Shallow and Deep Dose Performance Test Data

DOELAP Category Description	DOELAP Criterion	Performance (a)		
		Basic	HMPD	HBPD
<u>Shallow Dose Component</u>				
Low-energy photons, plutonium environments	0.3		0.09	0.20
High-energy photons, ¹³⁷ Cs	0.3		0.04	0.13
Beta particles, ⁹⁰ Sr	0.3			0.28
Mixtures:				
Low-energy photons + high energy photons	0.4		0.08	0.21
Low-energy photons + beta particles	0.4			0.24
High-energy photons + beta particles	0.4			0.28
<u>Deep Dose Component</u>				
Low-energy photons, accident levels	0.3		0.22	0.19
High-energy photons, accident levels	0.3	0.10	0.18	0.25
Low-energy photons, plutonium environments	0.3		0.16	0.22
High-energy photons, ¹³⁷ Cs	0.3	0.20	0.06	0.14
Neutrons, unmoderated ²⁵² Cf	0.3		0.10	
Mixtures:				
Low-energy photons + high energy photons	0.4		0.12	0.23
Low-energy photons + beta particles	0.4			0.35
Low-energy photons + neutrons	0.4		0.12	
High-energy photons + beta particles	0.4			0.10
High-energy photons + neutrons	0.4		0.11	

(a) Performance results for Hanford basic dosimeter, Hanford multipurpose dosimeter (HMPD), and Hanford beta/photon dosimeter (HBPD).

TABLE 14. Concerns Noted During the DOELAP Onsite Technical Program Assessment

1. The responsibility for maintaining and revising the QA manual is not clearly defined. (a)
2. Program documentation does not adequately describe a training program that prepares staff members to conduct processing protocols. The training provided also does not include basic dosimeter theory, nor does it directly emphasize operating procedures.
3. The program documentation does not describe the retraining of staff members when protocols are revised or to correct any performance deficiencies.
4. Competency reviews do not include documentation of observations of the conduct of processing protocols by technically qualified individuals or by written examinations.
5. The responsibility for maintenance, calibration, and servicing is not clearly defined.
6. Procedures are not in place for bringing backup equipment into service in the event of the loss of the ability to operate the readers, which are all located in a single room. This finding addresses only a catastrophic loss of all readers in the processing room, due to fire, widespread facility contamination, etc. Loss of a single reader would not adversely affect program performance.
7. The QA program does not adequately describe records kept from the point of receipt through the final delivery of data to the users. (a)
8. A procedure to define final acceptance of process data based upon the analysis of reader parameters, QC dosimeter results, etc., does not exist.
9. There is no written description of the checks that are performed internally by the reader to check its operating conditions. The acceptance criteria are programmed into each reader, are protected by password, and are printed each day. The program documentation does not describe the origin of all of these limits, approval for changes in the limits are not in proceduralized or documented, and no periodic verification that the limits in the reader are correct is documented.
10. Radiological surveys are not performed in the processing areas. Contractor personnel are required to perform contamination surveys prior to returning dosimeters for processing, but this is not documented (e.g., with a 'green tag'). Dosimetry personnel do not perform or request follow-up or routine surveys to confirm that the facilities and dosimeters are free from contamination.
11. Thermoluminescent dosimeters (TLDs) are not adequately packaged for issue to users.
12. Site-wide direction concerning the handling of dosimeters during the issue and collection process is needed to preclude the 'in-transit' exposure of dosimeters.
13. Fading of the TL materials under normal conditions is not accounted for. The environmental correction factor, which is used for background subtraction, corrects the background signal for fading, but no correction of the net TL signal for fading is made.
14. The dosimetry system documentation does not include the design specification of the maximum level of exposure the dosimeter is capable of recording during routine processing.
15. No procedure exists for a detailed review of data produced between the last successful QC dosimeter and the first QC dosimeter that fails to meet control limits.
16. The useful dose range for the dosimetry system is not established and documented for each radiation category of interest.

(a) The QA manual and program are internal to the Hanford Internal Dosimetry Program.

TABLE 15. Observations Noted During DOELAP Onsite Technical Program Assessment

1. The entire staff, technicians and professionals, demonstrated a commitment to a high-quality dosimetry program. Their positive attitude and cooperative spirit contributed greatly to the effectiveness of this inspection.
2. A list of facilities and equipment used in the processing protocols is not available, but is not updated enough to permit their correlation with calibration records. The sequence number generated for a dosimeter at the time of processing, which is a primary dosimeter tracking mechanism, is coded to identify the reader used for processing. The managers and staff are all familiar with the sequence number coding convention. However, program documentation does not describe the current version of this convention.
3. Some program records (e.g., charts used during dosimeter acceptance) do not individually identify the reader used for processing and other pertinent data that further identify the run. These records are attached to a cover page that does identify those elements, but if a record becomes separated it would be difficult to identify the reader/run with which it was associated.
4. PNL actively participates in the Hanford Personnel Dosimetry Advisory Committee, which is considered an excellent forum for resolving Hanford dosimetry problems and communicating the QC performance of the program.
5. PNL has instituted an excellent quality review and acceptance of process data prior to the release of dosimetry data for reporting.
6. Technicians do not understand critical functions of TLD processing equipment, including heating/temperature cycle, inert gas purging, and the purposes of the annealing cycles. A heavy reliance is placed on the ability of the reader to internally control the readout process. The vital role of the technician in assuring the integrity of the processing results is not emphasized. This is most evident in the lack of a formal training program. Technicians are taught procedure but not theory or policy. (See CONCERN 2 in Table 14.)
7. The (neutron) test and acceptance criterion for dosimetry material is adequate to identify TLD-800, but may not be adequate to distinguish between TLD-100 and TLD-700. No tests are performed to confirm the proper positioning of TLD-200 within the assembled dosimeter.
8. The duties of the technician when equipment fails to operate within process limits are clearly identified. The Maintenance Log and its implementing procedure provide a positive control against using equipment that is not operating properly.
9. Excellent documentation exists regarding the history and development of dosimeter algorithms.
10. PNL has instituted a superior records archive and retrieval system by their Occupational and Environmental Protection Section, Radiological Records Group. The system was demonstrated to include a comprehensive collection of dosimetry program and personnel data.

HANFORD PERSONNEL DOSIMETRY ADVISORY COMMITTEE

During 1989 several external dosimetry issues were reviewed by the Hanford Personnel Dosimetry Advisory Committee (HPDAC) as follows:

- Sigma pile audit dosimeters
- Hanford convention for rounding dosimeters results
- Note code 5D dosimeter results
- Simplified fast neutron dose algorithm
- Total neutron dose reporting only
- Ad hoc committee to examine Hanford Fast Neutron Dose Assessments
- New DOE security credential
- Hanford practice for contaminated skin and clothing

A brief discussion of committee review for each of these issues follows.

Sigma Pile Audit Dosimeters

At the January 5 meeting of the HPDAC, (a) the calculated fast neutron dose for sigma-pile-irradiated WHC audit dosimeters was discussed. The practice of exposing dosimeters in the sigma pile for evaluating the slow neutron dose only has been used by PNL since the inception of the TLD in 1972. In addition to the slow neutron dose calculated for sigma-pile-irradiated dosimeters, a relatively large fast neutron dose is also calculated. For example, a slow neutron dose of 30 mrem can easily have a calculated fast neutron dose of a few hundred millirem. WHC has been evaluating audit dosimeter results in which the reported fast neutron dose is compared with a given fast neutron dose of zero as provided by PNL calibration staff. The sigma pile exposures are used to determine the thermal neutron response of the dosimeter and are necessary to compensate the dosimeter response for thermal neutron exposure prior to calculating the fast neutron dose component. There

(a) Fix, J. J., and M. J. Sula. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on January 5, 1989." Letter to Distribution, dated January 17, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

was concern that the WHC evaluation of the fast neutron dose in addition to the thermal dose from sigma pile irradiations did not properly reflect the performance of the dosimeter and should not be used for several reasons, as follows:

1. The exposure geometry in the sigma pile is not indicative of any personnel exposure geometry.
2. No phantom is used in the exposure that is essential to the performance of an albedo dosimeter.
3. The sigma pile exposure is a technical necessity as a basis for the thermal neutron correction used in the formulation of the historical fast neutron dose algorithm.
4. It is not a category included in any ANSI or DOE LAP performance test.
5. People reviewing the information will be confused by these results unless they are intimately familiar with the many technical details involved.

The committee discussed the historical precedent for these exposures and the evaluation conducted by PNL of the results prior to October 1, 1988, when PNL assumed responsibility for conducting the routine processing. There was a stated need to audit each dose category reported by PNL that includes both slow and fast neutrons. The desirability of reporting only a total neutron dose was discussed. It was concluded that WHC should continue with the precedent set by PNL, where each reported dose category is audited. The sigma pile irradiations will be used to assess the accuracy of the slow neutron dose category only.

Hanford Convention of Rounding Dosimeter Results

At the HPDAC meeting on January 5, (a) the committee discussed a proposed improvement in the Hanford convention used to correct dosimeter results for reader background. The convention used for many years involves the subtraction of an average background signal from each chip reading and the use of the

(a) Fix, J. J., and M. J. Sula. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on January 5, 1989". Letter to Distribution, dated January 17, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland Washington.

resulting readings to calculate shallow, deep, fast neutron, and slow neutron dose components in centirem using appropriate algorithms. Thereafter, 0.5 centirem is added and the value is truncated down to the nearest integer and multiplied by 10 to determine the millirem dose for each dose component. Then an environmental dose correction is applied to the shallow and deep dose components.

Implementation of a statistical procedure to replace the convention was proposed because improved data would be obtained and the process could be readily explained to outside technical reviewers. At present, it is difficult to technically explain the appropriateness of the Hanford convention with dosimeters with little or no dose. It was suggested that determination of an expected background signal be calculated for each chip position at the 95% confidence level from the numerous background control dosimeters processed. Doses could be calculated to the nearest whole millirem or to multiples of 10 mrem as done in the past from the net chip count for each position. There was some discussion that reporting doses to the nearest millirem is needed to provide consistency between internal and external dose results in the calculation of the effective dose equivalent. The statistical validity of the Hanford convention of rounding to the nearest multiple of 10 mrem appears to be technically sound considering the variability in dosimeter results. The committee did not adopt a formal position on the issue. Other issues related to this topic include the use of detection levels for which all lower dose estimates would be reported as zero, the variability in calculated cumulative dose for worker groups with low doses, the use of Hanford personnel doses in epidemiological studies, and the dose threshold of 50 mrem used for reporting visitor doses.

Note Code 50 Dosimeter Results

During 1989 a practice was initiated in which any questionable dosimeter results are flagged with a note code 50. With this note code, the dosimeter result is reported to Radiological Records using routine procedures; however, the result is not reported to the contractor radiation protection staff until a letter is received with a recommended dose from the contractor. External Dosimetry staff send a letter to the appropriate contractor explaining the reason for identifying the record with a note code 50 with a copy to Radio-

logical Records for placement in the individual's exposure record. The contractor is required to conduct an investigation and provide a recommendation to Radiological Records. This practice was adopted to eliminate reporting dosimeter results that are known to be in error. A copy of all correspondence is placed in the individual's exposure record.

Total Neutron Dose Reporting Only

At the February 9 HPDAC meeting, (a) Radiological Records requested that the feasibility of External Dosimetry reporting only a total neutron dose component be examined. This would provide space in the existing computerized ORE record system for recording and reporting the eye dose as required in DOE 5480.11 (1988a). Relationships between slow and fast neutron chip signals would be incorporated into the dose determination system as QC flags to ensure that a fast neutron dose is not determined for a highly thermalized spectrum. External Dosimetry was interested in using this information as a QC criterion in the reporting of neutron dose. If the relationship is suspect, these doses would be flagged with a note code 50, indicating the need for additional investigation. There was concern about reporting eye dose until a suitable algorithm was developed to report a 300-mg/cm² tissue depth dose. The committee discussed several aspects of this proposal during following meetings with final agreement as follows:

- Effective January 1, 1990, External Dosimetry would begin reporting only the total neutron dose component in the computer field currently used to report the fast neutron dose.
- For the historical record, slow and fast neutron dose components would be combined prior to any rounding to provide the total neutron dose.
- Effective January 1, 1990, External Dosimetry would report measurements of the eye dose in the computer field currently used to report slow neutron dose. Unless special measurements are done, an eye dose of zero will be routinely reported.

(a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on February 9, 1989." Letter to Distribution, dated February 16, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

- Radiological Records staff will make a note to the Historical Files explaining the change in procedures.

Simplified Fast Neutron Dose Algorithm

Discussion of using an alternative fast neutron dose algorithm was discussed at the July 13 meeting of the HPDAC.^(a) Historically, the results of several field studies have shown that the calibration and algorithm, using a slow neutron correction term (employed at Hanford since the inception of the TLD albedo dosimeter), results in accurate fast neutron dose estimates for field conditions, which contribute the greatest employee exposure compared with parallel measurements using tissue-equivalent proportional counters. However, this algorithm, with the slow neutron correction term, will not assuredly meet the DOELAP performance criterion of 0.3. This occurs because of error propagation within the many terms of the algorithm. The results algorithm would likely meet the National Voluntary Laboratory Accreditation Program (NAVLAP) criterion of 0.5. Error propagation increases according to the number of terms used in the algorithm. The slow neutron correction term shows significant variability. To minimize error, PNL used the same fast neutron algorithm in DOELAP performance testing as used by several other laboratories, such as LANL and Oak Ridge National Laboratory (ORNL). This is identical to the Hanford algorithm without a correction for the slow neutron signal. This action is justified by the lack of need for making a slow neutron correction for the low-scatter, laboratory geometry used in the DOELAP exposures. Several possible alternatives were discussed as follows:

- Eliminate the slow neutron correction term for field measurements. (This action would result in significant over-reporting of fast neutron dose.)
- Introduce a facility-specific calibration factor and eliminate the use of the slow neutron correction term. (This approach is difficult because of inadequate control of personnel work assignments as well as the significant effort necessary to implement this option.)

(a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on July 13, 1989." Letter to Distribution, dated July 17, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

- Introduce the capability to float the calibration coefficient for the fast neutron dose based on the relative thermal and fast neutron dose components. (The technical adequacy of this approach, which had been discussed on several previous occasions, was still of concern because fast neutrons contribute the vast majority of the personnel neutron dose, but the dosimeter responds primarily to slow neutrons.)
- Implement a computer code to flag dosimeter fast neutron dose results in which the respective chip results indicate an energy spectrum significantly different than the spectrum used in calibration.
- Implement a different dosimeter for neutrons. (At present, the albedo dosimeter appears to be the best dosimeter to use, because it responds to any significant neutron exposure. However, determination of dose is highly dependent on the energy of the neutrons. The parallel laboratory and field evaluation between CR-39 and Hanford albedo dosimeters conducted last year showed significant QC problems with CR-39 [Lyon et al. 1989]. There is no other proven dosimeter capability available.)

Because of the complexity of these issues, HPDAC formed an ad hoc committee to examine the issues in greater detail.

Ad Hoc Committee to Examine Fast Neutron Dose Results

An ad hoc committee was formed at the October 5 HPDAC meeting^(a) to examine several issues involving fast neutron dose determination for Hanford personnel. The issues involved the precision of existing chip sensitivity factors determined prior to October 1, 1988, when PNL assumed responsibility for dosimeter processing; use of the simplified algorithm in DOELAP performance testing; and the appropriateness of using the historical algorithm for Hanford personnel dose assessments. The ad hoc committee finalized their report on these issues for discussion at the November 2 HPDAC meeting.^(b) A fundamental concern involved the tradeoffs between using the historical fast neutron algorithm (i.e., $FN = C_4 * R_4 - C_5 * R_5 - C_7 * (R_3 - R_4)$) or the

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- (a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on October 5, 1989." Letter to Distribution, dated October 11, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.
 - (b) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on November 2, 1989." Letter to Distribution, dated November 6, 1989. Copy in the Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

simplified algorithm (i.e., $FN = C_8 * (R4 - R5)$) used in the DOELAP performance testing. (Error propagation within the historical algorithm can result in significant error. A precision of less than 5% for each chip position is estimated to assuredly meet the DOELAP criterion of 0.3 [i.e., variability of 5% for each chip position results in a two-sigma confidence interval of 0.31 for a bare ^{252}Cf exposure]. Error propagation will be even greater in mixed field irradiations.) The ad hoc committee recommended using the simplified algorithm effective with the January 1990 dosimeter results and providing routine reports to the committee on the status of efforts to improve the performance of the historical algorithm, particularly with respect to passing DOELAP performance criteria.

Because the thermal correction term (i.e., $C_7 * (R3 - R4)$) is always set to zero if it is negative, the historical algorithm will always err in the negative direction. There was some discussion regarding the technical merit of letting the thermal neutron correction term fluctuate according to statistical causes instead of setting the term to zero based on physical principles (i.e., negative thermal neutron signal is not physically possible). It was speculated that a significant source of error with the historical algorithm is variability in chip sensitivity factors for Hanford dosimeters. This particularly affects the fast neutron dose component because of the significant error propagation for this particular algorithm compared with the algorithms used to calculate shallow, deep, and slow neutron dose components. A serious problem with using the historical algorithm is the potential to underestimate dose for audit or DOELAP dosimeters and, more importantly, for personnel. Tradeoffs between the algorithms are understandable if the difference in calculated dose was relatively small. However, significant dose differences are involved. The committee generally agreed that it is preferable to overestimate the recorded dose if there is to be a choice between errors. After further discussion the committee adopted the following recommendations:

- The simplified algorithm should be used as soon as possible, preferably with the October 1989 monthly dosimeter processing. (Note: This was done).

- Dose reports should be given to WHC, PNL, and KEH, showing personnel dose results calculated with the historical and simplified algorithms for each routine processing.
- External Dosimetry should calculate 1989 doses for selected groups of personnel using 1) the actual recorded dose, 2) historical algorithm using PNL-determined chip sensitivity factors, and 3) the simplified algorithm using PNL-determined chip sensitivity factors. These results should be reported to the committee by February 1, 1990.
- The External Dosimetry Program should report the status of program improvements to the committee by July 1, 1990, as recommended by the ad hoc committee report.

Further discussion of policies for considering changes to individual dose records was discussed at the December 7 meeting with the conclusion that changes should be based on a case-by-case review.

New DOE Security Credential

At the June 15 HPDAC meeting, (a) DOE plans to implement a new security credential were discussed. DOE-RL will be the first organization at Hanford to begin using the new credential. The new credential is smaller and slightly thicker than the current credential. The credential includes "card key" access capability. Options discussed to implement the new credential include:

- Separate the new security credential from the Hanford multipurpose dosimeter and replace the currently used credential with a new one.
- Provide direct replacement of the existing holders to accommodate the smaller security credential. (This will require re-fabrication and acceptance testing of replacement multipurpose dosimeter holders at substantial cost.)
- Upgrade the Hanford dosimeter with the objective of implementing a single holder design for all Hanford personnel. (This dosimeter would utilize two dosimeter inserts, meet all existing DOELAP criteria, and include an option for personal neutron accident dosimeter [PNAD] as well as CR-39 capabilities. This dosimeter would be similar to the multi-element dosimeters being implemented at other DOE laboratories.)

(a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory committee Meeting on June 15, 1989." Letter to Distribution, dated June 19, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

Discussions at later HPDAC meetings resulted in a plan to separate the credential and dosimetry components, while implementing a method similar to ORNL's in which the security credential is attached to the dosimeter. This two-piece approach enhances the ability to verify that both the security credential and the dosimeter are being worn, while also physically separating the two systems for easier processing. This issue will continue to be examined during 1990.

Hanford Practice for Handling Contaminated Skin and Clothing

At the March 9 HPDAC meeting, (a) the External Dosimetry Program was requested to develop Hanford practices for handling contaminated skin and clothing for compliance with the requirements of DOE 5480.11 (DOE 1988a) non-uniform exposure. This effort continued throughout the year for review by the committee. The committee requested that separate practices be developed for contaminated skin and for contaminated clothing. The practice for contaminated skin was formally adopted by the HPDAC at the July 13 meeting (and is attached to the minutes of the July 13 HPDAC meeting in the Historical Files). (b) Final adoption of the Hanford practice for contaminated clothing was still under discussion at the December 7 and final meeting of the committee during 1989.

SUPPORTING INVESTIGATIONS AND STUDIES

Studies were conducted during 1989 to upgrade program documentation, resolve technical issues, and improve QC of dosimeter fabrication, use, processing, or dose assessment. These studies are discussed in the following subsections.

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- (a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee on March 9, 1989." Letter to Distribution, dated March 13, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.
 - (b) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on July 13, 1989." Letter to Distribution, dated July 17, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

MicroVAX Memory Upgrade

Efforts were completed during the year to upgrade the primary and backup microVAX computers with three large disks (655 megabytes formatted) each. These disks replaced the substantially smaller 159-megabyte disks used previously. The larger disk capability significantly enhances the ability to conduct routine processing and development work and provide backup within the primary computer system as well as with the backup system. The larger disk capability was needed to fully implement the glow curve analysis and retrieval capabilities. Glow curves of each dosimeter processing are maintained for 60 working days.

High Dose Response of the Hanford Reader Systems

Characterization of the high dose response of the Hanford reader systems was necessary to participate in DOELAP performance testing and to meet the criticality dosimetry requirements of DOE 5480.11 (DOE 1988a). Figure 13 shows the original and corrected dose response for dosimeters processed on the Hanford automated reader systems exposed to 100,000 mR to 1,000,000 mR from a ^{60}Co source. It is apparent from the figure that the reported dose without correction at 1,000,000 mR would be underestimated by about 50%. The corrected dose response is based on the following formula:

$$\text{Dose} = 0.631 * (\text{Chip 2} / (1 - \text{Chip 2} * 6.15 \times 10^{-7})) \quad (1)$$

where Dose = deep dose from penetrating photon radiation greater than about 100 keV

0.631 = calibration constant for the Hanford dosimetry system terms of rem per reader count for position 2

Chip 2 = adjusted reader signal for position 2 of the Hanford multipurpose dosimeter

6.15×10^{-7} = dead time correction factor determined previously.

This formula was used in the DOELAP performance testing described previously.

FIGURE 13. High Dose Response of Hanford Reader Systems

Extremity Dosimetry Intercomparison Study

Efforts are under way to develop a DOE LAP extremity dosimetry performance standard. Hanford participated in pilot testing of a draft standard during 1989. The Hanford two-chip ring dosimeter was used in the testing, using the usual ^{137}Cs calibration only. The beta and photon energy response of the ring dosimeter is illustrated in Figure 14. The response for photon and beta radiation is normalized to the response to ^{137}Cs . The dosimeter will over-respond to most photon sources, whereas the response decreases with the decreasing energy of the beta radiation.

Dosimeter Response to the 100°C and 80°C Oven Anneal

Tests were conducted to determine the effect on the response of the same dosimeter for selected annealing cycles. Dosimeters were exposed to 80°C or 100°C 16-hour annealings to simulate the routine practice of annealing dosimeters prior to their issuance to Hanford contractors (i.e., "pre-issue anneal"). All dosimeters received the usual 30-minute annealing at 80°C prior to processing (i.e., "pre-read anneal"). The 80°C, 16-hour pre-issue and 30-minute pre-read oven anneals are the routine practice. The results are

FIGURE 14. Hanford Ring Response

summarized in Table 16. It is apparent from the results that there is an approximate 20% to 30% decrease in dosimeter response for the 100°C anneal compared with the usual 80°C 16-hour anneal.

TABLE 16. Results of Oven Anneals on Dosimeter Response

<u>Dosimeter</u>	<u>Annealing</u>		<u>Percent Difference</u>
	<u>80°</u>	<u>100°</u>	
1TG03	1587	1103	-31
1TG28	1395	1138	-18
OT204	1190	875	-27
OT296	1207	865	-28

(a) Average of five chip results for each dosimeter. Raw chip counts are used in the comparison.

DOCUMENTATION

Formal documentation of the Hanford External Dosimetry Program are contained in two draft PNL manuals, as follows:

- Pacific Northwest Laboratory (PNL). 1987. Location of Criticality Alarms and Nuclear Accident Dosimeters at Hanford. PNL-MA-583, Richland, Washington.
- Pacific Northwest Laboratory (PNL). 1989. Hanford External Dosimetry Program. PNL-MA-568, Richland, Washington.

In addition to these documents, several internal technical documents are used by program staff to document the design, algorithm, calibration, and dose response characteristics of the different dosimeters and procedures for evaluating the nuclear accident and environmental dosimeters. Letter reports are prepared and submitted to the HPDAC for review and comment for significant program issues. Copies are included in the minutes of these committee meetings and provided to the Historical Files maintained by the Hanford Radiological Records Program.

PRESENTATIONS

Public presentations made by the External Dosimetry Program staff during 1989 include:

1. Nichols, L. L., A. W. Endres, M. A. Parkhurst, and W. A. Decker. 1989. "Angular Dependence and Field Tests on CR-39." Presented at the Annual Health Physics Society Meeting, June 25-29, 1989, Albuquerque, New Mexico.
2. Fix, J. J. 1989. "Compliance with DOE Order 5480.11 Requirements for Non-uniform Exposure to the Skin." Paper presented at the DOE and DOE Operations Contractor Radiation Protection Conference, January 31-February 3, 1989, Albuquerque, New Mexico.

PROGRAM-RELATED PROFESSIONAL ACTIVITIES

1. Fix, J. J.--Chairman of Health Physics Society Standards Committee Working Group to develop a standard titled "How to Estimate the Overall Accuracy in Occupational Dose Determinations."
2. Fix, J. J.--Chairman of DOELAP Oversight Board as identified in DOE Order 5480.15 (DOE 1987).

3. Fix, J. J.--Member of Health Physics Society Standards Committee Working Group to revise ANSI N319, titled "Personnel Neutron Dosimeters (Neutron Energies less-than 20 MeV)."
4. Fix, J. J.--Member of ad hoc dosimetry working group to support an International Agency for Research on Cancer (IARC) project to pool existing epidemiological studies.
5. Rathbun, L. A.--Member of the American Society for Testing and Materials (ASTM) Task Group E-10-04-16, writing a standard "How to Perform Field Measurements of Beta Spectra."

INSTRUMENT CALIBRATION AND EVALUATION PROGRAM

The operation of a complete radiation protection instrument program is an integral part of Hanford radiation protection programs. The Instrument Calibration and Evaluation Program provides a complete radiation protection instrument service, thereby equipping the Hanford contractors with quality, reliable, and accurate instrumentation capable of performing at the level necessary to ensure personnel safety as required by DOE 5480.11 (DOE 1988a). Calibrations are performed using the guidance in ANSI N323-1978 (ANSI 1978). The routine program activities fall under the five base tasks that comprise the program: 1) Routine Portable Instrument Pool, 2) Hanford Instrument Evaluation Program, 3) Deployment of High-Range Cutie Pie (CP) Instruments, 4) Documentation of the History of Hanford Instruments, and 5) Calibration of WHC 200 Area continuous air monitors (CAMs). The following subsections discuss details of and activities performed under these five basic tasks and other important support tasks performed during 1989.

ROUTINE PROGRAM

The routine program provides for a complete radiation protection instrument program. This consists of procuring new and replacement instruments; overseeing an instrument pickup and delivery service; keeping records; and surveying, decontaminating, maintaining, and calibrating instruments. The routine program also includes the following:

- maintaining traceability of radiological and electronic calibration systems to NIST
- operating a program to service radiation protection emergency kits
- modifying and updating written calibration procedures as new instruments are introduced and calibration techniques are improved
- procuring, acceptance testing, calibrating, and distributing pencil dosimeters
- performing specification development and acceptance testing on all instruments purchased for pool use and as required by Hanford contractors.

Routine Portable Instrument Pool

The usage of portable instruments on the Hanford Site during CY 1989 is summarized in Table 17, including instrument types, the number of instruments, and the percent of the total number of instruments for each contractor (i.e., PNL, KEH, WHC - 100, 200, and 300/400 Areas). The instrument types are described in detail in PNL-MA-562, Radiation Protection Instrument Manual.

During 1989 a number of new instruments were procured to replace instruments damaged or disposed of as low-level waste as a result of contamination. Ten Eberline Model RO-3B CPs were procured. Fifty Bicron count rate meters were also received. Fifty pancake probes were fabricated by PNL Craft Service personnel and are now in the instrument pool.

Hanford Instrument Evaluation Program

The Hanford Instrument Evaluation Committee (HIEC) provides a mechanism for Hanford intercontractor information exchange to assure that the highest-quality program for portable and semi-portable radiological protection instrumentation is maintained at Hanford. Committee responsibilities include the following:

1. Discuss and propose solutions to ongoing or potential radiological instrumentation problems and needs on site.
2. Identify new radiological instrumentation available from manufacturers that may be useful to the Hanford Site operations.
3. Oversee the procurement of the instruments and review the evaluations of the performance by contractor organizations.
4. Establish or review minimum acceptable operational criteria for portable and semi-portable radiological instrumentation used for safety on the Hanford Site.
5. Promote information exchange between contractors on radiological protection instrumentation usage and problems/resolutions.

Representatives from all of the Hanford contractors and a representative of DOE-RL are on this committee. Meetings are normally held every other month. During CY 1989 HIEC efforts were increased to attempt to better meet the needs of the Hanford Site.

TABLE 17. Portable Instrument Usage for CY 1989

Instrument Type	Kaiser		100 Area		Westinghouse 200 Area		300 and 400 Areas		PNE	
	Number of Instruments	Percent of Kaiser Total	Number of Instruments	Percent of 100 Area Total	Number of Instruments	Percent of 200 Area Total	Number of Instruments	Percent of 300 & 400 Area Total	Number of Instruments	Percent of PNL Total
ERM			1	0			10	1		
EP	8	3	320	15	1187	20	100	10	494	13
DAD/GAD	225	95	709	33	130	2	23	2	65	2
EQs			455	21	1017	27	246	21	1285	35
TPC			6	0	26	0	3	0	35	1
LPC					1	0				
HPC			20	1	42	1	34	3	4	0
XCP			8	0	20	0				
SNOOPY			9	0	69	1	32	3	40	1
PAM			132	6	930	10	150	14	610	17
LUD(a)	3	1	4	0	209	4	47	4	119	3
PNACAKE			320	15	1184	20	220	20	012	22
LLM			10	1	19	0	3	0	27	1
HRCF					4	0	1	0	3	0
BBCF			10	0	43	1	15	1	70	2
PAC-B			31	1	409	7	2	0	64	2
BWCP						5	0	2	0	170
R02			27	1			0	0	15	0
R07			12	1			0	0	15	0
EXT			19	1	4	0	5	0	4	0
HW21d			22	1	10	0	5	0	14	0
SNM ₂ (u)			3	0			164	13	0	0
TOTAL BY AREA/CONTRACTOR	230		2127		5924		1160		3607	
PERCENT OF TOTAL	2		10		45		9		20	

(a) Includes Ludlum models 177-0, 177, 177-30, 177-50, 177-52.

(b) Includes MHD470P, MHD440, Ludlum Model 3, Ludlum Model 310.

Fifteen ion chamber dose rate instruments, competitors of the CP, were ordered in CY 1987. Five Eberline Model R0-2s and five Bicron Model RS0-5s were received in late CY 1987 and CY 1988. The last 5 units (Victoreen Model 450Bs) were received in CY 1989. These 15 units continued to be evaluated by field personnel during CY 1989.

Deployment of High-Range CPs

The High-Range CP (HRCP) is an air ionization chamber with a pistol-shaped handle used to measure high levels (up to 50 krem/hr) of beta and gamma radiation. This instrument was originally designed by Instrumentation and External Dosimetry (I&ED) personnel and is now commercially available from Victoreen, Inc. In CY 1989 the only HRCP instruments that were being calibrated were those that were issued previously to the field for use and were returned for routine calibration. Other 1987 units would "freeze up" during initialization of the calibration program and would not accept the necessary calibration factors. Also, some dose rate readings would fluctuate excessively. The problem was diagnosed as a timing sequence problem and work to solve the problem was initiated by PNL personnel.

Modifications that were made to the High-Exposure Facility during 1989 will assist in the timely evaluations of these instruments.

Documentation of the History of Hanford Instruments

The document titled A Historical Review of Portable Health Physics Instruments and Their Use in Radiation Protection Programs at Hanford, 1944 Through 1988 was published in 1989 (Howell et al. 1989). This report documented the use and calibration of portable health physics instrumentation on the Hanford Site from 1944 through 1988.

Calibration of WHC 200 Area Alpha Continuous Air Monitors

For most of CY 1989, PNL continued to calibrate 25% of the WHC 200 Area alpha CAMs. A letter was distributed in September 1989 from A. J. Rizzo, Assistant Manager for Operations of DOE-RL, to J. E. Nolan, President of Westinghouse Hanford Company. In that letter, it was stated that a transfer of all Alpha CAM calibration responsibility from the 200 Areas to PNL was to take place by December 31, 1989. Efforts are currently being made to make

this transition as smooth as possible. The need to purchase 30 new Eberline Model Alpha 5A CAMs has extended the scheduled transfer date to June 1990. The number of instruments being calibrated by PNL has been increased so that 50% of the CAMs in the 200 Area were being calibrated at PNL by the end of the calendar year. A support document to assist in the transition was written and meetings were held every 2 to 4 weeks between WHC and PNL personnel to ensure that progress is being made to reach the conclusion of this task.

SUPPORT ACTIVITIES

Program support activities in two additional areas were conducted in 1989.

Linear Beta Source

The concept and new design for a $^{90}\text{Sr}/^{90}\text{Y}$ beta source holder to replace the "Fan Source" holder were developed by I&ED personnel in CY 1987. The design was slightly modified in CY 1989 to allow for a higher activity source and to ensure proper personnel protection. Based on I&ED specifications, the fabrication of 30 holders was initiated by PNL Craft Services for PNL, WHC, and several offsite DOE facilities and operations (UNC Geotech, the Savannah River Plant, the Gaseous Diffusion Plant at Paducah, Kentucky, and the Y-12 Plant at Oak Ridge, Tennessee). Figure 15 is a photo of linear beta source (in its new holder) being used to field test a CP instrument

R. A. Stephen Pocket Alarming Dosimeters

I&ED personnel calibrated and acceptance tested 290 R. A. Stephen pocket alarming dosimeters (see Figures 16 and 17) during CY 1989. Of these units, 250 were distributed to WHC for use in the 100 Area and 40 units are being used by KEH. Two programmers for each company were also acceptance tested and sent to the field for use.

FIGURE 15. Field Testing a CP Instrument Using Linear Beta Source
(in its new holder)

FIGURE 16. Pocket Alarming Digital Dosimeter with Controller. Dosimeter controller reads and prints all dosimetry information and is used to program dosimeter operational parameters.

FIGURE 17. Pocket Alarming Digital Dosimeter
(with dime to show relative size)

PUBLICATIONS

One program-related publication was issued during 1989:

1. Howell, W. P., C. D. Corbit, J. L. Kenoyer, L. V. Zuerner, M. L. Kress, D. M. Fleming, K. L. Swinth, and H. W. DeHaven. 1989. A Historical Review of Portable Health Physics Instruments and Their Use in Radiation Protection Programs at Hanford, 1944 Through 1988. PNL-6980, Pacific Northwest Laboratory, Richland, Washington.

PRESENTATIONS

The program-related presentations made during 1989 are listed here.

1. Fleming, D. M., and J. L. Kenoyer. 1989. "The PNL Calibration Facility." Paper presented at the Annual Health Physics Society Meeting, June 25-29, 1989, Albuquerque, New Mexico.
2. Fleming, D. M. 1989. "Health Physics Instrumentation at Hanford." Paper presented at the DOE and DOE Operating Contractor Radiation Protection Conference, January 31-February 3, 1989, Albuquerque, New Mexico.

PROGRAM-RELATED PROFESSIONAL ACTIVITIES

The program-related professional memberships of the staff during 1989 are listed here.

1. D. M. Fleming--Member of Task Group 4, writing a National Council on Radiation Protection and Measurements (NCRP) Handbook titled "Calibration of Survey Instruments for the Assessment of Ionizing Radiation Fields and Radioactive Surface Contamination."
2. D. M. Fleming--Member of the ANSI Working Group N42.17, writing three standards entitled "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Normal Environmental Conditions," "Performance Specifications for Health Physics Instrumentation-Occupational Airborne Radioactivity Monitoring Instrumentation," and "Performance Specifications for Health Physics Instrumentation-Portable Instrumentation for Use in Extreme Environmental Conditions."
3. J. L. Kenoyer--Consultant to the ANSI Working Group N42.17, writing the same three standards listed above under item 2.
4. F. E. Owen--Member of the Working Group American Nuclear Society/Health Physics Society Standards Committee (ANS/HPSSC) ANSI 6.8, writing the standard titled "Area and Process Monitors."

RADIATION STANDARDS AND CALIBRATIONS PROJECT

The Radiation Standards and Calibrations Project maintains radiological calibration standards, special instrument and dosimeter response-characterizing equipment, and calibration data-handling equipment at Hanford. This activity provides the means to characterize response to various radiation fields encountered at Hanford and ensures that calibration fields are described in accordance with recommended standards and guides. This activity includes QA responsibilities for routine calibration of instruments and dosimeters. The project routinely

- reviews calibration standards, regulations, and handbooks
- ensures that the calibrations procedures used are in agreement with technically accepted methods
- maintains basic radioactive sources and instruments that serve as radiological standards
- provides traceability of the calibration sources to the NIST
- maintains a data management system for instrument repair and calibration records.

Project activities conducted during CY 1989 are discussed in the following subsections.

ROUTINE PROGRAM

Two major functions comprise the project's routine program: 1) maintenance of standards and capabilities, and 2) maintenance of the data management system. These functions and any related improvements are discussed in the following subsections.

Maintenance of Standards and Capabilities

Various radioactive sources and radiation-generating devices are used routinely for dosimeter and instrument calibrations. The "maintenance of standards" task provides for NIST-traceable calibrations of the sources used in calibrating radiation detection devices and dosimeters. Room 106 in the 318 Building houses a pneumatic source transfer and storage system, commonly called a Rabbit system, which contains ^{137}Cs and ^{60}Co photon sources and two

levels of ^{252}Cf neutron sources used for low-scatter irradiation geometries. Room 6, in the basement of the 318 Building, houses an x-ray machine that can perform the majority of NIST-specified x-ray techniques. The photon sources are calibrated periodically. Each source is measured in the most commonly used geometries. During 1989 agreement among the measurement data was within $\pm 2\%$ of the values expected due to decay of the sources, or, in the case of the x-ray machine, to NIST-published data. Calibration checks of the ^{252}Cf sources are performed by comparing them with a plutonium-beryllium (Pu-Be) source. Reference calibration data were collected in 1989 to allow for the use of the free-field Pu-Be neutron spectrum as the source standard.

A high-level photon irradiator is housed in Room 8 of the 318 Building. The system consists of a highly shielded source-storage mechanism, a turntable for source selection, a closed-loop source-transport system, and a well-collimated irradiator with a conical beam port. The selected source is transported pneumatically to the irradiation position. An operational control panel is positioned outside the irradiation room and is well shielded against radiation exposure. A rail system is installed as a trolley support track over a 6-m range on the floor parallel to the beam axis. A laser, centered on the beam axis, is intersected by a cross laser at the 100-cm distance to provide alignment capabilities. All four sources in the high-level irradiator are calibrated annually. Measured exposure rates in 1989 were within tolerance of the values (2%) expected due to decay of the sources. The calibration measurements are performed using measurement and test equipment that have certified traceability to NIST. In 1989 a new lead collimator was fitted to the high-level irradiator. Measurements were made to determine the dose reduction factor for two of the installed sources with the conical-shaped attenuator placed in the irradiator port. The irradiation geometry necessary to achieve 1-mR/hr and 10-mR/hr exposure rates using these sources were also determined.

Room 113 of the 318 Building houses a set of Buchler secondary beta standards (^{204}Tl , ^{147}Pm , $^{90}\text{Sr-Y}$) contained in a semi-automated irradiation jig system. Irradiations are performed in support of the Hanford personnel dosimetry program, as well as a number of other DOE-sponsored projects.

Exposure rates of the sources measured in 1989 were consistent with expected results, corrected for decay.

Four wells containing isotopic sources are housed in Room 121 of the 318 Building. These wells are used primarily in the routine calibration program for portable instruments. Computer programs are used to control a trolley system that moves the source vertically to any desired point within the 9-m depth, based on the calibration of the wells. The programs allow for selection of either the desired exposure, the dose-equivalent rate, or the distance with known rate. The program is also capable of stepping through the exposure rate points of the desired instrument calibration with only minimal operator involvement. The distance from the plane of the well's surface to the detector center is entered as an offset and is included in the selected overall distance. All wells receive extensive annual calibration in addition to the less extensive quarterly calibration checks that are directly related to routinely used instrument calibration points. No unusual variances were observed from the expected decay of source emissions due to isotopic half-lives in 1989.

Improvements to the Maintenance of Standards and Calibrations Functions

The new ^{252}Cf source was received from NIST and successfully placed into the Room 106 Rabbit system. The report of calibration of the source was also received from the NIST in late December. The data were used to calculate expected dose equivalent rates from the source in both the moderated and unmoderated configurations. Verification of the calculated rates using a total dose meter, tissue-equivalent proportional counter, a ^3He tube, and TLDs will continue into 1990. Initial data indicate that agreement between the spectra of the old source and the new one is excellent. It is expected that the new source will be available for routine DOELAP and NAVLAP irradiations by the middle of January 1990. The new source represents a considerable improvement in capabilities. The dose equivalent rates of this source, both in the moderated and unmoderated configuration are approximately 10 times higher than those of the old source. The replaced source is expected to be moved into one of the isotopic wells in Room 121 sometime in 1990; it will be used for some of the lower-level routine instrument calibrations.

A major redesign of the north irradiation station in Room 106 was planned to begin in 1989. However, J. J. Fix of the Hanford External Dosimetry Program requested that the tower in the low-scatter room be used (instead of the north station) to irradiate Hanford dosimeters in order to be consistent with DOE LAP criteria. The tower is presently used for all other DOE LAP irradiations. In view of this change, reconstruction of the north station was cancelled. Plans are under way to use the north irradiation station as a port for maintenance of the radiation sources stored in the pneumatic system.

A 5-Ci ^{241}Am irradiator was received as a backup to the x-ray machine for 59-keV photons. Characterization of the irradiator's spectrum and radiation output were begun late in 1989.

Maintenance of the Data Management System

Maintenance and updating of the process-control system, including the Hewlett Packard (HP)-9000 computer, its peripherals, and the data management software comprise the data management system.

Improvements to the Maintenance of the Data Management System Function

The HP-9000 Model 560 computer was upgraded to a Model 825. This upgrade is fully supported by Hewlett-Packard and represents a considerable improvement in speed of operation over the previous model. The instrument database and most other programs supported on the Model 560 were successfully moved to the upgraded system.

The database software was modified several times during the year. A database was created for tracking pencil dosimeters. The "MAIN" program was modified to handle air monitors and nuclear criticality detectors. The "BILLING" program was expanded to include more instruments and a few new instrument locations were added. The instrument conversion routine was not updating the manual master entry; this problem was corrected.

SUPPORTING INVESTIGATIONS AND STUDIES

Three special studies were performed to help improve the QA programs for dosimeter and instrument calibrations.

Measurement Quality Assurance for Photon Beams

In order to verify the consistency (or traceability) of PNL calibrations measurements with national standards, the Radiation Standards and Calibration Project participated in a measurement quality assurance (MQA) program for photons with NIST. Under this program, NIST sent PNL a high-quality transport ionization chamber whose response to radiation was not known by the project staff. The project staff then determined the response (signal per unit of radiation) for the transfer standard and reported the results. NIST then provided a report of the ratio of the project's measured response obtained with the national standard. Verification of photon beam half-value-layers and homogeneity coefficients with accepted values was also performed during the MQA interaction with NIST. This process is carried out periodically to assure that the project's measurements stay within agreed-upon control limits (usually 2%). In 1989 agreement with published NIST values was within 1%, with the exception of the M30 x-ray beam where there was a 4% variation. This low-energy x-ray beam is particularly hard to standardize between laboratories. Discussions with NIST determined that this difference was probably influenced by the chemical composition of filtration material used by both the NIST and PNL for this beam. Work to resolve this issue continued through the end of the year.

Measurement Quality Assurance for Beta Irradiations

Arrangements were made in 1989 with NIST to initiate beta MQA testing. The testing protocol is similar to that described above for photons. The necessary beta detection instrumentation will be shipped from NIST to PNL in early 1990 so that the testing can begin.

Evaluation of Instrument Bar Code Labels

Work continued on the feasibility of using bar code labels to identify instruments. Two bar code readers were received for use with the pencil dosimeter program. A bar code printer was also received. Further work in this area is expected to continue in 1990.

HANFORD RADIOLOGICAL RECORDS PROGRAM

The Hanford Radiological Records Program supports the DOE-RL and Hanford contractor radiation protection programs by preserving and administering radiological exposure records for all Hanford workers and visitors, past and present. The program is also responsible for the Hanford Radiation Protection Historical Files and the Hanford Radiological Incident File (Incident File). Program personnel operate the computer systems and equipment necessary to input, store, and retrieve the records and produce the required records.

The records program utilizes the ORE system, which includes a database with the personnel exposure data that are readily retrievable via a system of PCs. The ORE system also includes all of the supporting exposure documentation on microfilm that is indexed into a computer-assisted retrieval (CAR) system. The CAR system allows for rapid retrieval of the documents for any individual using identifiers, including payroll number, social security number, and/or name.

The historical records include documents such as policies, procedures, reports, important communications, etc., that define the Hanford radiological dosimetry and protection programs during its history. The historical records are microfilmed and indexed into a second CAR system. These records are retrievable by author, date or range of dates, document number (if applicable), title, and up to three keywords.

The Incident File contains a record of all available radiological incidents that have occurred at Hanford since 1945. They are located in the Radiological Records Library in a chronological file.

The program is operated under the applicable sections of ANSI N13.6-1972 (1972), DOE Orders 130D.1, 1324.2A, 5480.11, and 5484.1 Chg 3 (1980, 1988b, 1988a, 1987c) as assigned by the Hanford Site Services Handbook (DOE-RL 1983). The program also complies with the applicable sections of the Privacy Act (1974) and the Freedom of Information Act (1966).

ROUTINE PROGRAM

The Hanford Radiological Records Program is organized in three major functional areas: data handling, report issuance, and the library. The data handling function provides for the entry of data elements into the ORE database and for the validation of all data entry. Validation is accomplished by establishing audits to be matched to entries of results, resolving unmatched results, and interacting directly with contractor personnel.

The report issuance function provides for generation and issuance of routine exposure status reports to the contractors, quarterly man-rem and annual statistical reports to DOE, annual reports to employees, and special reports requested by former employees, as well as those requested by the contractors and DOE-RL. Both the data handling and report issuance functions are performed by the Radiological Records data processing center. This function requires close liaison with DOE-RL, the contractors, and other personnel dosimetry functions.

The library function provides for the maintenance of the individual exposure records that are not reducible to database elements as well as the Historical Files and Incident File. The library staff file and retrieve current hard-copy documents, prepare documents for long-term storage, and track and account for the documents through the microfilming and indexing process. The library contains the individual exposure record documentation for all Hanford personnel since 1945 (almost five million microforms). There are also some exposure records remaining from the DuPont era. These and the Historical Files microforms are retrievable through two CAR systems that are maintained by the library staff.

Although the results from the dosimeter and excreta processing, as well as the in vivo counts, are received by electronic transmission or magnetic tape, much of the data that are placed in the records are received in hard-copy form. These data are entered manually by the data processing center staff. The hard copies are then sent to the library for entry into the CAR system. Table 18 presents CY 1989 statistical information on many of the documents that are entered into the database and microfilmed and indexed into the CAR system.

TABLE 18. Records Activity for CY 1989

<u>Document</u>	<u>Number</u>
Personal Radiation Exposure History Form (used to document exposure history prior to Hanford and exposure record for new employee)	3,502
Employee and Dosimetry Change Forms (used to document personnel or dosimetry changes)	3,223
Employee and Dosimetry Change Forms (used to document employee terminations)	2,768
Temporary Dosimeter Assignment Forms (used for visitors and employees who forgot their dosimeters)	16,939
Investigation of Dosimeter Result Forms (used to estimate exposure for lost, damaged, or otherwise suspect dosimeter results)	1,872
Special Process Forms (used to document data for specially processed dosimeters)	4,125
Request for Special Excreta Sample Analyses (used to initiate the collection of samples for analysis)	2,912
Request for Exposure Summaries (used to request summaries for current and prior Hanford employees)	1,392
Letters Sent to Request Prior Exposure (used to request summaries for new employees with prior exposure)	630
Microfilm reels indexed into a CAR system (personnel and historical documents; each reel contains over 2000 images)	40

Changes to the Routine Program

The new order, DOE 5480.11 (DOE 1988a), became effective January 1, 1989. This required a number of changes in the routine program. The changes included: 1) the summation of internal and external effective dose equivalents, 2) the requirement for a termination letter, 3) changes to the annual report card, and 4) changes to the Radiological Exposure Information Reporting System (REIRS) report format. Other changes to the routine program included adding a second address (in addition to the bioassay address) to the ORE

database and including invalid in vivo counts in the ORE record. A program manual was produced and issued.

Summation of Internal and External Effective Dose Equivalents

DOE 5480.11 (DOE 1988a) requires that: "the annual effective dose equivalent shall be determined by summing the annual effective dose equivalents from internally deposited radionuclides and from external exposure to radioactive material and/or radiation generating devices...." To incorporate this requirement the ORE database was programmed to add any internal effective dose equivalent to the external effective dose equivalent after January 1, 1989. The annual internal effective dose equivalent from depositions in prior years is calculated by Internal Dosimetry for the upcoming calendar year and is entered into the individuals' records on or about the first day of the new calendar year. For depositions that occur during the year the effective dose equivalent for the remainder of the calendar year is calculated by Internal Dosimetry and entered into the individual's record.

Termination Letter

DOE 5480.11 (DOE 1988a) states that: "records of exposure ... should be provided for terminated employees as soon as the data is available but within 90 days of termination." A termination letter was programmed into the ORE database and letters are issued to personnel upon termination of their dosimetry requirement. The wording of the original letter was modified to note that the letter was for termination of dosimetry; not necessarily for termination of employment. This was done because personnel going on leaves of absence were receiving the letters and were concerned that they were actually being terminated. The letter as finally configured is shown in Figure 18.

If an individual has had an internal deposition, the Internal Dosimetry group attaches an additional page to the letter describing the results of his evaluation. The attachment includes annual effective dose equivalents for 50 years and the committed effective dose equivalent.

Annual Report Card

In previous years the annual report card included only the annual whole body, skin of the whole body, and extremity dose in rem. DOE 5480.11 (DOE

PACIFIC NORTHWEST LABORATORY

REPORT OF HANFORD OCCUPATIONAL RADIATION EXPOSURE STATUS
CALENDAR YEAR 1989

THIS REPORT INCLUDES ALL OCCUPATIONAL RADIOLOGICAL EXPOSURE RECEIVED WHILE AN EMPLOYEE OF DOE-RL AND/OR ONE OR MORE DOE-RL HANFORD CONTRACTORS AND IS PROVIDED TO YOU AS REQUIRED BY DOE ORDER 5480.11.

<u>NAME</u>	<u>ORG CODE</u>	<u>PAYROLL NUMBER</u>	<u>SOC SEC NUM</u>
I M EMPLOYEE	00000	00000	000-00-0000

PREPARED FOR

HANFORD CONTRACTOR

	<u>RADIOLOGICAL EXPOSURE DATA (DOSES IN MREM)</u>			
	(1) <u>WHOLE BODY</u>	<u>SKIN WHOLE BODY</u>	(2) <u>EXTREMITIES</u> <u>HANDS</u> <u>FEET</u>	
(3) DOSE FOR 1989	10	10	10	10
(4) DOE ANNUAL DOSE STANDARD	5000	50000	50000	50000
(5) LIFETIME WHOLE BODY DOSE	560			

*0" DOSE IS DEFINED AS A DOSE BETWEEN 0 AND LESS THAN 5 MREM

- (1) THE ANNUAL WHOLE BODY DOSE FOR THE YEAR INCLUDES THE EXTERNAL DOSE PLUS ANY INTERNAL DOSE RECEIVED DURING THE YEAR.
- (2) EXTREMITIES ARE RECORDED AS; HANDS AND FOREARMS BELOW THE ELBOW, FEET AND LEGS BELOW THE KNEES.
- (3) THE AVERAGE WHOLE BODY DOSE FROM NATURALLY OCCURRING RADIATION TO ALL UNITED STATES CITIZENS IS 300 MREM PER YEAR, BASED ON A PUBLICATION FROM THE NATIONAL COUNCIL ON RADIATION AND MEASUREMENTS.
- (4) DOE ANNUAL DOSE STANDARD IS THE MAXIMUM ALLOWABLE DOSE IN A CALENDAR YEAR.
- (5) THE LIFETIME WHOLE BODY DOSE INCLUDES ALL EXTERNAL DOSE RECEIVED AT HANFORD PLUS ANY INTERNAL DOSE RECEIVED SINCE JANUARY 1, 1989.

QUESTIONS REGARDING INFORMATION PROVIDED HEREIN SHOULD BE BROUGHT TO THE ATTENTION OF: DOSIMETRY 373-2295

FIGURE 18. Termination Letter

1988a) requires that a summary of annual, cumulative, and committed effective dose equivalent shall be provided to each radiation worker on an annual basis. The new annual report card was programmed to include the annual doses for whole body (effective dose equivalent), skin of the whole body, and extremities (broken down to hands and feet) in millirem. It was decided that, because the skin and extremity dose had been reported on previous report cards this practice should continue. It will also list the lifetime whole body dose, which is defined as all external dose received at Hanford plus any internal dose received since January 1, 1989. It was decided that this definition would create less concern for the workers than using the DOE 5480.11 (DOE 1988b) definition: "the cumulative effective dose equivalent is the sum of the annual effective dose equivalents for each year of employment since the effective date of the order." The annual report card will continue to be provided to all personnel that are issued dosimeters, as has been the practice in the past; not to only radiation workers as required by the order.

The committed effective dose equivalent is not included on the report card because of a decision made by the HPDAC at its May 4 meeting.^(a) Due to the definition of committed effective dose equivalent it will only be reported for the year in which the deposition occurs. This practice was considered sufficient to meet the requirement of the order. The contractor reports the deposition results, including the committed effective dose equivalent, directly to the employee receiving the deposition.

A copy of the annual report card is shown in Figure 19.

REIRS Changes

DOE 5484.1A Chg 3 Attachment 8 (DOE 1987), had several items listed for the REIRS report that had been deferred pending issuance of DOE 5480.11 (DOE 1988b). These deferred items were planned for inclusion in the CY 1989 REIRS report. The items included: 1) total annual effective dose equivalent,

(a) Fix, J. J. 1989. "Minutes of Hanford Personnel Dosimetry Advisory Committee Meeting on May 4, 1989." Letter to Distribution, dated May 9, 1989. Copy in the Hanford Radiation Protection Historical Files, Pacific Northwest Laboratory, Richland, Washington.

PACIFIC NORTHWEST LABORATORY
P. O. BOX 999
RICHLAND, WASHINGTON 99352

REPORT OF TERMINATION OF OCCUPATIONAL RADIOLOGICAL
MONITORING OF HANFORD EMPLOYEE

THIS REPORT INCLUDES ALL OCCUPATIONAL RADIOLOGICAL EXPOSURE RECEIVED WHILE AN EMPLOYEE OF DOE-RL AND/OR ONE OR MORE DOE-RL HANFORD CONTRACTORS AND IS PROVIDED TO YOU AS REQUIRED BY DOE ORDER 5480.11. IT IS YOUR RECORD OF RADIOLOGICAL EXPOSURE RECEIVED AT THE HANFORD DOE FACILITIES. IT SHOULD BE RETAINED FOR YOUR RECORDS. IT MAY BE USED TO PROVIDE FUTURE EMPLOYERS A RECORD OF YOUR HANFORD EXPOSURE. THIS REPORT IS NOT A NOTIFICATION OF TERMINATION OF EMPLOYMENT AT HANFORD, BUT A NOTICE OF TERMINATION OF DOSIMETRY MONITORING.

<u>NAME AND ADDRESS</u>	<u>SOC SEC NUM</u>	<u>BIRTH DATE</u>	<u>REPORT DATE</u>
I M EMPLOYEE P.O. BOX 000 ANYTOWN WA 00000	000-00-0000	00-00-00	00-00-00

PERIODS OF EXPOSURE

• 00-00-00 TO 00-00-00

RADIOLOGICAL EXPOSURE DATA (DOSES IN MREM)

	<u>WHOLE BODY*</u>	<u>SKIN</u>	<u>EXTREMITIES** HANDS</u>	<u>FEET</u>
CURRENT QUARTER	0	0	0	0
CURRENT YEAR	0	0	0	0
CUMULATIVE	0	0	0	0

"0" DOSE IS DEFINED AS A DOSE BETWEEN 0 AND LESS THAN 5 MREM

*WHOLE BODY DOSES ARE EFFECTIVE DOSE EQUIVALENT, WHICH INCLUDES ALL EXTERNAL EXPOSURE PLUS INTERNAL EFFECTIVE DOSE EQUIVALENT ONLY SINCE JANUARY 1, 1989. ALL OTHERS ARE DOSE EQUIVALENT.

**EXTREMITIES ARE RECORDED AS HANDS AND FOREARMS BELOW THE ELBOW AND FEET AND LEGS BELOW THE KNEES.

INTERNAL DOSES [] WERE [X] WERE NOT RECORDED DURING THE PERIOD COVERED BY THIS REPORT. IF INTERNAL DOSES WERE RECORDED PLEASE SEE THE ATTACHED SHEET.

PACIFIC NORTHWEST LABORATORY MAINTAINS THE OCCUPATIONAL RADIOLOGICAL EXPOSURE RECORDS FOR ALL EMPLOYEES OF HANFORD DOE FACILITIES. FOR FURTHER INFORMATION PLEASE CALL (509) 376-6342.

BARBARA M. OAKLEY, TECHNICAL SPECIALIST

FIGURE 19. Annual Report Card

2) internal annual effective dose equivalent, including year of uptake and radionuclides, and 3) annual extremity dose reported as a) forearms and hands and, b) lower legs and feet.

Second Address Field

To accommodate the termination letter a second address was programmed into the ORE database. This was required because the only address previously available was the bioassay address, which is not always the same as the mailing address. The new mailing address is updated weekly from the contractors' payroll systems, which are updated by the contractor dosimetry personnel. This change reduced the number of undeliverable termination letters due to incorrect addresses.

Invalid In Vivo Results

The in vivo data entering the ORE database from the WBC now include all counts that were made, including invalid counts. The invalid counts do not have any results showing in the database. They show the date, time, and the reason the count was invalid. This change was made at the request of WHC, whose employees were complaining that they had several counts but only one was recorded in the records. Several counts often result from having to recount for various reasons.

Program Manual

The Radiological Records Program staff completed and issued PNL-MA-553, Hanford Radiological Records Program Manual. This manual documents the operation of the Hanford Radiological Records Program, which is operated for DOE-RL. The program has not had this type of documentation in the past.

SUPPORTING TASK

The four-phase redevelopment of the ORE system is the only supporting task under this program in 1989.

Lyon et al. (1989) discussed a report recommending the redevelopment of the ORE system, noting that the effort would not be pursued during FY 1989 due to budget constraints. Allocations were approved for FY 1990 for the start of

the redevelopment effort, which is expected to take over 2 years. The four sequential phases of the redevelopment effort are defined as follows:

1. Systems Requirements Analysis--This analysis will define the new system objectives and produce a document that will be used to design and construct the new system.
2. Preliminary Design--This step in the redevelopment follows and is based on the requirements analysis. It includes:
 - development of the functional specifications for the new system
 - analysis of alternatives
 - production of a preliminary design document
 - final analysis of cost/benefit
 - development of schedules and plans for the detailed design and construction, verification, installation, and startup phases.
3. Detailed Design and Construction--This phase includes the detailed design and programming of the new system defined in the previous two phases and is expected to take at least 12 months.
4. Certification and Implementation--This phase includes conversion of data from the old system to the new system and certification that the installation is correct. Parallel runs of the old system and the new system will be conducted as part of the certification process. Training of records personnel and users is included in this phase.

PROGRAM-RELATED PROFESSIONAL ACTIVITIES

The program-related professional memberships of the staff during 1989 are listed here.

1. Lyon, M.--Chairman of Health Physics Society Standards Committee Working Group to review ANSI N13.6, American Standard Practice for Occupational Radiation Exposure Records Systems.

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