

Current Programs for Estimating Radiological Dose and Chemical Exposure

Volume I

Section I • General

Section II • Programs for Estimating Radiological Dose



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**Centers for Disease Control and Prevention
Department of Health and Human Services**

**Center for Epidemiologic Research
Oak Ridge Associated Universities**

March 31, 1997

***Current Programs for Estimating
Radiological Dose and Chemical Exposure***

Volume I

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Section II • Programs for Estimating Radiological Dose

by

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Foreward

In response to heightened worker awareness and concern regarding possible associations between occupational exposures and disease, it is becoming increasingly important to provide adequate worker exposure surveillance and to store and maintain results generated from such surveillance so the results are available for review and analysis. Because the significance and interpretation of results depend so heavily on the instrumentation and methodology associated with the monitoring event and sample analysis, it is equally important to document these components. Since late 1990, the National Institute for Occupational Safety and Health (NIOSH) has become increasingly involved with the health and safety of the Department of Energy (DOE) nuclear facility workers. In this new role, NIOSH is expending considerable effort and funding toward understanding the history of the DOE nuclear facilities activities and preparing for a greater participation by a broad set of researchers in future activities. To this end, NIOSH awarded Oak Ridge Associated Universities/Center for Epidemiologic Research (ORAU/CER) a grant to evaluate the current exposure monitoring programs and the uses of monitoring data at the Y-12 Plant in Oak Ridge, Tennessee, in a manner that will be useful to future researchers conducting epidemiologic studies at this facility. ORAU/CER researchers have been involved in DOE worker studies for nearly two decades and have had a particularly close involvement with the Y-12 plant through the completion of a number of peer-reviewed journal articles dealing with both radiation and chemical hazards present in the facility. The products of this work are these two volumes that describe in detail the programs that generate or derive data that may be used for assessment of workers' exposure to radiation or chemical hazards. Information included are (1) the purpose(s) of each program and the present utilization of measurements generated by each program; (2) populations or areas monitored in each program and the algorithm or logic used for selection of monitored participants or areas; (3) relative costs of each program; and (4) major advantages and disadvantages of each program relative to utilization of program data for exposure evaluation. Special emphasis is placed on the use of the programs' results. Recommendations are made, if indicated, relative to improvement in the use or quality of the data for exposure or dose estimates.

It is proposed by the authors that the value of these volumes is significant as both a current resource and as an archive. During the past 20 years, a great amount of detective work and resources were expended by researchers at ORAU/CER and other institutions in discovery and retrospective evaluation of exposure monitoring programs at many DOE nuclear facilities for the purpose of conducting occupational health studies. Resources were also expended by the nuclear facilities to locate resource documents and to provide qualified personnel to interpret data and answer questions posed by hazards assessment research personnel. As the number of researchers involved in prospective and

retrospective health and hazard evaluation increases through NIOSH intramural and extramural funding programs in the future, nuclear facility personnel may be taxed to their limit in their ability to assemble and disseminate information. It is hoped that these volumes may serve as a starting place for discussions with new researchers and may assist the facility personnel by documenting the answers to many of the questions that will be asked routinely. If thorough documentation of past monitoring programs had been available similar to the present volumes, a very large savings in time, effort, and cost would have been realized. It is expected that the present volumes will find use as technical references and as tools in occupational health studies and will increase in value with time.

ACKNOWLEDGMENTS

The authors would like to acknowledge the contributions of all the Y-12 Plant employees that were contacted as shown in the Personnel Resources Listing. All made unique contributions to our knowledge of Y-12 programs so that they could be adequately and accurately reported in these volumes. We are especially appreciative of the support of Ron Keyser who was our primary contact at the Y-12 facility and to Bobby Bowers, Kem Branum, Tim Denton, Rich Hamby, Jim Hendershot, Laura Schwanke, Joe Sherrill, and Lisa Snapp for the substantial efforts they made to assist us in gathering the information that went into these reports. In addition, we are appreciative to Donna Cragle, Lisa Larmee, and Jolene Jones of the ORAU/CER staff for the administrative, editing, and clerical support given in this effort.

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LIST OF ACRONYMS

ALARA	-	As Low As Reasonably Achievable
ANSI	-	American National Standards Institute
ASO	-	Analytical Services Organization
CAM	-	Continuous Air Monitor
CDC	-	Centers for Disease Control
CEDE	-	Committed Effective Dose Equivalent
CEDS	-	Centralized External Dosimetry System
DAC	-	Derived Air Concentration
DEC	-	Digital Equipment Corporation
DOE	-	Department of Energy
DOELAP	-	Department of Energy Laboratory Accreditation Program
FNAD	-	Fixed Nuclear Accident Dosimeter
IH	-	Industrial Hygienist or Industrial Hygiene
IHD	-	Industrial Hygiene Department
LCL	-	Lower Control Limit
LEGe	-	Low Energy Germanium (detector)
LLNL	-	Lawrence Livermore National Laboratory
LMES	-	Lockheed Martin Energy Systems, Inc.
MDA	-	Minimum Detectable Activity or Amount
NIST	-	National Institute of Standards and Technology
OHIS	-	Occupational Health Information System
ORAU	-	Oak Ridge Associated Universities
ORNL	-	Oak Ridge National Laboratory
PAV	-	Plant Action Value
PCM	-	Phase Contrast Microscopy/Microscope or Personnel Contamination Monitor
PEL	-	Permissible Exposure Limit
PMI	-	Personnel Monitoring Instrument
QA	-	Quality Assurance
QC	-	Quality Control
RADCON	-	Radiological Control
RCO	-	Radiological Control Organization
RCT	-	Radiological Control Technician
RL	-	Reporting Level
RWP	-	Radiological Work Permit
TEDE	-	Total Effective Dose Equivalent
TLD	-	Thermoluminescent Dosimeter
UCL	-	Upper Control Limit
WORM	-	Write Once Read Many

FORWARD AND GENERAL REPORT

INTRODUCTION

This report pertains to research performed by Oak Ridge Associated Universities (ORAU) for the U.S. Centers for Disease Control and Prevention (CDC) under Grant R01/CCR412029-01. This research included three distinct projects. The two volumes, where the present report resides, are the physical products resulting from Task 1 of the grant; hence, the work performed for this portion of the grant will be referred to as Task 1.

There are three purposes for this General Report. First, the report summarizes the efforts expended toward collection, analysis, and presentation of information on all monitoring programs currently installed at the Y-12 Plant in Oak Ridge, Tennessee, that may generate data useful for health and safety activities or studies. Secondly, the report presents general or collective information that is more effectively and efficiently presented in a single report rather than distributed among the 15 specific monitoring program reports. Thirdly, the report provides an overall evaluation of the use and quality of the exposure monitoring program results.

SUMMARY OF TASK 1 EFFORTS

The information generated for Task 1 is divided into two volumes. Volume I includes this report and all reports that relate specifically to the Radiological Control (RADCON) Department Programs used to estimate doses to ionizing radiations or radioactive material. Volume II includes all reports that relate to Industrial Hygiene Department (IHD) Programs used to estimate exposures to chemical toxicants. There are also two reports in Volume II that describe programs that relate to both ionizing radiation and chemical toxicants. Each volume contains a Table of Contents, List of Acronyms, and List of References.

In gathering the information necessary to prepare the 16 reports describing and analyzing 39 monitoring programs, approximately 2,000 pages of documentation (procedures, reports, manuals, etc.) were collected. The pertinent parts of each document were reviewed. A listing of these resources is included as a part of each volume. In addition, 260 interviews or telephone queries were conducted with 52 persons to collect or verify the information included in these reports. For additional assurance that the reports accurately represent the monitoring programs described, all draft reports were sent to the IHD and RADCON Department for review and comment. Comments were evaluated and

incorporated as appropriate in the final reports.

GENERAL RESPONSES TO TASK I COMMITMENTS

Some commitments made by ORAU in the response to CDC Program Announcement 534 can be more effectively met in this report than within the other 15 individual reports. Among these are the commitments to discuss (1) the strengths and weaknesses of the various programs for evaluating dose or exposure; (2) meaningful approaches for extrapolating dose or exposure information from available periods and not available periods, or from persons for whom it is available to persons for whom it is not available; and (3) other ways that data generated from these programs can be utilized to estimate exposure or dose. Each of these commitments is discussed separately in the sections below.

Strengths and Weaknesses of Methods for Estimating Dose or Exposure

Presently, dose or exposure are not being estimated from any of the surface contamination monitoring programs reported in these volumes. Also, no estimates are being made from any air samples other than those collected with personal air samplers. The programs that are not being used to estimate dose or exposure are included in this report because it is possible to use the results from these programs as dose or exposure indices if the need for the estimates justifies the required time and effort.

As will be noted in many of the reports that follow, there is a scarcity of monitoring information available on many of the potential exposures at the Y-12 Plant. Because of known cases of disease caused by occupational exposure to beryllium, an effort is presently being made by ORAU and Y-12 staff to relate air samples collected in beryllium areas to workers in those areas. The chief advantage of using area air and surface smear results to estimate exposure is in many situations these are the only results available and, therefore, would serve as the best available index of exposure. In addition, these samples are relatively inexpensive to collect and analyze. The disadvantage of using such results as exposure indices is the difficulty in associating individual employees with specific areas where the air or surface samples were collected. Typically, areas have been designated by location within buildings while employment records on workers are maintained by job classification (job title, job code, and department number).

It is important, particularly for historical periods, that department names are not maintained within the employee work history database and are not readily available. Y-12 department names were previously linked with department numbers by ORAU with the expenditure of

considerable effort and funding. While department names are quite useful in epidemiologic studies for linking individuals with monitoring data, only in rare instances are the department names descriptive as to building location.

Even if the association between air sampling results and persons is achieved, there remains the significant question of how well air sampling results represent the exposure potential to the individual employees. In the case of surface smear analyses, an additional disadvantage is that the association of personal exposure with removable contamination levels can only be established within wide limits. The association between direct measurement of fixed plus removable contamination and personal exposure is even more difficult to ascertain.

There are two means of directly measuring exposure to radiation or radioactive materials: (1) the badge meter for external radiation, and (2) *in vivo* monitoring for internal exposure to the lung. A major advantage of both of these methods is that the generated results are specific for individual workers. Consequently, no linking procedures or dosimetry algorithms are necessary. Another important advantage of direct measurement methods is they can furnish quick results when the individual is involved in an incident. The *in vivo* results are available as soon as the measurement is finished, and the meter badge can be processed within hours.

A significant disadvantage of *in vivo* monitoring is that currently available gamma spectrometry devices lack the sensitivity to measure uranium (the major potential internal exposure element in Y-12) at the level required by the present DOE directives. Another disadvantage of *in vivo* monitoring is that it is only capable of measuring U^{235} and U^{238} progeny, while U^{234} is the source of some (most, in many situations) of the radiation from the uranium exposure of greater importance. Yet another disadvantage is that the *in vivo* methods measure the radiation from all sources in the chest, not only that from the lungs.

Advantages of the external radiation meter badge are that it is relatively inexpensive, and, perhaps more significant, it provides continuous work place monitoring, therefore, if worn as prescribed, an integrated dose. The major disadvantage of the meter badge is it monitors only a small portion of the body. If the radiation dose to the portion of the body monitored is not representative of the total body, the measurement will be in error.

In other personnel monitoring programs, measurements are made on either urine or blood for the contaminant of interest or some associated material. The levels measured are then used as dose or exposure indices for the contaminant. Major advantages of this approach are that (1) it is specific for individual workers; (2) it is a means to monitor large populations

with little expenditure of employee time; and (3) it is relatively financially inexpensive as compared to personal air samples. A major disadvantage of this method is the usual relatively large variance in the association between the measured material and the actual dose or exposure. This discrepancy is caused by such factors as differences in biological parameters for different persons, variations in the time between exposure and sampling, and variations in doses among individuals receiving the same exposure because of differences in particle size, material solubility, breathing rate, excretion rate, and so forth.

Except for mercury urinalyses and blood lead analyses, all IH personal measurements are made with personal air samples. This approach has two major advantages: (1) results are worker specific, and (2) difficulties in associating area or operational samples with individuals are eliminated. The major disadvantages of personal air sampling are (1) only an extremely small percentage of the total individual work time is sampled, and (2) the extreme cost in time and money to collect a significant number of samples. Consequently, the personal air monitoring program either must be very expensive or must accept results and make decisions based on an extremely small sample of total work time.

The Medical Surveillance Programs are maintained for purposes other than evaluation of exposure; however, data generated by the programs can be used as qualitative indications of exposure. The major advantage of the programs is that in many situations they are the only programs that generate documentation of some employees having potential exposures to chemical toxicants. The major disadvantages of the Medical Surveillance Programs for exposure estimation are the qualitative nature of the data, and there is no system to determine how accurately supervisors are identifying exposure potential. There is evidence that supervisors are over designating lead and mercury workers since more persons are designated as having potential for exposure to these elements than are placed on the blood and urine programs established by the IHD for these materials.

Data generated by the Personnel Radiological Contamination Programs are not judged to be useful as indices of exposure potential, because, in part, there is little documentation generated or maintained. The only measurements documented are those that involve instrument alarms and measurements made by RADCON Department personnel. (There were fewer than 300 such incidents in 1995.) An additional difficulty in these cases is making reliable judgements of the amount of internal exposure resulting from different levels of personal contamination at varying anatomical sites.

Methods for Extrapolating Data

Current Data

An evaluation of current RADCON personnel monitoring programs disclosed there is no need to recommend additional methods for extrapolation of dose data. The RADCON Department currently generates dose estimates for workers with missing quarterly doses because of lost or damaged dosimeters. These estimates are made by the external dosimetrist shortly after the quarter ends and are based on data such as workers' own doses received in previous quarter(s) and doses of other workers with like work assignments for the same quarter. These surrogate doses are then entered into the official record. There is no occasion for a missed internal radiological dose. RADCON personnel attempt to avert any missed scheduled urine samples by implementing an administrative procedure which bars any worker from working in radiological controlled areas if the worker's urine samples is more than four weeks overdue. Moreover, the calculation of dose from urine results is done in a fashion that estimates a dose for each period regardless of whether all samples were given as scheduled.

The situation in IHD monitoring programs is considerably different. In the programs that include biological sampling, such as blood sampling, workers are typically sampled annually, except for the mercury urine program in which workers are sampled quarterly. These time periods give ample opportunity to reschedule missed samples; however, the IHD has no procedure for extrapolating exposure if these samples are missed. Since the reporting procedure for these programs is to report single results, it is not apparent to the authors whether missed samples can be readily recognized.

Other inadequacies/deficiencies/weaknesses exist in IHD programs. In programs with no scheduled sampling of biological fluids, personal air samples are periodically collected on a small fraction of the population involved. Presently, there is no effort to extrapolate the exposures determined for the few sampled workers to other workers or to other periods.

Retrospective Doses

Neither the RADCON nor the IHD attempt to extrapolate data when reporting past dose or exposure. The present policy is to provide to requesters only dose or exposure information directly recorded and to state that the information provided is the only information available for the employee. In some cases, it is further stated that the exposure potential was not necessary to monitor the employee.

In the case of beryllium exposure, as mentioned above, efforts are being made to generate exposure estimates by associating workers geographically and chronologically to a large body of continuous general air monitoring data or with data from individuals with personal air sampling results by matching department, job title or code, and time.

Other Available Methodologies

Although not used by the Y-12 RADCON Department or the IHD, several methodologies have been developed and used at the Center for Epidemiologic Research (CER) for exposure assessment. These methods could be used with Y-12 monitoring results if it were necessary or desirable. A brief description of these methods, along with references to their use, is presented below. Although all these references relate to radiological measurements, these techniques can be applied equally well to results from the IHD.

Inferred Dose Estimates

Both internal and external doses to a worker can be inferred from known doses for other periods for the same worker. It can be inferred from doses or exposures to other workers for the same periods if the exposure for the missing period is likely to be similar to that for periods or for persons with available data (1,2).

Internal Exposures from Air Results

If air monitoring results are available and can be associated with individual workers, the results can be used to estimate internal exposures in either current or retrospective situations (2,3). While this methodology is full with deficiencies and usually requires considerable time and effort, it can often be very useful and may be the only methodology appropriate in situations where air monitoring results are the best or only results available. (This is one of the methodologies currently being used by ORAU to estimate beryllium exposures to Y-12 workers.)

Population-Based Exposure Assignments

Another methodology used for assigning notional doses or exposure estimates to workers involves the use of summary data for the population to which the workers belong (4). It is common for persons to have no results for a particular period of interest and to have no other monitoring information for a chronologically nearby time period that can be used with the methodology described above. In these cases, another technique that can be used is to assign median doses or exposures based on data for other workers in the same work group, department, division, or plant.

Other Indirect Uses of Monitoring Data for Estimating Dose or Exposure

All of the methods described thus far for estimating exposures offer advantages and disadvantages. Because of the magnitude of the task of predicting what areas and individuals are likely to have exposure potential, there will always be scenarios that require different methods for exposure assessment. In some cases, information from two or more

sources may be integrated, therefore producing a considerably more useful basis upon which to make exposure estimates.

As an example of this general methodology, qualitative information from the Medical Surveillance Programs identifying certain workers as having potential for exposure to a particular chemical toxicant might be combined with area air sampling data on the same chemical toxicant to roughly quantify the exposure to the identified employees. Such an approach could be significantly refined if workers were more precisely identified by their exposure potential and if workers could be more accurately geographically and chronologically associated with work areas. A method for classifying workers according to exposure potential, the Potential Exposure Profile System (PEPS), was developed and tested as Task II of this project. An efficient and practical system for monitoring worker activities by location and time using bar code technology, the Worker Exposure Surveillance System (WESS), was developed and tested as a pilot study at the Y-12 Plant as Task III of this project. The implementation of both these methodologies, as described in reports for Tasks II and III of this project, with a comprehensive area air monitoring program would greatly increase the database useful for exposure assessment, and increase the number of workers for whom exposure related data were available. Such a system would make it possible to relatively and precisely quantitate exposures to materials with exposure potential great enough to warrant a routine air sampling program and to more adequately qualify exposures to materials of lesser exposure concern.

EVALUATION OF USE AND QUALITY OF RESULTS

Use of Results

Overall it is determined that good use is being made of the results generated by the monitoring programs described in these volumes. Both the RADCON Department and IHD report results of the personnel monitoring programs to the individuals involved and their supervisors. In addition, the RADCON Department issues departmental reports on these results so supervisors can compare employee doses for the supervised department to those of other departments. Reports are also issued, to the members of the As Low As Reasonably Achievable (ALARA) committee, presenting the year-to-date status of the radiological monitoring programs and ALARA goals for the plant.

In the case of results from personal air sampling programs, utility of results could be extended by documenting names of workers who are determined to have similar exposure, or a specified relevant exposure, to that of the worker being sampled. Although the IHD record system is designed to record such information, none is presently being recorded. If such information were consistently and accurately documented, it could greatly expand the usefulness of the few personal samples that are being collected.

Reporting of sampling results not directly related to personnel is accomplished by the RADCON Department by issuing frequent computer generated reports to supervisors of the relevant departments. Summaries of the results of direct measurements and area tab smear surveys are posted at boundary control stations and are available to all persons entering these areas for reading.

There are limited numbers of area air and surface smear results from IHD programs. The results are reported to supervisors if they indicate unusually high levels or if the samples were collected for projects of special concern.

Neither the RADCON Department nor the IHD produce a continuing overall status report that compares current results with established standards and previous levels. It is judged by the authors that such reporting would be helpful to the Y-12 Plant in general and, in particular, to the RADCON Department and IHD. Such reporting would likely improve communication and understanding between the employees and managers and offer an opportunity for the RADCON Department and IHD to showcase their successes and indicate actions being taken in the cases of incipient problems.

Quality of Results

The overall quality of results generated from the current exposure monitoring programs at Y-12 are judged to be excellent. Results are based on samples collected by professional technicians who are adequately trained in procedures that are updated to remain current. In addition, both departments responsible for exposure monitoring have standard procedures to assure that field measurement equipment is calibrated and operating correctly. Quality control and quality assurance programs are also in place to provide continuing assurance that laboratory analyses performed on the samples collected by these departments remain in good control, or that appropriate corrective actions are taken when required. Samples are analyzed by standard or special methods that are recognized as among the best available, and reported results of control programs indicate that the laboratories are executing their procedures correctly.

Since 1991, the external dosimetry programs maintained by the RADCON Department have been accredited by the Department of Energy Laboratory Accreditation Program. The operators of the uranium urinalysis program, which is the major program for internal dosimetry, participates in and do well in inter-laboratory comparison studies.

There are two aspects in which the procedures for handling of analytical results at Y-12 could be improved. The first improvement, and by far the more important, would be to report all results as determined, i.e., zero, not significantly positive or negative, and significantly positive. Although HPS N13.38-1996 *Performance Criteria for Radiobioassay* requires that exposure monitoring results are to be reported as just described with the exception of results from the uranium urinalysis program, no results are reported in this fashion. Instead, results are reported below the Minimum Detectable Activity or Amount, less than the Lowest Reported Amount, or as zero. Doses calculated for reporting averages or evaluating trends would be more meaningful if they were based on results reported exactly as determined. Such results would also be considerably more useful in evaluating dose response in epidemiologic studies.

Presently, internal exposure estimates are somewhat positively biased by the use of a conservative algorithm for conversion of urine sample results to dose. This bias is of little significance at the present time since the conversion algorithm only produces slightly biased results and the dose levels are very low. However, it is noteworthy that the dose conversion algorithm used before 1989 is more conservative, and monitoring results were much higher in earlier periods. Consequently, it would be judicious to remove the conservative assumptions from any newer algorithm used to reconvert old urinalysis results to dose.

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EXTERNAL RADIATION MONITORING PROGRAMS

OVERVIEW

Purpose of Programs

Lockheed Martin Energy Systems, Inc., (LMES), operator of the Oak Ridge Y-12 Plant for the U.S. Department of Energy (DOE), has a Centralized External Dosimetry System (CEDS) for measuring external ionizing radiation doses of its employees, contractor personnel, and visitors. The purpose of this report is to describe how the operation of that system by the Y-12 Radiological Control (RADCON) Department accomplishes the monitoring of personnel associated with the Y-12 Plant.

Brief Description of Programs

The external radiation monitoring programs, described in more detail below, consist of procedures and activities for monitoring all employees and visitors who have external radiation exposure potential. For example, by wearing a small dosimeter worn above the waist for a specific amount of time, a worker can be measured for radiation exposure. These dosimeters are periodically replaced and then processed through an automated reader. During processing, the thermoluminescent elements of the dosimeters are heated. This causes light to be released in proportion to the amount of radiation exposure received. The measured light output is factored with a series of calibration values, and the resulting calculated values are used as estimates of dose (in mrem) received by the monitored individuals.

Exposure Potential

During World War II, the mission of the Y-12 Plant was to enrich the U-235 content of natural uranium to the level required for atomic bombs. The enrichment was accomplished using an electromagnetic separation methodology employing large devices called calutrons. Subsequently, the Y-12 facility became a manufacturer and assembler of atomic and nuclear bomb components. Presently, the facility disassembles weapon components containing uranium, stores enriched uranium, and maintains a standby weapons production capability.

The routine exposure potential to external radiation at the Y-12 Plant is threefold:

1. The Y-12 Plant contains more than 100 discrete beta or gamma sources or x-ray facilities. These sources and facilities are, or have been, used for the radiography of plant products and equipment and have associated ionizing radiations ranging in energy from a few keV to more than 10 MeV.
2. The plant chemically or metallurgically processes large amounts of uranium and has processed, to a lesser extent, other radioactive material with low-level external radiation exposure potential.
3. The plant handles uranium solution from reactors which is slightly contaminated with fission products. Such a source of external exposure is of a low order of magnitude and relatively innocuous in exposure potential unless these fission products become concentrated during the process. Concentration can occur under some circumstances.

Since much of the uranium handled at the Y-12 Plant is fissile, there is some potential for an inadvertent criticality event resulting in a tremendous amount of associated radiation. Because of these two distinct exposure potentials, the facility has continuing programs for monitoring routine, low-level external exposure using a dosimeter which also has capabilities for evaluating high levels of exposure should a criticality event occur.

Purpose of Report

The purpose of this report is to provide details of the external radiation monitoring programs and how the programs are administered with special emphasis on the use of results. The report is part of a larger volume aimed at documenting currently installed monitoring programs at Y-12 that may generate data useful for health and safety activities or studies.

PROGRAMS

Dosimeter

Since 1980, the primary device for monitoring external radiation exposure at the Y-12 Plant has been the Thermoluminescent Dosimeter (TLD). A special holder for four TLD elements is worn above the waist attached to the individual's clothing with the same plastic strap and clip that holds the plant security identification badge and hangs above the security badge. Since the security identification badge is required for plant entry and occupancy, this configuration helps assure that the dosimeter is always located as required on the front of the upper torso. The TLD holder (41 mm X 62 mm, subsequently referred to as dosimeter) contains four lithium fluoride elements mounted in an aluminum substrate and

encapsulated between two sheets of 0.06 mm thick Teflon (Figures 1 and 2). The aluminum substrate makes it possible to handle the dosimeter without handling the individual elements. The dosimeter is covered (shielded) with filters of various materials to attenuate the radiation striking the dosimeter, thereby increasing its measurement abilities and range.

POS. ELEMENT

- 1 TLD-700 (.015")

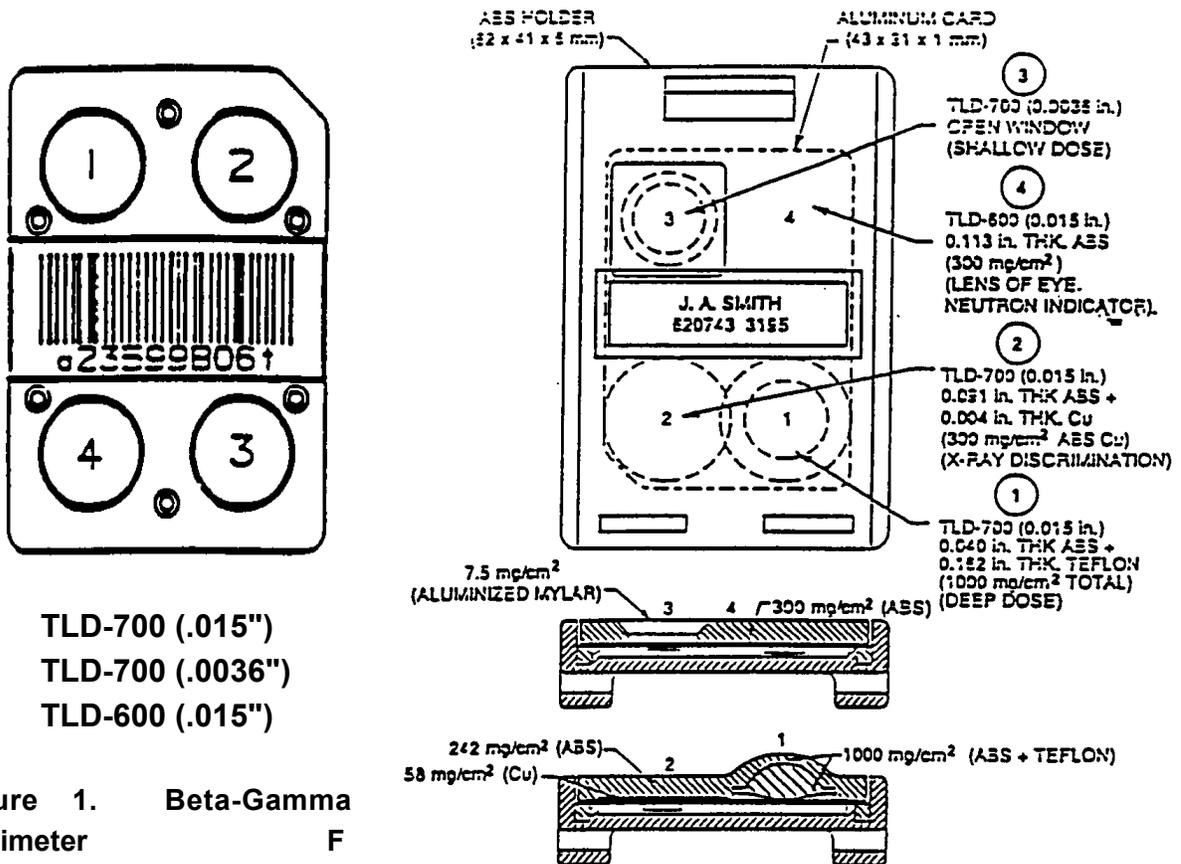


Figure 1. Beta-Gamma Dosimeter

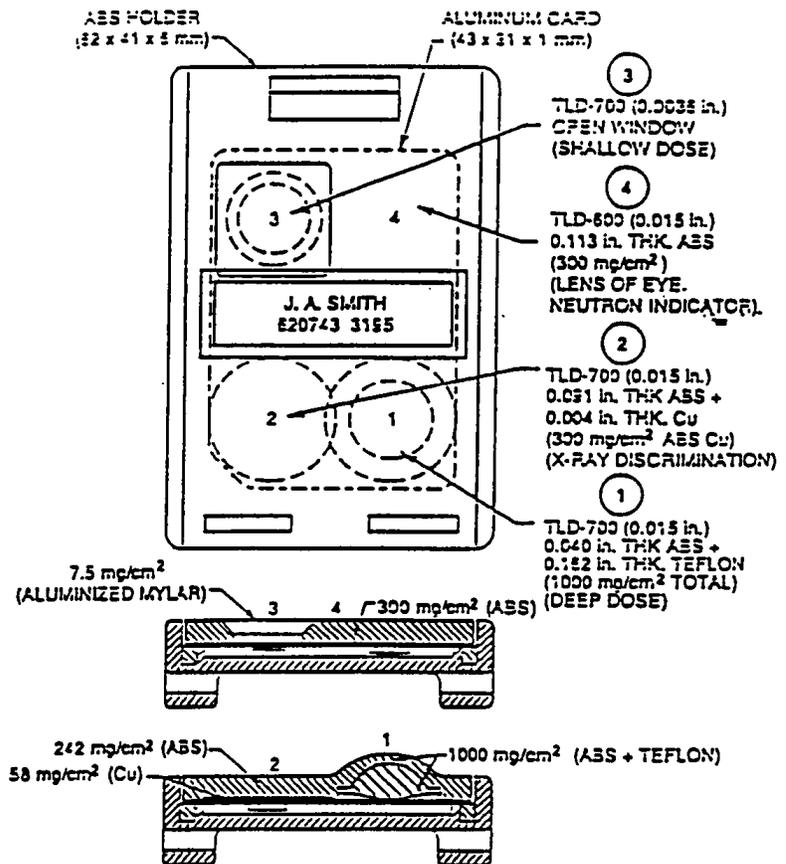


Figure 2. Beta-Gamma Dosimeter

Card Configuration

Assembly Configuration

The ability of TLDs to record radiation exposure is based on the physics of thermoluminescence by which light is emitted by the lithium fluoride elements, when they are heated to high temperatures, which is proportional to the ionizing radiation to which they have been exposed. Shielding multiple lithium fluoride elements with filters of various materials make it possible to quantify the exposure and to qualify the type of radiation to

which the meter has been exposed. Since the TLDs are of two thicknesses and contain two isotopes of lithium (which respond differently to neutron radiations) the exposure estimating capabilities are further improved. All of these characteristics combine to make the TLD a very capable device for estimating the dose to the individual wearing the dosimeter.

The dose response of these dosimeters works well for this Y-12 application. TLDs have a linear response range of 10 mrad to 100 rad which provides adequate sensitivity for low-level monitoring with enough upward range to adequately monitor most employees in the case of a nuclear excursion. Higher doses can be evaluated by using a modified reading protocol which raises the upper range of this unit to more than 2,000 rad. Since the dosimeter has a TLD element that is sensitive to neutrons, it is possible to use it for neutron dosimetry once the associated neutron spectrum is determined. It is noted that a separate dosimeter with two different TLD elements is worn by a few individuals with routine exposure potential to neutrons while a single element dosimeter is sometimes used to estimate extremity dose.

Distribution and Collection of Dosimeters

Routine

TLDs are worn by Y-12 employees for three months. The RADCON Department is responsible for assuring that all employees are provided appropriate dosimeters and that dosimeters are exchanged at this frequency.

Sets of TLDs are sorted alphabetically by department within plant division and transported to the appropriate Division Coordinator in special carrying cases for quarterly distribution. On a predetermined date, the dosimeters are distributed to the designated individuals who combine the dosimeters with their security badges by attaching both to a common strap. Upon receipt of replacement dosimeters, employees return the dosimeters worn during the previous period. The exposed dosimeters are delivered to the RADCON Department's Distribution Center where they are checked with a survey meter for contamination. If any dosimeters are found to be contaminated, steps are taken for them to be either cleaned or removed from the system. Following the dosimeter contamination check, the RADCON Distribution Center then transfers the exposed dosimeters to the Processing Center where the dosimeter cards are removed from their cases and processed. After processing, the dosimeters are returned to the RADCON Distribution Center in preparation for the next distribution.

Nuclear Accident Procedures

The same type dosimeter as just described for routine monitoring would be used for measuring doses should there be a criticality event. Individuals working in, or inhabiting, an alarmed (criticality) area would immediately evacuate to predetermined assembly points at the sound of the alarm. From these assembly points employees would be sent to a personnel monitoring station where: (1) they would be screened for blood sodium activation using a portable beta-gamma survey meter as a means of identifying those involved in the accident; and (2) their dosimeters are collected. The dosimeters of any employees showing blood sodium activation would be processed on a priority basis. The parameter of most interest from the dosimeter results is the determination of excess activation of the ${}^6\text{Li}$ element in the dosimeter. Based on this determination and the appropriate calibration factor, an estimated neutron dose is calculated. The calibration factor used is selected from a catalog as the appropriate factor for the most likely neutron spectrum to which employees may have been exposed based on the type of criticality experienced and the individual's location at the time of the excursion. The estimated neutron dose thus calculated can be combined with the beta-gamma dose, determined as usual, to provide an estimate of total dose.

Subsequently it would be possible to compare the total individual dose with the total dose calculated from the most appropriate Fixed Nuclear Accident Dosimeters (FNAD) for additional assurance of accuracy. The FNAD consists of a regular dosimeter and a neutron dosimeter mounted on a plastic box designed to simulate the backscatter from a human. There are 88 FNADs in the Y-12 Plant, and Figure 3 shows a front and side schematic of an FNAD.

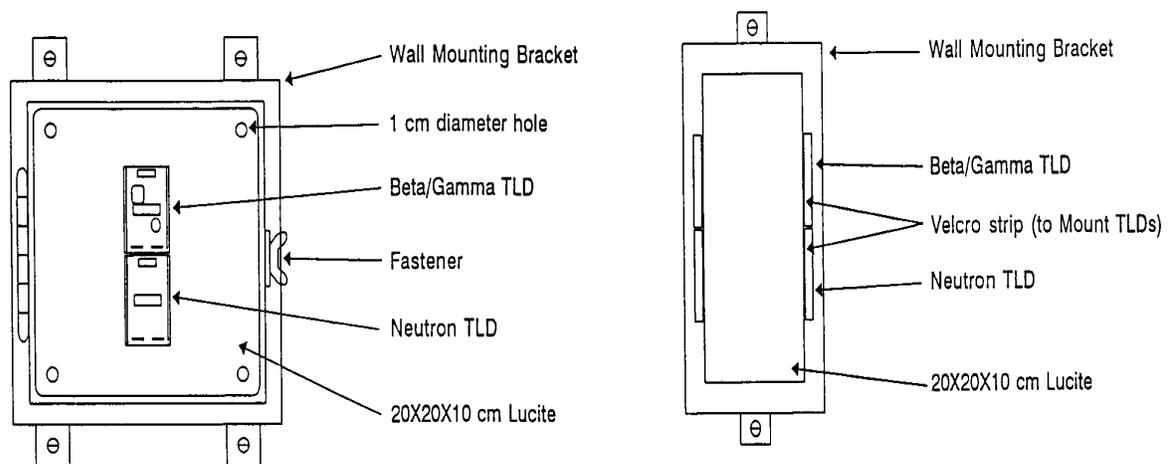


Figure 3. FNAD Phantom

ANALYSIS TO DETERMINE EXPOSURE

Each dosimeter presented for processing is designated as either worn by a radiation worker or nonradiation worker, so that the radiation workers' dosimeters can be processed first. The dosimeter cards are stacked in a receiving holder, automatically read, and expelled into another holder after processing.

Equipment

The equipment used at the Y-12 Plant to read dosimeters is a Harshaw/Bicron TLD System 8800 card reader. Mechanically, this automated reader consists of carousels for holding TLD cards before and after they are processed, read stations for the four TLD elements, and a transport system. The TLD reader system is also equipped with an internal ^{14}C source enabling system monitoring on a continuing basis for sensitivity changes.

Processing of Dosimeters

Once an exposed dosimeter is positioned in the read station, it is heated with a jet of hot dry nitrogen gas. The heat from the hot gas is transferred efficiently and results in a rapid light output from the TLD element which is proportional to the amount of radiation to which the TLD has been exposed. The emitted light is measured by a photoelectric multiplier which converts it into an electrical charge and amplifies the charge. This charge is measured and integrated into a quantity that, with the appropriate calibration constants and algorithms, is converted into an external dose estimate. The person to whom a TLD has been assigned can be identified by scanning the bar code on the TLD card.

After the cards are read, they are stored in preparation for reissuing. It is necessary to reanneal the lithium fluoride elements before they can be placed in service again. Annealing is accomplished by reheating the dosimeter elements. This reannealing process is begun approximately six weeks before the next quarterly dosimeter exchange. After annealing, the cards are reassembled into holders. Bar coded information, (on the cards and backs and fronts of the holders) is scanned thereby associating persons' names and ID numbers with card numbers in a computer database. During assembly, the TLDs are sorted in alphabetical order by department within plant division. The dosimeters are then transferred back to the RADCON Distribution Center.

The dosimeters and reader system have been used successfully by Y-12 RADCON Department personnel as shown by testing and earning accreditation for meeting the operational and performance standards specified by the Department of Energy Laboratory Accreditation Program (DOELAP). The RADCON Department was first accredited in 1990 and has remained accredited for all types and mixtures of radiation for which accreditation

is awarded.

CALCULATION OF DOSE

Based on luminescence measurements of the four TLD chips, deep dose and shallow dose are ordinarily calculated for depths of 10 mm and 0.07 mm, respectively. Under certain conditions the dosimetric algorithms will also calculate a 3mm depth eye dose and a neutron dose. All calculated doses are automatically entered into the CEDS computerized record system.

Background Considerations

Natural background radiation is taken into account when calculating estimated doses. The amount of background radiation subtracted depends upon the length of time between reannealing of the TLDs and reading. Based on a 1991 study performed by Y-12 using 1,680 dosimeters placed in 70 homes in Tennessee and Kentucky, background accumulation formulas for the four TLD chips were determined as shown in Table 1, where t is the time in weeks between annealing and processing.

Table 1. Background Radiation Levels

Chip	Background (reader units)
1	$3 + 0.75 t$
2	$3 + 0.75 t$
3	$14 + 0.75 t$
4	$4 + 0.9 t$

Reporting Level (RL)

Statistical analysis by the Dosimeter Processing Center has established an administratively defined RL for measured dose equivalent. Results below this level are considered to be zero. Analyses of the standard deviation associated with the same set of 1,680 background doses as just described, showed that the standard deviation for the doses depended primarily on the variability in background levels, and increased as a function of time between annealing and reading. Formulas for determining minimum background RLs for each TLD chip and the resulting RLs for each chip are shown in Table 2. For practical purposes these levels serve as minimum detectable amounts for these programs.

Table 2. Quarterly RLs for TLD Elements

Chip	Reader Response Units (mr*)
1,2	$1.2 + 0.40 t = 10$
3	$12 + 0.32 t = 19$
4	$2.2 + .39 t = 11$

* The quarterly dosimeters are in service an average of 22 weeks. The reader is intentionally calibrated so that for chips 1 and 2, reader units are directly convertible to mrem.

Reader Calibration

The basic calibration for the dosimeter reader system was done when the dose algorithm was developed at the instrument manufacturer. The reader calibration for ^{137}Cs is checked daily by running one Quality Control (QC) card with each of the 25 routine cards. Each of these QC cards has been exposed to 250 mrem of radiation from ^{137}Cs at the Oak Ridge National Laboratory (ORNL) calibration facility. The levels shown by these QC cards are reviewed to determine if they are within prescribed limits. Should the QC levels be within the established limits, the basic calibration factor is adjusted as required for the day. If the QC levels are not within the prescribed limits, the dosimeter reader must be repaired and rechecked. The basic calibration includes seven radiation fields that are used by the DOELAP as follows:

- ^{137}Cs high-energy photons;
- $^{90}\text{Sr/Y}$ high-energy beta, point-source geometry;
- ^{238}U high-energy beta, slab-source geometry;
- M30 low-energy x-ray (17 kev effective-energy);
- H150 high-energy x-ray;
- ^{204}Tl low-energy beta;
- ^{241}Am low-energy x-ray (59 kev); and
- ^{252}Cf bare and moderated.

Various algorithms are developed from these calibrations to assure that the generated doses will meet the DOELAP standards.

Quality Control Programs

To ensure QC, several programs are implemented. Among the more important of these are a (1) daily calibration check of the dosimeter readers described in the above section, and (2) submission for processing of a series of double-blind controlled exposed dosimeters by the ORNL calibration facility. The control dosimeters are submitted quarterly and have been exposed to most of the types and ranges of radiation doses to which the test dosimeters provided by the DOELAP laboratory are exposed. The results from the control dosimeters are reported by ORNL to assist the Y-12 Processing Center in continuing to perform in accordance with DOELAP standards. The tables below are excerpts from the third quarter 1995 *Health Physics Performance Assessment Database Report*. Table 4 shows the responses of the two Y-12 readers to the 250 mrem check sources.

Table 4. Dosimeter Reader Intercomparison, QC Card Response

Parameter	Reader 22	Reader 55
Mean	247	246
Standard Deviation	8.41	8.05
Sample Variance	70.8	64.7
Median	246	245
Range	54	43
Minimum	228	225
Maximum	282	268
Count	534	423

The results of selected double-blind control samples submitted by ORNL each quarter are shown in Table 5.

Table 5. Double-Blind Controlled Exposed Samples from ORNL (Moderated ²⁰⁴Cf and High Energy Photons (¹³⁷Cs))

Dosimeter No.		Reported Dose			Delivered Dose			Performance Quotient		
H.G.	NEW	Photon	Neutron	Total	Photon	Neutron	Total	Photon	Neutron	Total
181360	903004	244	187	431	265	225	490	-0.079	-0.169	-0.120
180805	902876	250	206	456	265	225	490	-0.057	-0.084	-0.069
178189	902841	240	209	449	265	225	490	-0.094	-0.071	-0.084
					Bias B =			-0.077	-0.108	-0.091
					Std. Deviation (S) =			0.029	0.041	0.026
					B + S =			0.106	0.149	0.117

A third QC program is a quarterly external confirmation program in which controlled exposures at the Pacific Northwest Laboratory to Y-12 dosimeters are processed at Y-12 in single-blind tests. These tests also help assure continuing compliance with DOELAP performance criteria. Of course, the DOELAP reaccreditation system plays a very important role in QC at the Y-12 Plant and other DOE facilities. This program not only tests the laboratories' performances in meeting the standards for evaluating unknown exposures, but also ensures that laboratory personnel meet educational, training, and administrative control criteria established by the DOELAP. The Y-12 and ORNL laboratories were accredited in 1990 and reaccredited in 1993 and 1995.

USE OF RESULTS

Limits and Action Levels

The employee dose, from the external monitoring programs, is combined with the dose determined for internal exposure to yield a Total Effective Dose Equivalent (TEDE). The TEDE limit, established by DOE, is five rem per calendar year. The action levels established by Y-12 for these programs are listed below.

Table 6. Y-12 Plant Radiation Exposure Action Levels

Type of Exposure	Action Level	Type of Dose
Deep Dose	100 mrem/year	External
Shallow Dose	1,000 mrem/year	External
Extremity Dose	1,000 mrem/year	External
Lens of Eye Dose	Any calculated dose	External
CEDE ¹	100 mrem/year	Internal
TEDE ²	100 mrem/year	Internal and External

¹ Committed Effective Dose Equivalent.
² The sum of the CEDE and the Deep Dose.

As Low As Reasonably Achievable (ALARA) Objective

The ALARA objective for total collective TEDE for 1995 was set at 15.1 person-rem with a maximum TEDE for an individual of 200 mrem. The total collective dose at the end of 1995 was 9.3 person-rem and the maximum individual dose was 150 mrem; therefore, both ALARA objectives were met. A similar ALARA objective has been established for 1996.

Records

Doses, as calculated from dosimeter reader output and adjusted calibrations, are entered into the CEDS database which is part of the Occupational Health Information System where they are archived. Retrieval of the data is possible for current and past periods (beginning in 1989) as needed for historical reporting should an employee or attorney request the individual's results. External monitoring data for periods before 1989 are maintained elsewhere.

Reports

Reports which summarize quarterly results for the year are given to individuals through their supervisors. These reports are furnished by the RADCON Department in the format shown in Table 7 and also include the internal dose for individuals on programs for monitoring internal exposures. The internal dose determination is described in the Internal Radiation Monitoring Programs - *In Vitro* report.

Table 7. Third Quarter, Year-to-Date Radiation Dose Report

Report: RC001 STATUS: Employee		YEAR: 1995 RAD/CONRAD: All		DATE: 28-NOV-95 OR: Dept/EACH 2366-92		PAGE: 2217
Name	Badge No. or SSN	TEDE (mrem)	CEDE (mrem)	DEEP (mrem)	SHALLOW (mrem)	EXTREMITY (mrem)
L J Laser*	9970	110	50	60	120	120
¹ CEDE = COMMITTED EFFECTIVE DOSE EQUIVALENT (INTERNAL DOSE). ² TEDE = TOTAL EFFECTIVE DOSE EQUIVALENT (CEDE + DEEP DOSE). * These data are examples to illustrate how such data are reported.						

Supervisors are also furnished quarterly, summary data for all departments in the format shown in Table 8.

Table 8. Third Quarter, Year-to-Date Radiation Dose Report

DEPT	TEDE (mrem)		CEDE (mrem)		DEEP (mrem)		SHALLOW (mrem)		EXTREMITY (mrem)		No.	PAGE: 6000	
	avg	max	avg	max	avg	max	avg	max	avg	max		No. TED E ≥100	Total TEDE (mrem)
2A66-00*	0	0	0	0	0	0	13	202	13	202	16	0	0
2A73-12*	1	19	0	19	0	11	5	116	5	116	74	0	51
¹ CEDE = COMMITTED EFFECTIVE DOSE EQUIVALENT (INTERNAL DOSE). ² TEDE = TOTAL EFFECTIVE DOSE EQUIVALENT (CEDE + DEEP DOSE). * These data were excerpted from an actual report for illustration; however, the Dept is fictitious.													

From this information supervisors can compare average and maximum doses between their department and other departments. At the end of each calendar year, similar information is provided to DOE for entry into their records depository. A copy of the data furnished to DOE on each individual is mailed to all persons annually. At this time DOE also is provided an electronic copy of data generated by the facility during the year. From this information, DOE prepares a frequency distribution of doses in designated dose ranges by facility.

The information just described is also furnished to the RADCON Department ALARA Coordinator for determining the status of the plant relative to its current ALARA objective. This information is presented to the ALARA Steering Committee and, through minutes of that Committee's meeting, to the other Y-12 Plant, Division, and Department Managers.

COST AND RESULTS OF PROGRAMS

Extent and Cost of Programs

Approximately 5,500 Y-12 employees are assigned to participate in the External Radiation Monitoring Programs per quarter, and an additional 1,500 subcontractor employees are furnished dosimeters. An additional 1,300 dosimeters are issued to visitors or to employees losing or leaving their badges at home for a total of 8,000-9,000 dosimeters processed per quarter. The estimated cost of this service (\$650,000 per year) represents a quarterly cost of less than \$20.00 per dosimeter. The total cost of the programs is less than 10 percent of the total budget for the RADCON Department.

Summary of Results

Table 9 shows average results to the nearest mrem for the years since the Y-12 facility implemented the present system. Results from 1990-1995 provide the following summary information on average doses for the Y-12 population.

Table 9. Average External Radiation Exposures (1990-1995)

Radiation Workers				All Y-12 Employees			
		Average mrem				Average mrem	
Year	Total Employees	Shallow	Deep	Year	Total Employees	Shallow	Deep
1990*	2,560	83	10	1990	7,330	36	4
1991	2,393	44	5	1991	7,094	19	2
1992	2,269	32	4	1992	7,150	16	1
1993	2,094	41	8	1993	6,171	17	2
1994	1,597	29	6	1994	6,055	11	2
1995	1,650	12	2	1995	5,614	8	1

*The large number of radiation workers is due to implementation of DOE Order 5480.11 requiring that all workers with either external or internal exposure potential be classed as radiation workers. Many of these Y-12 workers have no potential for external exposure.

For 1995, the total collective deep dose for all employees was 3.27 rem, for an average of 0.6 mrem per person. The 1,650 employees classed as radiation workers had an average deep dose of 1.5 mrem. However, because of the policy of setting results below 10 mrem to zero, a significant portion of the dose to employees classed as radiation workers may be missed (1). The remaining 3,964 employees who were not classed as radiation workers averaged only 0.2 mrem.

EFFECTIVENESS OF PROGRAMS

Evaluation

The Y-12 Plant dosimeter analysis programs appear to be state-of-the-art and are adequately precise and free from bias as indicated by the continuing accreditation by DOELAP of these programs. The External Radiation Monitoring Programs, as a whole, are very effective and have achieved startlingly low results over the six most recent years. These low exposure levels are attributed to: (1) the plant's outstanding RADCON Department's control and ALARA programs, (2) well-designed QC programs, and (3) the plant's low exposure potential during normal operation. The very low dose for 1995 is partly due to the plant being in standdown and very little production work being done.

Observations

1. A number of employees for whom monitoring is not required by DOE orders are being monitored. Of the 355 departments monitored for the first three quarters of 1995, about 91 percent had an average exposure per employee of 0 mrem, (actually <0.5 mrem since results are rounded to the nearest mrem). The average deep dose for all employees for 1995 was 0.6 mrem per employee.
2. A significant amount of dose to radiation workers (compared to the amount recorded) may be unrecorded due to the practice of setting to zero any dose of less than 10 mrem.

Conclusions

1. With limited funding and the low dose levels being found, consideration should be given to the cost-effectiveness of monitoring all employees. It should be adequate, from a regulatory standpoint, to monitor only employees with potential for external exposure of 100 mrem or more. It is our understanding that this idea is being considered.
2. Consideration should be given to recording the exact calculated dose as the official dose. While this value is not statistically different from zero, it is the most likely dose and is the most useful value for epidemiologic studies and calculating mean exposures. If such a policy is not deemed desirable, consideration should be given to recording the exact calculated result along with the "0" normally reported for <MDA determinations.

INTERNAL RADIATION MONITORING PROGRAMS - *IN VITRO*

OVERVIEW

Purpose of Programs

The Radiological Control (RADCON) Department at the Y-12 Plant in Oak Ridge, Tennessee, currently operated by Lockheed Martin Energy Systems, Inc., (LMES) for the Department of Energy (DOE), manages urine and fecal analysis programs. The objective of the programs is to determine the amount of certain radioisotopes contained in excreta to: (1) evaluate the continuing effectiveness of controls on the intake of these radioisotopes; (2) help ensure worker safety and health; (3) detect unexpected radiological intakes; (4) generate data for calculating internal doses; and (5) show compliance with applicable regulations.

Brief Description of Programs

Arrangements are made for members of the possibly exposed population to submit a 24-hour urine sample for analysis of uranium contamination. The analyses of such samples yield results in disintegrations per minute for uranium activity in a day's urine voiding. These results are converted into doses using the best available information on material class, date of intake, and whether the exposure is acute or chronic. Fecal analysis is used in special situations to further characterize radioisotope retention in and elimination from the body.

Exposure Potential

The exposure potential to internal emitters at Y-12 is mainly to depleted and enriched uranium. Other nuclides such as thorium are present in smaller quantities and are monitored as needed. Some processed uranium is contaminated with small amounts of fission products, technetium, and transuranics, but the potential for exposure from these small amounts of contaminants has been of little concern from a radiation control standpoint when compared to the potential from uranium. There have been very low levels of tritium associated with lithium deuteride, but the levels were so low that it was never necessary to have a routine urine monitoring program. Generally, uranium is the single most significant internal exposure hazard in this facility.

Purpose of Report

The purpose of this report is to describe the uranium urinalysis program in detail since it is the major internal *in vitro* monitoring programs at Y-12, as well as to comment briefly on other excreta analysis capabilities. This report is part of a larger volume documenting currently installed monitoring programs at Y-12 that may generate data useful for health and safety activities or studies.

PROGRAMS

Determining Who Participates

The Radiological Work Permit (RWP) system implemented at Y-12 determines which employees should participate in the programs. Any person who enters a uranium radiological work area and performs duties that require the person to be monitored for internally deposited uranium is assigned to this program. Those employees who actually do hands-on work are assigned to participate quarterly while those with technical or supervisory responsibilities are assigned to annual participation. This assignment can occur in three ways:

1. Supervisors may place newly hired or transferred employees on the program by sending in a Bioassay Data Management Form when they determine that an individual should participate.
2. An individual can execute this form or ask his supervisor to do so if the individual is to be in an RWP area requiring such participation.
3. As a continuing reminder to supervisors, a list of uranium urinalysis program participants is sent to each supervisor at the time the quarterly Y-12 Year-to-Date Dose Report is sent. Each supervisor is requested to add or delete employees from this program as needed.

Scheduling Participation

The RADCON Department schedules routine appointments for participation in the urinalysis program three weeks in advance by using an alphabetic computerized algorithm. Such appointments assure that scheduled employees in each department give samples throughout the year, thus providing a continuing check on the exposure of department employees. Nonroutine appointments can be made by RADCON personnel at any time a special, baseline, termination, or a resample is required.

When sampling is requested, labels are sent to the appropriate department manager to pass on to the scheduled person for monitoring. When a special sample is being requested, a red and white label is attached to the sample carton to alert the Analytical Services Organization (ASO) to process the sample with dispatch and to report the results to the RADCON Department when available. Sampling kits for both the routine and special samples are delivered to the urine pickup station by an employee of the ASO. Rad Worker II training is requested for designated radiation workers prior to submission of their first sample. Individuals who do not give the scheduled sample within four weeks of the date it was due are restricted from working in any RWP area until a sample is submitted. This restriction is imposed or lifted by the RADCON Department via electronic notices to the appropriate managers.

Participation Protocol

The urine sample kit is picked up by the participating employee before the employee's scheduled off days (sample to be collected during this time). The sample can be either a true 24-hours voiding or a simulated 24-hours voiding during the worker's off-days. The minimum amount of urine required is two-thirds of a liter. The participant places the furnished labels on the liter bottle(s) and the kit then returns the sample kit to a urine station refrigerator.

Calculation of Dose from Laboratory Results

The data file transferred from the analytical laboratory has sample results in units of disintegrations per minute per 24-hours (d/m/24-hours) voiding. This data is converted into a dose through a computer program, *DOSEXPERT*, developed by the Oak Ridge National Laboratory (ORNL). Most samples are converted to dose assuming the exposure was to a mixed solubility class known as Q-material which the RADCON Department has determined is representative of the most insoluble material type usually encountered by Y-12 radiation workers. Q-class material has been defined as having a mass medium activity size of 8 microns, 90 percent of which clears from the lung like W-class material but with a longer half-life (120 days in the lung) while 10 percent of the material clears the lungs as Y-class material. Such material has an Annual Limit of Intake of 2.3×10^4 Becquerel (Bq) and a Derived Air Concentration of 9.8×10^0 Bq/m³ (588 disintegrations/minute/cubic meters). Using the approach of the International Commission on Radiological Protection Handbook 54 for calculating dose, it was determined that a result of 10 d/m/24-hours voiding would be representative of a dose of 100 mrem. This calculation assumes that the intake occurs 45 days prior to the sample and the material class is Q. Any special or unusual samples are converted to dose using parameters determined by the dosimetrist

to be most appropriate for the particular circumstances involved.

Other Capabilities

Other Isotopes

Although the description above is specific to uranium, procedures also exist to analyze urine for ^{99}Tc , ^{90}Sr , ^{232}Th , ^{234}Th , ^{237}Np , ^{238}Pu , ^{239}Pu , and ^{241}Am since these may be handled within Y-12 in isolated jobs of short duration. Baseline and termination results are usually the only measurements required for these isotopes. So few of the samples are analyzed at Y-12 that no additional description of the programs for these materials is planned for this report.

Fecal Analysis

Very few fecal samples are processed, however, the ASO laboratory has methods to analyze fecal matter for U and ^{237}Np . Since these procedures are used infrequently, no further description of them is included in this report.

ANALYSIS

Sample Pick Up

The refrigerated urine samples are picked up by an ASO expediter and delivered to the laboratory. Chain of custody is maintained by electronic bar code scanning until each sample reaches the laboratory where it is assigned a unique ID number. This ID number is used to track the sample through the laboratory preparation and counting processes.

Preparation for Counting

The urine samples are prepared for isotopic uranium alpha activity determination using ASO Procedure Y/P-65-7173 Rev. C. This procedure specifies use of the following equipment in this preparation.

- Beaker, 400 mL, Teflon.
- Column, plastic chromatography.
- Filter, 47 mm cellulose.
- Filters, replacement for the shaft of Pipetman Model P-4000, or equivalent (this is the most convenient and suitable filter for use as a sample prefilter).
- Filters, 25 mm Metrical, 0.1 μm polypropylene.

- Pump, peristaltic, capable of a 2 to 3 mL/min flow rate.

This procedure also lists 21 reagents and materials used in this preparation and gives the following summary of the test method:

The sample is collected over a 24-hour period. Up to two liters of urine, along with a ^{232}U tracer, are treated with nitric acid (HNO_3) and hydrogen peroxide (H_2O_2). The sample is wet-ashed and the uranium is coprecipitated with calcium oxalate. After dissolving the precipitate in hydrochloric acid (HCl), the uranium is further separated by ion exchange chromatography. The uranium is eluted from the column with a solution of diluted HCl to which titanous chloride (TiCl_3) has been added to reduce actinides that may be in an elevated oxidation state.

The final fraction of the eluate is first treated with ascorbic acid to reduce the presence of any ferric iron, next with hydrofluoric acid (HF), and then the uranium isotopes are coprecipitated on neodymium fluoride (NdF_3 , 150 μg of Nd^{+3}). Neodymium fluoride is caught on a 0.1 μm filter, rinsed, dried, and then mounted on a planchet for alpha spectrometry.

Counting Procedures

The previously prepared planchet is counted according to ASO Procedure Y/P-65-7203 Rev. 0 which specifies use of the following list of equipment.

- Alpha spectrometer, Tennelec Model TC-256 with solid-state alpha detectors.
- Bar code reader.
- Multi-channel analyzer system, Canberra ND 9900 Micro VAX III-based system, with associated peripheral instrumentation.
- Write-Once-Read-Many (WORM) optical disk drive for data storage.
- Calibrated alpha activity reference standards consisting of ^{238}Pu , ^{241}Am , ^{234}U , and ^{238}U , electroplated onto stainless steel planchets.

The following summary description of the method used is taken from this procedure.

Prepared planchets containing alpha emitting nuclides separated from urine or fecal samples are received in batches from the Bioassay Separations Laboratory where each sample has been mounted in a suitable form for alpha spectrometry counting. Samples are counted for 1,000 minutes (16 hours and 40 minutes), and the output data are processed to determine the activity for each nuclide isotope present.

Handling of Results

The ASO staff reviews the alpha counting results with the help of a computer that displays questionable results and those that exceed the agreed upon reporting level. ASO personnel report any such atypical results and the results of any special samples to the RADCON Department as soon as these data are available so prompt and appropriate action can be taken. The ASO arranges for data from routine samples to be entered in the regular Occupational Health Information System (OHIS) database where radiation doses are calculated.

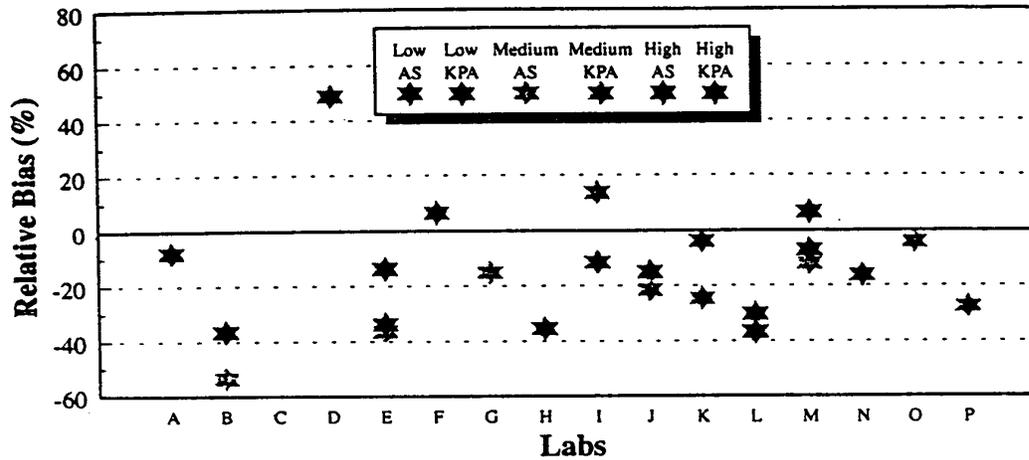
Quality Control Programs

Daily and weekly spectrometer performance checks are done, and extensive quality control is performed on spectrometers.

The ASO also has an internal quality control program specifically related to the ^{232}U spike. The results of each analysis are adjusted by the recovery fraction determined from this spike based on the known amount of ^{232}U tracer. Very low or very high ^{232}U results are causes for declaring the results invalid. In addition, the laboratory runs reagent blanks and control samples of known activity with each batch of samples. If such determinations indicate a lack of adequate control, the situation will be checked by laboratory supervision prior to the acceptance of sample results as valid.

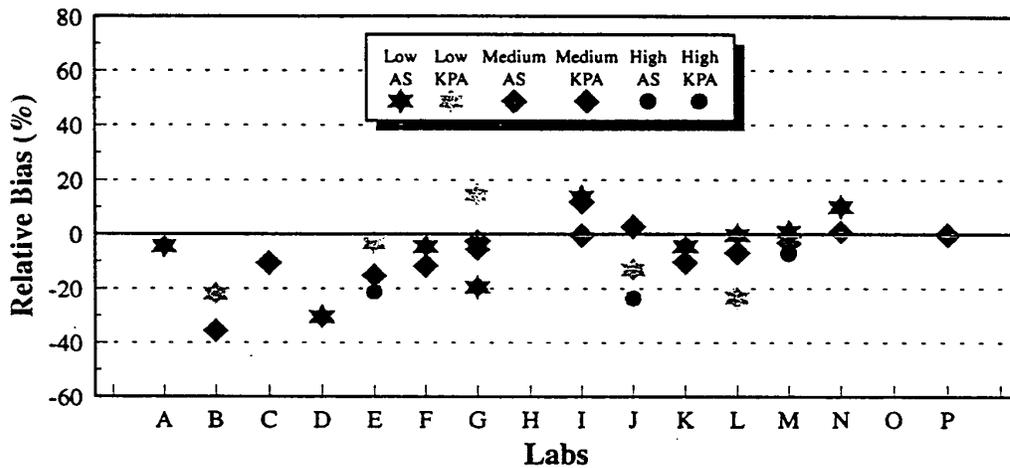
In addition, there are two control programs run by personnel independent of the ASO. The first of these is managed at ORNL. Spiked urine samples are submitted to the ASO laboratories and to other laboratories in the DOE complex doing urine uranium analysis. The biases of these analyses are determined for the participating laboratories and reported quarterly. From these results it is possible to determine how well each laboratory is performing and how performances compare among similar laboratories (Figure 1). A double-blind control sample program is operated by the Y-12 Statistical Services Department. Urine samples with known amounts of uranium added are submitted as

routine samples from personnel assigned to the program. Results from these samples are reported quarterly and precisions found are compared with those previously determined. Figure 2 shows the information contained in the most recent issue (1995) of these reports.



* AS = Alpha Spectroscopy.
KPA = Kinetic Phosphorescence Analysis.

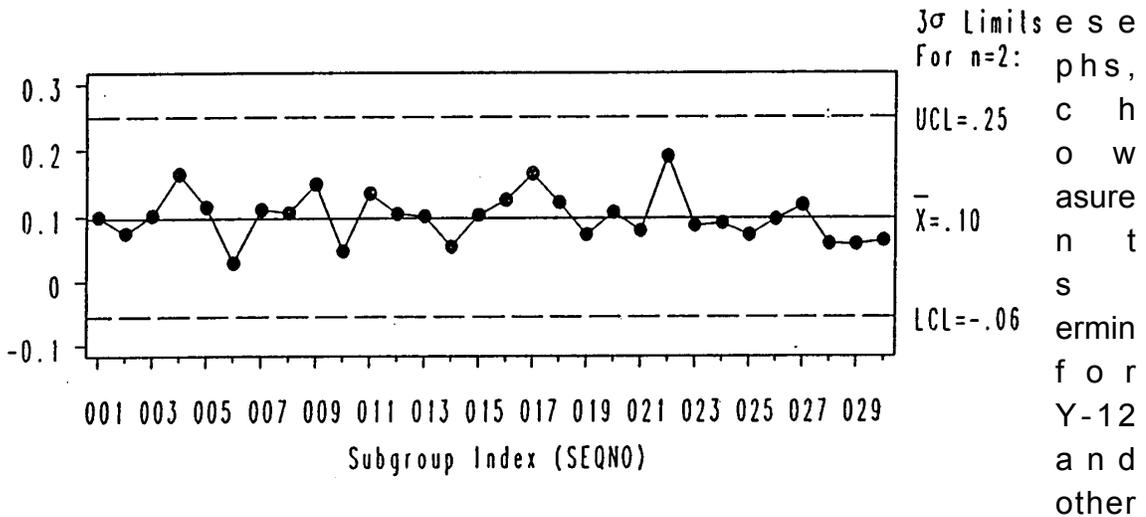
Figure 1a. Bias for January 1992 - September 1995 Period



* AS = Alpha Spectroscopy.
KPA = Kinetic Phosphorescence Analysis.

Figure 1b. Bias for July - September 1995 Period

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DOE laboratories performing uranium urinalyses, were excerpted from an ORNL report. The desired objective would be to have the results bunched near zero. The code for the Y-12 urine analysis lab is "M." It can be observed from these plots that the Y-12 labs show superior performance for both periods and for facilities that measured at two or three levels.

Figure 2. Precision for the July - December 1995 Period

Figure 2, showing measurement precision for the last half of 1995, was excerpted from a January 1996 Quality Control System Report. The Upper Control Limit (UCL) and the Lower Control Limit (LCL) have been established from previous results. The objectives here are (1) to have all individual points representing results to fall between the UCL and the LCL, and (2) for the points to be relatively randomly distributed around the \bar{X} line. As can be observed, the points on this graph meet both objectives. Such controls are run at

five different activity levels. This particular graph, with a \bar{X} of 0.1 d/min/sample, demonstrates measurement precision at the level considered by the Y-12 laboratory to be their limit of detection.

No DOE Laboratory Accreditation Program presently exists for uranium in urine analysis; however, the DOE is in the process of establishing such a program and has done several pilot studies. Y-12 has participated in and performed well in these studies.

Minimum Detectable Activity (MDA)

The MDA is a function of the precision of background measuring. The ASO Laboratory uses a standard formula to calculate their MDA using the standard deviation of the counter background and the standard deviation of interfering isotopes from the reagent blank. The laboratory states this MDA to be about 0.1 d/min/sample. The measurement precision is stated to generally be $<\pm 20$ percent with a bias of approximately 10 percent absolute value.

The average background amount of uranium in urine in the southeastern United States has been found to be 0.2 d/min/24-hour sample. Until recently this was not subtracted and a dose from any uranium naturally found in the urine was actually attributed to the workplace dose. However, after confirming that 0.2 d/min/day was reasonable based on average water intake and the amount of uranium found in locally available water, this background activity is presently being subtracted prior to calculation of dose.

USE OF RESULTS

Review of Results

All routine *in vitro* results are reviewed monthly by the RADCON Department, and at the discretion of the Dosimetry Service Manager or the Internal Dosimetrist, follow-up samples are scheduled for individuals showing an increasing trend, a sudden spike, or an unusual pattern. Any employee whose results indicate a dose greater than 100 mrem using the standard interpretation, is restricted from work in a radiological area until such time as it can be assured that the dose is less than 100 mrem. Only a small percentage of workers are restricted based on this criterion.

Limit and Action Points

In vitro urine results are compared to established limits and action points so that appropriate actions can be taken in response to atypical or unexpected findings. The limit for an internal dose is 5,000 mrem Committed Effective Dose Equivalent (CEDE) and the

plant's dual-level action points are CEDEs of 1,000 and 100 mrem. For effective and efficient use of these milestone doses within the program, the limit and action values are also expressed in terms of uranium excretion rates in urine. For the routine program with a quarterly sampling frequency and Q-class material, this translates to 500d/min/day, 100d/min/day, and 10d/m/day, respectively. It should be understood that such limits and action points are only used for initial evaluation of routine samples. Persons who exceed these levels will be resampled and their dose will be determined by a dosimetrist. In addition, the results of urine samples given after an incident with possible exposure are assessed by a dosimetrist to determine if the results indicate doses above the limit or action points.

As Low As Reasonably Achievable (ALARA) Goals

The results from the *in vitro* urine monitoring program are compared to the ALARA goals set by the plant for the year to determine if the goals are met. The ALARA goals for radiation doses are set in terms of Total Effective Dose Equivalent (TEDE) which includes both internal and external doses. In recent years, these goals have been set on annual collective dose for Y-12 employees and on the maximum individual annual doses. In the years that were surveyed for this report (1994 and 1995), these goals were met by the plant.

Records

Dose records generated by the dosimetrist are kept in employees' personnel files. The routine analysis results are kept in the OHIS database which began in 1989. Data from the OHIS can be retrieved at any time to generate reports.

Reports

Reports to Employees

Quarterly and annual reports (Figures 3 and 4) are distributed to the individuals on the dosimetry programs. In these reports, the CEDE is combined with the external penetrating (deep) dose and displayed as a TEDE as shown in the table below. The quarterly reports are sent to supervisors to be passed on to the individuals involved. The annual report is mailed to the employees' homes.

LOCKHEED MARTIN ENERGY SYSTEMS Y-12 PLANT 3RD QUARTER, YEAR-TO-DATE RADIATION DOSE REPORT

REPORT: RC001 STATUS: Employee		YEAR: 1995 RAD/NONRAD: All		DATE: 28-NOV-95 ORG: Dept 2366-92		PAGE: 2217
NAME	BADGE NO. Or SSN	TEDE (mrem)	CEDE (mrem)	DEEP (mrem)	SHALLOW (mrem)	EXTREMITY (mrem)
LJ LASHER	9970	110	50	60	120	120
<p>These data are fictitious to illustrate the reporting format. CEDE = Committed Effective Dose Equivalent (Internal Dose). TEDE = Total Effective Dose Equivalent (CEDE + Deep Dose).</p>						

Figure 3. Excerpt From Quarterly Individual Radiation Dose Report

MARTIN MARIETTA ENERGY GROUP
ANNUAL SUMMARY OF RADIATION DOSE FOR 1994 H.A. PEST SSN: 419-61-9234

The following is a summary, as of 04/28/95, of the occupational radiation dose you received during 1994 while working on site at Energy Group - managed DOE facilities in Oak Ridge, TN and/or Paducah, KY. A zero indicates you were monitored and that no dose was measured. An "N/M" indicates you were not monitored for that particular category.

Your total effective dose equivalent for 1994 was 170 millirem, which is the sum of 100 millirem from external radiation and 70 millirem from internal radiation. The DOE limit is 5,000 millirem per year.

Your shallow dose equivalent was 400 millirem. The DOE limit is 50,000 millirem per year.

The dose equivalent to your extremities (hands, forearms, lower legs and feet) was 400 millirem. If you did not wear extremity dosimeters, this is set to your shallow dose equivalent. The DOE limit is 50,000 millirem per year.

Your cumulative effective dose equivalent through 1994 was 1,020 millirem. This is the sum of your total effective dose equivalents received at Energy Group facilities since 1989.

If you have any questions, contact the Y-12 Health Physics Department at (423) 576-5039.

Figure 4. Example of Annual Summary of Radiation Dose Report

Reports to DOE

At the end of the calendar year, when the results for all quarters are available, data for each individual are sent to the Radiation Exposure Information Recording System (REIRS). From these data, DOE prepares statistical frequencies of doses by dose ranges by facility.

Reports to Supervisors

Supervisors are also provided a listing of dose information for all department organizations. Figure 5 is an excerpt from such a table. From this information supervisors can make comparisons between departments.

Plant reports are generated quarterly through the ALARA Steering Committee. The individuals on this steering committee and their chairperson are appointed annually by the Facility Manager. The committee consists of (1) managers or their representatives from the divisions or departments having employees most influenced by ALARA objectives (departments with employees having the most exposure potential), and (2) persons who

have administrative responsibility for these programs. This group formulates the ALARA goals for this plant. One of the committee's tasks is setting of achievement goals for plant maximum collective dose in persons-rem and maximum dose to an individual. This committee meets each quarter after the previous quarter's results are available, reviews the current status of exposure limit goals for the plant and for the various plant departments, looks into any problem areas or situations, and checks the investigations of any radiation accidents or incidents during the previous quarter. Minutes of the meeting are sent to plant, division, and department managers.

LOCKHEED MARTIN ENERGY SYSTEMS Y-12 PLANT 3RD QUARTER, YEAR-TO-DATE RADIATION DOSE REPORT													
REPORT: RC001 STATUS: EMPLOYEE				YEAR: 1995 RAD/NONRAD: All				DATE: 28-NOV-95 ORG: Dept			PAGE: 6000		
Dept	TEDE (mrem)		CEDE (mrem)		DEEP (mrem)		SHALLOW (mrem)		Extremity (mrem)		No. in Group	No. TEDE >=100	Total TEDE (mrem)
	avg	max	avg	max	avg	max	avg	max	avg	max			
2A66-00	0	0	0	0	0	0	13	202	13	202	16	0	0
2A73-12	1	19	0	19	0	11	5	116	5	116	74	0	51

These data were excerpted from an actual report for illustration. However, the Dept identified is fictitious.
 CEDE = Committed Effective Dose Equivalent (Internal Dose).
 TEDE = Total Effective Dose Equivalent (CEDE + Deep Dose).

Figure 5. Excerpt From Quarterly Department Radiation Dose Report

COST AND RESULTS OF PROGRAMS

Extent and Cost of Programs

Presently, there are ~1,940 persons in the *in vitro* monitoring programs. Approximately 6,000 urine samples were run in 1995 in the monitoring of these persons. The estimated cost of these programs in 1995 was \$750,000 for laboratory costs and \$250,000 for the administration of the programs (\$1,000,000 total). This cost represents less than 10 percent of the total budget for the RADCON Department.

Recent Results

Of the 362 departments listed in the Lockheed Martin Y-12 Plant Third Quarter, 1995 Year-to-Date Dose Report, only 94 showed maximum internal CEDEs greater than zero. These maximum CEDEs ranged from 1 to 133 mrem. Only two departments showed maximum doses >100 mrem, 133 and 104 mrem, respectively. It is noted that many of the departments had no personnel on the internal monitoring programs and were listed as having zero maximum internal exposure.

EFFECTIVENESS OF PROGRAMS

Evaluations

The extremely fine control over internal doses at Y-12 are due to the well thought-out, comprehensive, and successfully executed RADCON Department monitoring and internal dose control programs. The personnel administering these programs seemed especially knowledgeable and conscientious. In addition, the high quality of the analytical protocols and their execution also appear obvious. The low MDA and bias, and high precision levels demonstrated by the ASO laboratories must be among the best, if not the best, in the country.

Observations

1. The doses from internal exposures are extremely low. These doses viewed in retrospect indicate that monitoring would not be required for almost all of these people using the current DOE criterion of 100 mrem for an annual dose as the level or potential level at which monitoring is required.
2. The development of a DOE accepted rationale for the use of Q-material as the basis for interpreting all routine results greatly simplifies program management with essentially no sacrifice of program effectiveness.

Recommendation

Consideration could be given to making the programs more cost-effective by reducing the sample load by either removing persons from the programs or extending the time between samples for more people.

INTERNAL RADIATION MONITORING PROGRAMS - *IN VIVO*

OVERVIEW

The Radiation Control (RADCON) Department at the Oak Ridge Y-12 Plant, currently operated by Lockheed Martin Energy Systems, Inc., maintains *In Vivo* Internal Radiation Monitoring Programs (*in vivo* programs). These programs are used to monitor the chest cavity of workers to detect and estimate enriched and depleted uranium and thorium in the lung. Presently the programs are considered secondary to the *In Vitro* Urinalysis Program in evaluating such exposures because *in vivo* monitoring is not sufficiently sensitive to measure at the 100 mrem Committed Effective Dose Equivalent (CEDE) level currently required by the Department of Energy (DOE) regulations.

Purposes of Programs

The purposes of the *in vivo* programs are to provide:

- Continuing monitoring for exposure to highly-insoluble uranium. A few incidents at the Y-12 Plant have resulted in significant exposure to uranium alloys or high-fired oxides with much longer half-lives than expected from the most insoluble of Y-12 uranium compounds. The amount of such materials in the lung would be underestimated by the *in vitro* programs.
- Continuing assurance that employees receive no major exposure to any radioactive materials detectable by *in vivo* methodology.
- A rapid determination if significant amounts of gamma-emitting isotopes are present in the lungs of persons involved in incidents.

Brief Description of Programs

The Y-12 Plant's *in vivo* bioassay protocol consists of directly scanning the chest of selected employees to detect low-energy gamma emissions from uranium or thorium, or associated progeny, that may be contained in the employees' lungs. By analyzing the energy and amount of the gamma spectrum obtained, an estimate of the amount and type of uranium or thorium within the chest can be made.

Exposure Potential

The internal exposure potential at the Y-12 Plant is mainly to uranium, either depleted or enriched, in the ^{235}U and ^{234}U isotopes. There is also a lesser exposure potential to ^{232}Th and ^{228}Th . Although *in vivo* monitoring is, or can be, programmed to quantify other gamma-emitting radioisotopes in the lung, there is presently no significant processing of such materials at the Y-12 Plant. Consequently, the *in vivo* activity counter is exclusively used for uranium and thorium monitoring.

Purpose of Report

The purpose of this report is to describe the Uranium *In Vivo* Monitoring Programs in detail. Capabilities for monitoring for other nuclides will also be briefly discussed. The report is part of a larger volume documenting currently installed monitoring programs at Y-12 that may generate data useful for health and safety activities or studies.

PROGRAMS

General

The Uranium *In Vivo* Program consists of a periodic or special monitoring of certain employees who:

1. have the greatest uranium exposure as indicated by the *in vitro* programs;
2. have been involved in an incident in which they may have received a significant internal deposition of uranium;
3. are newly hired or have transferred into an area where uranium is handled;
4. are terminees or transfers out of such uranium areas; or
5. are involved with special projects which have high exposure potential to insoluble uranium or thorium.

Although the exposure potential of uranium is almost entirely from the alpha particles emitted, low-energy gammas are also emitted. Consequently, individuals potentially exposed to uranium can be monitored for uranium in their lungs by: (1) placing them in a highly-shielded area, (2) monitoring the chest area with sensitive low-energy gamma detectors, and (3) analyzing the amount and energy of the gamma spectrum obtained.

Determining Who Participates

Participants in the *in vivo* programs are selected from those employees who participate in the Uranium Urinalysis Program. Persons who are assigned to the Uranium Urinalysis Program will be *in vivo*-monitored when first assigned to an area qualifying them for the urinalysis program and when they leave such an area by termination or transfer. In addition to routine *in vitro* monitoring, urinalysis program participants will be scheduled for *in vivo* monitoring if they: (1) are involved in an incident in which they may receive a significant exposure, (2) have relatively higher uranium urinalysis results, or (3) work on a project that has high exposure potential to known insoluble uraniums.

Scheduling Participation

Persons being hired or transferred into uranium handling areas are scheduled for a baseline *in vivo* lung count before or soon after they report to work in such an area. Terminees or transfers from such an area are scheduled for a lung count as part of a pretermination checkout procedure. As part of the report of the required investigation of any internal uranium exposure incident, persons involved are listed and scheduled for an *in vivo* monitoring count.

Quarterly, the manager of the Uranium Urinalysis Program prepares a listing of the individuals showing the highest urinalysis levels during the previous quarter. These persons are scheduled for an *in vivo* analysis. Should these individuals remain on the high urinalysis list in subsequent quarters, they will also remain on the Uranium *In Vivo* Monitoring Program.

Participation

Persons to be *in vivo*-monitored will be notified through their supervisor as to the date and time of their scheduled count. Participants will check in at the *in vivo* facility, give their badge to the operator who will sign them in, and then enter the body counter area through a change-shower room. Persons who have been in the uranium area just prior to the scheduled count will be asked to shower. All persons will be asked to remove their clothing and put on disposable paper coveralls and foot covers. They will proceed to the *in vivo* monitoring area where they will be weighed, their height measured, and their arms, face, and hair checked for contamination. A record of the contamination survey is entered on a form which is shown in Figure 1 of the Radiological Personal Contamination Survey Programs Report of this volume. Attempts will be made to decontaminate any individuals found to have external contamination, and those found with contamination will be rescheduled for monitoring later. Participants with no external contamination will sit in a reclining chair in the heavily shielded *in vivo* counting room where four detectors will be positioned over their chest, and a 30-minute count will be made. While this count is taking

place, the *in vivo* operator will enter all the previously obtained information into a computer.

After completion of this count, the participants will redress and will immediately be informed of the determined amount of *in vivo* uranium activity in their lungs or that the amount of uranium is below the Minimum Detectable Activity (MDA). Such reporting is possible because the computer program supporting the body counter provides a printout which shows either the MDA or the amount of activity determined, whichever is larger.

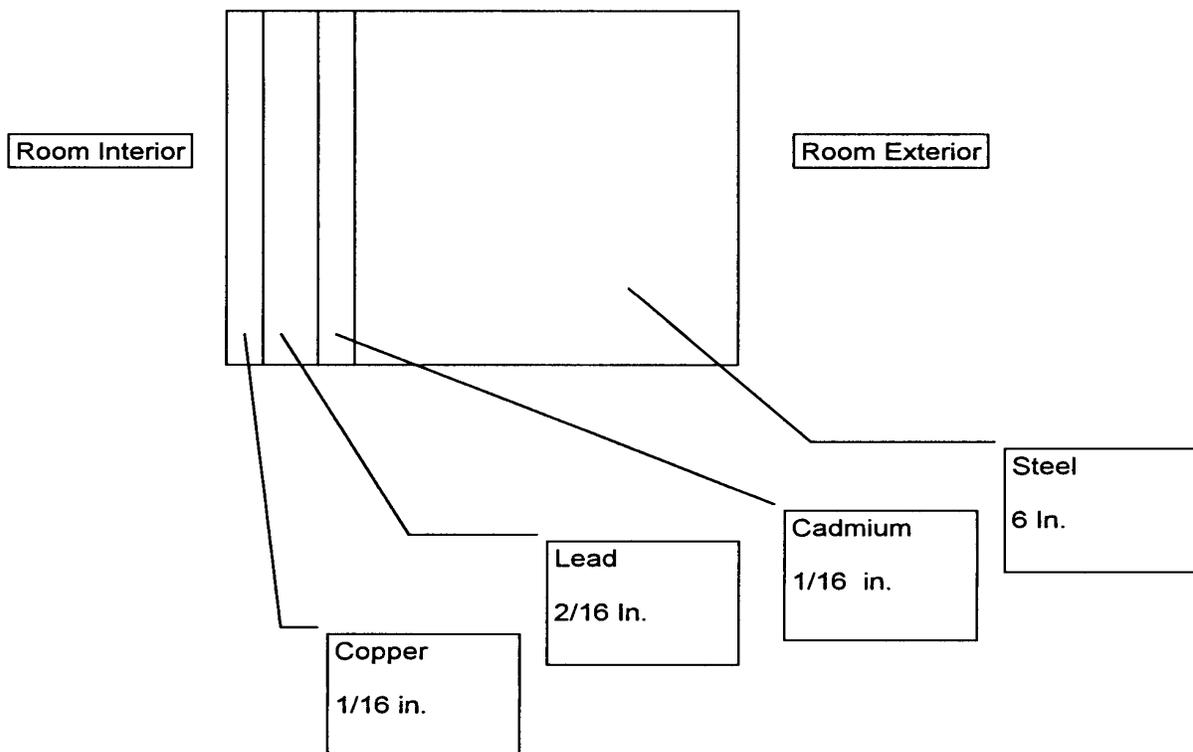
ANALYSIS

Description of Analysis Equipment

Shielded Room

In vivo counting is performed in a radiologically shielded room, 11' 2" wide, 11' 11" long and 8' high. The walls, ceiling, door, and other openings are shielded with steel, lead, cadmium, and copper; the floor is shielded with 6" of steel covered with stainless steel. Figure 1 is a schematic showing the thickness and positioning of these shields.

Figure 1. Y-12 *In Vivo* Counter Shielding Dimensions



Radioactivity Detectors

Four 20 cm² Low Energy Germanium (LEGe) detectors are used to detect gamma radiation

in the 20 to 400 keV energy regions. Signals from these detectors are amplified, digitized, sorted, and stored according to gamma energy in special electronic devices known as Acquisition Interface Modules. Data from the detectors are managed and manipulated by an integrated computerized operating system. The computerized operating system can control the acquisition, display, and analysis of spectral data.

Operating System

To acquire and analyze a lung count spectrum, the Y-12 *in vivo* counter utilizes a system consisting of the LEGe detectors, specialized electronics, and a dedicated Digital Equipment Corporation (DEC) VAX Station 3100 computer. The present detectors, electronics, and software were procured from DEC and Canberra.

With this system, the DEC VAX Station computer can: (1) store, analyze, and display the spectrum obtained, (2) track the quality assurance data base, (3) set up, maintain, and use a nuclide library, (4) determine the background activity of the persons being counted, (5) determine the MDAs for each person counted for each nuclide in the library, and (6) print a report of each lung count showing the actual activity (nCi) detected if it is above the MDA, or showing the MDA if the results are below that level.

Quality Control of Analyses

Verification. Prior to the *in vivo* counting system being used for routine counts, a series of verifications and validations were performed to: (1) assure the hardware was functioning properly and the software performing calculations as intended using the prescribed algorithms; and (2) establish parameters for planned daily quality assurance checks. The verification and validation processes were repeated in 1995 to assure that software upgrades installed since start-up had not significantly changed the intended performance of the system. The 1995 verifications and validations showed the original parameters established for the daily quality assurance checks described below were still valid. The software provider now furnishes certification that any software upgrades do indeed produce results that are comparable with those obtained from previous software. The relative bias and precision measured at the time of these verifications and validation tests were +0.96% and $\pm 1.05\%$, respectively. These were measured at the lower end of the Minimum Testing Level for enriched uranium specified in the Draft ANSI Standard N13.30 of 30K to 60K Bq and were well within the relative bias of -25% to +50% and the relative precision of $\pm 40\%$ specified by this standard.

DOELAP. Although there has been discussion about establishing a Department of Energy Laboratory Accreditation Program for lung and body *in vivo* monitoring, this has yet to be done. If and when such a program is established, it is the authors' opinion that the Y-12 facility will perform well in measuring the isotopes which are in its library.

Quality Assurance

In order to assure that all aspects of the *in vivo* counter (detectors, assorted electronics, computer software, and hardware), are performing as intended, a performance Quality Assurance (QA) package is assembled each day before any subjects are counted. The collection of these data on a routine basis over a long period of time makes it possible to identify small changes and trends. The assembled QA package also documents administrative control over the system and validates lung counts made on the system. The QA package consists of three parts:

1. *Energy Calibration.* The spectral energy calibration is performed with the use of a mixed gamma calibration source in a holder. The detectors are positioned vertically so that each detector is pointed toward the center of the holder. The shielded room door is then closed and the calibration update computer program is run. After the data acquisition is complete, the system prompts the user to review and accept or flag the updated energy calibration for each detector. The *In Vivo* Program Manager is notified of any out-of-bounds calibration flags, and the information printed during the operation is placed in the QA package.
2. *Environmental Background Check.* An overnight count is made of the counter room which contains all items present during routine counts (except the subject). These results are printed at the termination of the count. At the beginning of the day, the background check report is reviewed for out-of-bounds values, and the *In Vivo* Program Manager is notified if any out-of-bounds values are found. The printed results of this check are placed in the QA package.
3. *The Lawrence Livermore National Laboratory (LLNL) Phantom Count.* The LLNL Phantom is used with a National Institute of Standards and Technology traceable source lung set to make a phantom count. With the phantom placed in the examination chair, the detectors are positioned with the end caps lightly touching the phantom in the centers of drawn circles on its chest. The counting room door is closed and the phantom count is collected. After the count is completed, the report is reviewed, and the manager is notified of any out-of-bounds condition flags. The report generated from this count becomes part of the QA package.

These three reports are sent to the *in Vivo* Program Manager for approval and are placed in the QA logbook as a continuing record.

Minimum Detectable Activity

As mentioned above, the Y-12 *in vivo* counter computer can use the information generated during a count with an established algorithm, to determine the background for each channel in the field of interest. Using these background counts and counting statistics, the computer is programmed to calculate a count-specific standard deviation for each field of interest. The MDA is calculated using this standard deviation and the usual formula

developed by Currie. Spokesmen at the Y-12 Plant report this MDA as typically 0.2 nCi of ^{235}U and 3.0 nCi of ^{238}U . The actual MDAs for ^{235}U varied from 0.04 to 0.6 nCi for the persons counted in 1995.

Reporting the MDA as functions of ^{235}U and ^{238}U is traditional, but misleading to the uninitiated. About 97 percent of the activity of fully-enriched uranium (93% ^{235}U , 1% ^{234}U) comes from the ^{234}U , so the quoted MDA of 0.2 nCi for ^{235}U translates to an actual MDA of 6.7 nCi of fully-enriched uranium. The ^{238}U situation is less acute since about 83% of the activity in depleted uranium is ^{238}U which makes the actual MDA for the mixture about 3.6 nCi. Both of these MDAs are more than would be expected in Y-12 personnel given the air levels that have been reported over the past year as shown in the Radiological Air Monitoring Programs Report of this volume.

Other In Vivo Capabilities

The *in vivo* counter is also calibrated for the ^{232}Th progeny, ^{228}Ac , since the measured amount of ^{228}Ac is related to the amount of ^{232}Th . The amount of ^{232}Th found in the lung, or the MDA whichever is larger, is reported for each lung count. Thorium is no longer being processed at the Y-12 Plant. However, since there is still thorium contamination from previous processing, and since occasionally there is special processing of thorium, the *in vivo* counter is still used to monitor for thorium by including a thorium determination when any count is made. The *in vivo* counter could be used to estimate the amount of many gamma emitters in the body if the isotopes were contained in the isotope library, and the system were calibrated and programmed for such estimations.

In addition, uranium and other gamma-emitting isotopes could be measured in organs other than the lung if appropriate manikins and isotope-loaded organs were available for calibration and the other necessary steps taken to establish such a program.

USE OF RESULTS

Calculation of Dose

Since the present system was implemented, no dose calculations have been performed during routine *in vivo* lung counts because all results have been less than the MDA. Should there be a case when the results are confirmed being above the MDA, the lung count data would be evaluated by internal dosimetrists to decide how the results should be used with urinalyses and possibly fecal analyses data to determine dose.

Limit and Action Levels

Any results greater than the MDA would be compared to established limit and action points. The limit for internal exposure as measured by *in vivo* monitoring is that amount of activity in the lung that would result in a calculated CEDE of 5 rem. This activity amount has not been observed at the present counting facility since it was put into service in 1992. In addition, the limit cannot be quantitated in terms of an activity amount in the lung without considerable additional explanatory discussion; therefore, it will not be further discussed in this report.

As noted in the first paragraph of this report, the activity in the lungs corresponding to 100 mrem CEDE prescribed by DOE for required monitoring is less than the MDA for this equipment. Consequently, any confirmed positive result is above the established action level. The absolute amount of activity for this action point varies from count to count since a MDA based on person-specific factors, such as height and weight, is calculated for each count.

Records

As noted above, a record of each activity measurement is printed by computer at the end of the count. This record, along with a computer printout of the spectrum obtained, is filed in the associated individual's monitoring results folder. This record, including the spectral plot, is also maintained in electronic format on a compact disk. The results and the MDA also are maintained in the Bioassay Data Management System, a part of the Occupational Health Information System which is discussed in more detail in Retrospective Dose and Exposure Reporting Programs in Volume II.

Reports

Other than the immediate reporting of lung counts to the participating individuals, there is no other reporting of these counts outside the RADCON Department unless an individual has been involved in an incident. In the case of an incident, the lung count results, as well as any urinalysis and fecal results, are reported to the involved individual(s) and supervisor(s).

COST AND RESULTS OF PROGRAMS

Extent and Cost of Programs

During the last year, approximately 400 persons have had around 600 lung counts. It is estimated that the *in vivo* programs cost roughly \$250,000 per year. This is a small percentage of the total annual Y-12 RADCON Department activities cost (approximately \$14 million).

Recent Results

Since the present counting facility began operating in June 1992, there have been no confirmed results greater than the MDA. It is the authors' opinion that all monitoring results should be calculated and entered on the report regardless the level of results with respect to the MDA. To do otherwise truncates the full universe of monitoring information and may limit a full evaluation of exposure, since any truncated data are unavailable for scrutiny and averaging.

EFFECTIVENESS OF PROGRAMS

Evaluation

The *in vivo* counting facility appears to be exceptionally well managed and operated, with fine quality control and assurance programs.

Observations

1. The *in vivo* programs provide continuing assurance, based on objective measurement, that the persons being counted do not have more than MDA amounts in their chest cavities.
2. With minor changes in the operating system computer program, the computer-generated record could show the amount of uranium in the lung, as estimated by the count, with no truncation of data.

Recommendation

The operating system computer program should be changed to record both the amount of uranium indicated by the count and the MDA on hard copy and electronic records.

RADIOLOGICAL AIR MONITORING PROGRAMS

OVERVIEW

Purpose of Programs

Air monitoring programs are essential to evaluate the potential hazards of working where radioactive materials may become airborne. Air sampling data often provide the basis for developing and evaluating operational procedures, and can indicate if engineering controls or operational changes are necessary to adequately protect workers. The data from air sampling are also used for assessing the effectiveness of procedures for containment of radioactive materials and the control of airborne radioactive material in the workplace. Finally, air sampling data can be used to estimate personal exposure if urine and *in vivo* results are not available.

Brief Description of Programs

The primary function of these monitoring programs is basically the same. Air samples are collected by vacuum air pumps that draw known amounts of air through filter paper. Pertinent information relative to each air sample is documented either electronically or manually. The air samples, along with their respective and relative information, are taken either to the plant laboratory to be analyzed by alpha scintillation by Analytical Services Organization (ASO) radiochemistry personnel, or counted by Radiological Control (RADCON) Department personnel with the use of applicable portable radiation counters or radiation detection instruments.

Exposure Potential and Monitoring

The Department of Energy's (DOE) Y-12 Plant in Oak Ridge, Tennessee, operated by Lockheed Martin Energy Systems, Inc., (LMES) maintains air monitoring programs to evaluate and help control potential internal exposure from radiological air contamination. Presently the only significant potential for internal exposure to radiation at Y-12 is to enriched or depleted uranium.

Purpose of Report

The purpose of this report is to describe the Radiological Air Monitoring Programs with particular emphasis on the use of the generated results. This report is part of a larger

volume aimed at documenting current exposure monitoring activities that may generate data useful for health and safety activities or studies.

OPERATIONAL AIR MONITORING PROGRAMS

Programs

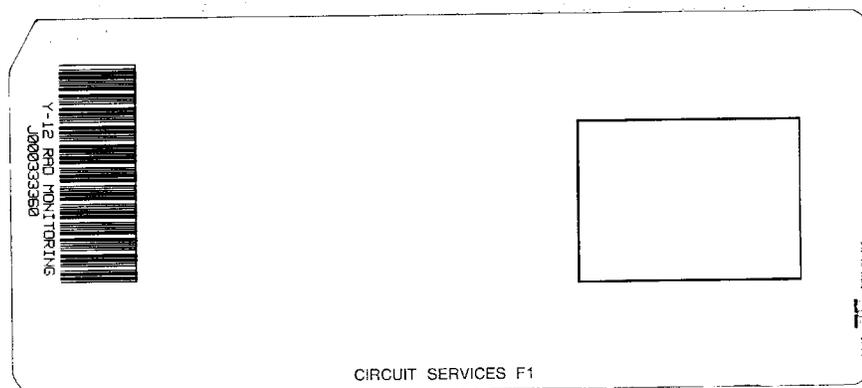
There are five specific Uranium Air Monitoring Programs that evaluate exposure potential and complement the Personnel Internal Monitoring Programs. Since retrospective uranium air sampling is the RADCON Department's primary air sampling program, it receives the most coverage in this report. The Continuous Air Monitor (CAM) Program is second in importance and is discussed in lesser detail. Three other air monitoring programs are used infrequently for special situations and are briefly discussed.

Retrospective Uranium Air Sampling

General Description

Retrospective uranium air monitoring consists of continuous sampling (daily to weekly) with subsequent off-line analysis to determine the average airborne radioactivity level during the sampling period. It is used to (1) signal losses of system containment, (2) provide data to determine appropriate levels of personal protective equipment, and (3) make decisions on frequency of area air sampling.

Retrospective air sampling utilizes fixed location sampling heads connected to central vacuum systems. The air samplers have a flow rate of 17 liters per minute producing a collection efficiency of at least 95 percent. Sampled air is drawn through a 1.0 inch diameter portion of the filter held within a card (Figure 1).



**A i r
C a r d**

**Figure 1.
S a m p l e**

Retrospective operational air samples are used in occupied areas where, under normal operating conditions, a person could receive an annual intake of two percent or more of the specific Annual Limit of Intake values, i.e., 40 Derived Air Concentration (DAC) hours. This amount of exposure generally represents a Committed Effective Dose Equivalent to a person of approximately 100 mrem.

Sampler Change-Out Frequency

A structured procedure is followed to determine air sampler change-out frequency. Computer-generated average d/min/m³ and maximum d/min/m³ for each monitored area are published for each month. Sampling frequency is changed as needed to maintain consistency with area averages and maximum criteria as indicated in the table below.

Table 1. Sampling Frequency as Based on Average or Maximum

Frequency	Average d/min/m ³	Maximum d/min/m ³
Daily	>4.4	≥44.0
3 times a week	>0.8-4.4	<44.0
1 time a week	<0.8	<44.0

Samplers are placed at strategic locations in normally occupied areas at a height of 6'4" to detect and evaluate airborne radioactivity near actual work locations. The air sampler which holds the air sample card with its filter paper insert is shown in Figure 2. The rate at which air is drawn through the filter is adjusted by use of a rotameter.

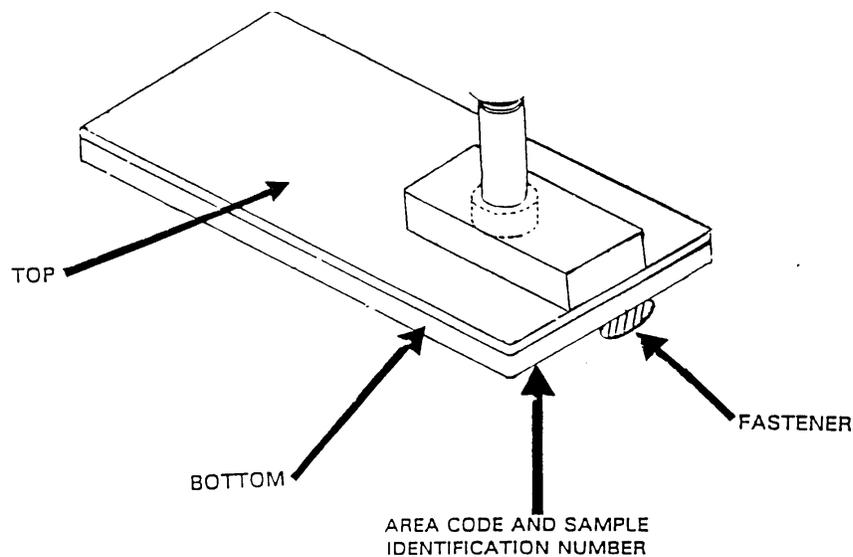


Figure 2.
Card Holder

Sample

Samplers are calibrated monthly (or when the calibration becomes suspect) for flow rate by using a standardized flow ratemeter (Figure 3). With the standardized flow ratemeter attached to the sampler, the flow is adjusted to obtain the required flow rate.

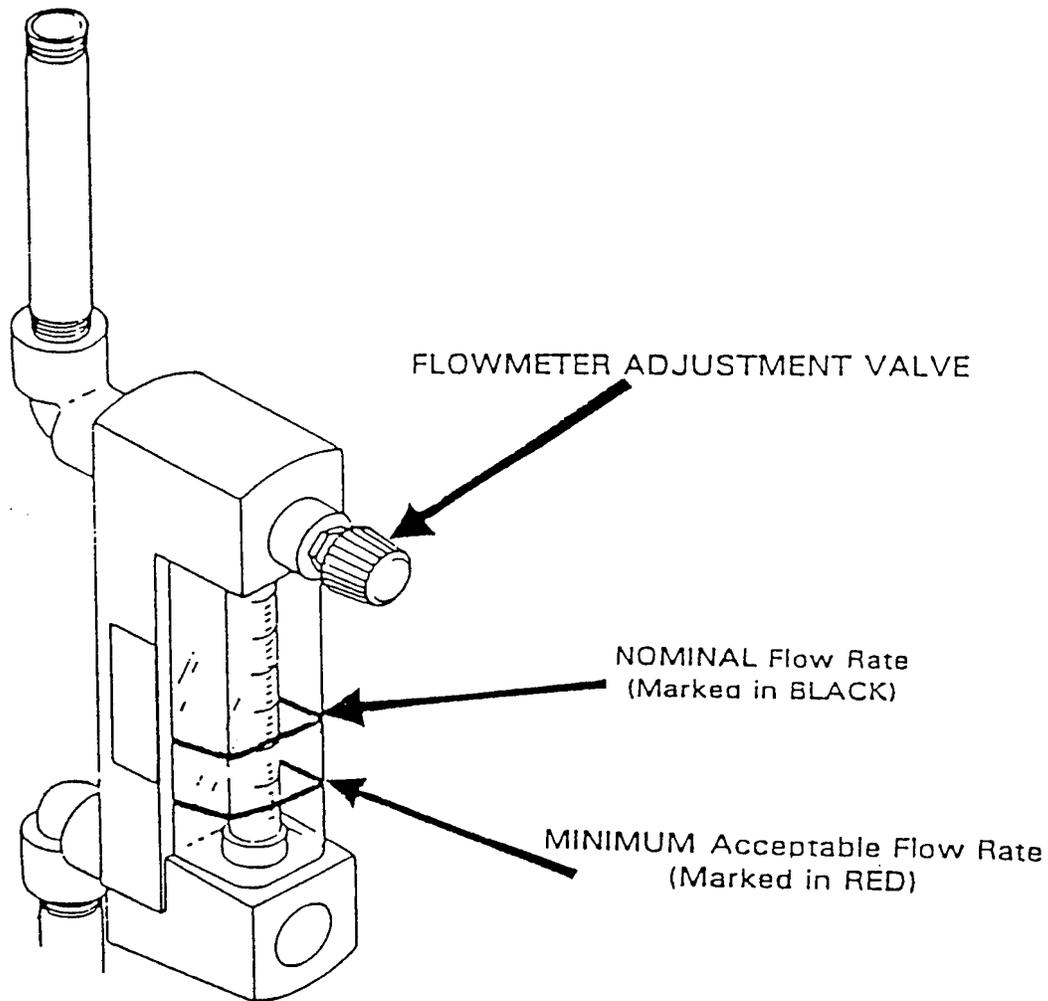


Figure 3. Flow ratemeter

gur

Sampling

A vacuum air pump connects to several samplers strategically located within an area. Each field office is equipped with several Intermec 9440 Trakkers and Scanners (Figures 4 and 5).

TRAKKER MENU
 F1 = NEW/DEL DD = DATE
 F2 = ROUTINE KK = DEL
 F7 = XMIT
 (Date) (Time)

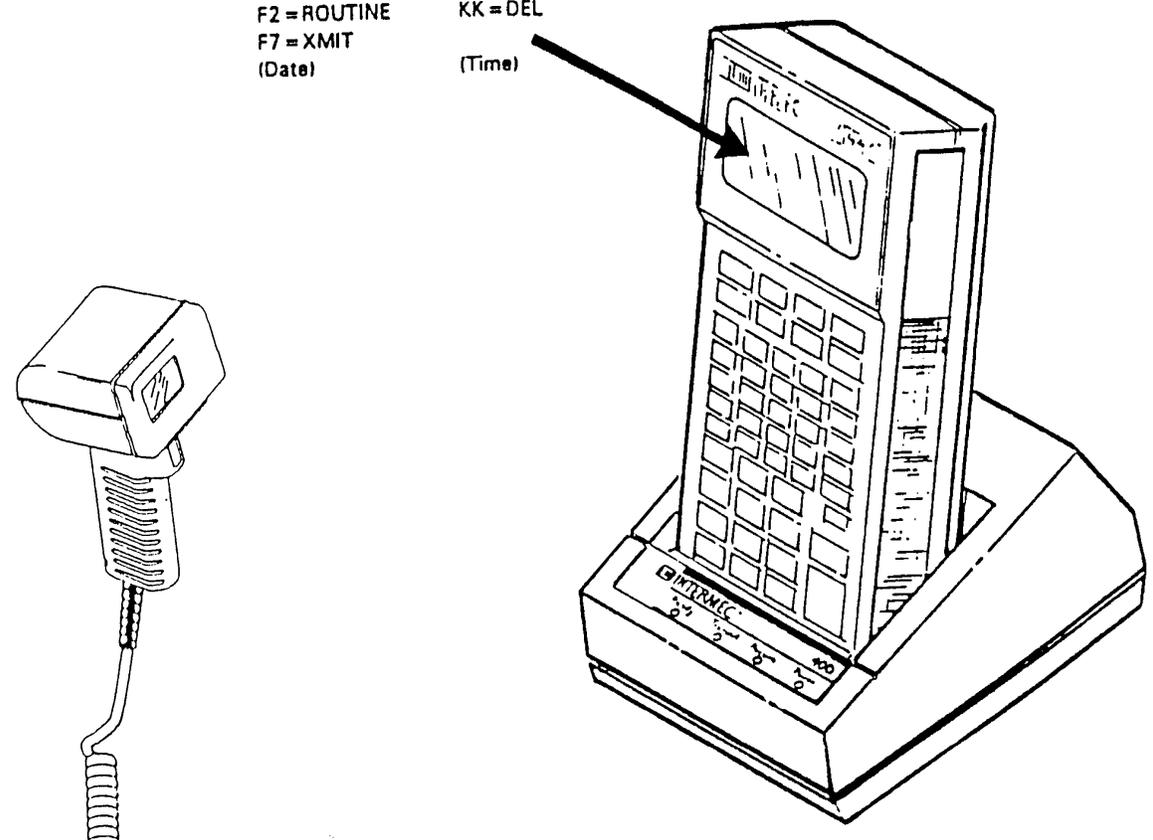


Figure 4. Intermec 9440 Trakker

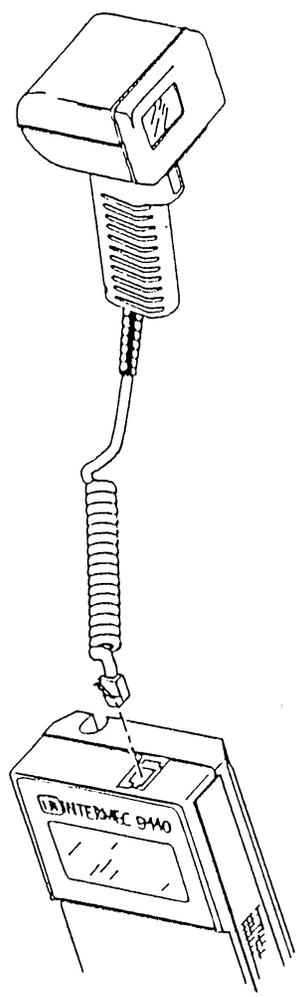


Figure 5. Intermec Scanner

This equipment is used to associate the air cards with such information as the RADCON Technician (RCT) performing the sampling, sampler location, flow rate, sampled area, and sampling date. The process for assigning the air card and air card information is as follows:

- RCT proceed to the intended sampling location.
- Scan badge of RCT.
- Scan air sampler location bar code on sampler.
- Scan flow rate bar code on flowmeter.
- Scan the bar code of the air filter card currently in the sample holder.
- Open the sample and remove the air filter card currently in the sampler.
- Scan the bar code of the air filter card to be used.
- Insert this filter card into the sampler.
- Place the used air filter card in a plastic bag.
- Proceed to the next sampler location and repeat the above process.
- All information is uploaded from the Trackker to the computer center at the K-25 Plant to be combined with analysis data similarly transmitted from the ASO laboratory.
- Information is processed and a computer printout is issued to RADCON Department and appropriate operations personnel.

Each air sample is identified by the unique bar code on the sample filter card which is used to electronically relate all the scanned information described in the previous paragraph to that sample.

Sample Analysis

Analysis. The samples collected on filter cards from operating areas are delivered to the plant laboratory for gross alpha analysis. Analysis is performed by ASO radiochemistry personnel using alpha scintillation counting. The cards are processed through an instrument that reads bar code information, removes the air filters from the cards, and places each filter into an analysis vial. Racks of the vials are placed into muffle furnaces overnight to destroy the paper matrix. A milliliter of concentrated acid is added to each vial with an automated dispenser. The vials are heated on a hotplate to convert the uranium in the filter ash to soluble uranyl nitrate, and the acid is evaporated to dryness. After cooling, a small amount of water and approximately seven milliliters of scintillation fluid are added to each vial with the automated dispenser. The vials are capped with an automated

capping machine and shaken to obtain clear homogeneous solutions. Each sample is then counted five minutes in an automated liquid alpha scintillation counter which is networked to a server computer that contains the initial sample bar code information. The analytical data are merged with the other data relevant to each sample in the server system, reviewed, and electronically transferred to a mainframe computer located at the K-25 Plant.

Minimum Detectable Activity (MDA). The average MDA for the laboratory's counting system is 2 d/min/filter. The MDA is calculated as

$$\text{MDA} = 4.65 (B)^{0.5} + 2.71/(E)(T)(R)$$

where

B = instrument background count

E = alpha counting efficiency (average E = 0.95)

T = counting time in minutes (T = 5 minutes)

R = recovery (R=1)

Quality Control (QC). The QC program consists of established procedures and activities such as sampler calibration, formalized training of the RCTs, and an internal control sample program maintained by the plant laboratory. Plant laboratory instruments are calibrated using a National Institute of Standards and Technology (NIST) traceable source. In addition, the scintillation counters are checked during operation using one of four levels of control standards. One standard is counted with each of the ten routine samples. Results for the calibration and control standards are maintained on control charts. An external blind sample control program is also maintained by the ASO QC Department in which a known amount of uranium is added to a sample paper which is sent to the laboratory for analysis, after which the laboratory results are compared to the amount of uranium added.

Use of Results

Limits and Action Values. Levels of uranium in air determined as described are compared to the DAC Limits and Plant Action Values (PAV), and if warranted, appropriate action is taken. The DAC for Class Y uranium is 44 d/min/m³ which is the level at which respiratory protection is required. The Y-12 Plant maintains the conservative position that all uranium within the plant belongs to this class. The Y-12 PAV of 4.4 d/min/m³ (1/10 of the DAC) is the level at which action is taken to determine the cause of the elevated air sampling result, and sampling frequency is assessed. Formal investigation is performed when the level of uranium exceeds 40 DAC-hours by completing Form-RCO-23, "RADCON Information Summary Sheet for Uranium Air Counts >40 DAC-hr" (Figure 6). In addition, areas that average 4.4 d/min/m³ or more must be posted as Airborne Radioactivity Areas which require radiation work permits for entry. Since the RADCON Manual only prescribes 10 percent of DACs as PAVs, the 4.4 d/min/m³ used only applies to Y-Class uranium

compounds. Compounds such as "D," "W," or "Q" would have significantly higher DACs and PAVs.

Form-RCO-23
Revised: 04/02/96

**RADCON INFORMATION SUMMARY SHEET
FOR URANIUM AIR COUNTS > 40 DAC-hr**

RADCCN TECHNICIAN NAME	BADGE NUMBER	DATE
------------------------	--------------	------

(1) Elevated Air Counts (> 40 DAC-hr)

Building/Area	Sample Code & Number	Date	Results (dpm/m3)
	1. _____	_____	_____
	2. _____	_____	_____
	3. _____	_____	_____
	4. _____	_____	_____
	5. _____	_____	_____

(2) Were Caused By:

Which Operation:

- (A) Trap Change
- (B) Filter Change
- (C) Maintenance Operation
- (D) Ventilation Problem:
 - 1. Failure ()
 - 2. Planned ()
- (E) Other

(A)
(B)
(C)
(D)
1.
2.
(E)

(3) Respirator Worn?

YES NO

If yes, indicate type:

- _____ 1. Half Mask (provides protection for air counts up to 440 dpm/m3)(air counts >440 dpm/m3 require urine samples and/or body counts).
- _____ 2. Full Face (provides protection for air counts up to 2,200 dpm/m3)(air counts >2,200 dpm/m3 require urine samples and/or body counts).
- _____ 3. Supplied Air Half-Face (provides protection for air counts up to 2,200 dpm/m3)(air counts >2,200 dpm/m3 require urine samples and/or body counts).
- _____ 4. Full-Face Supplied Air (provides protection for air counts up to 44,000 dpm/m3)(air counts >44,000 dpm/m3 require urine samples and/or body counts).
- _____ 5. Positive Pressure Self-Contained Breathing Apparatus (SCBA) (provides protection for air counts up to 440,000 dpm/m3)(air counts >440,000 dpm/m3 require urine sample and/or body counts).

(4) Personnel Involved?

No No personnel known to be in area or proper respiratory protection worn.
Yes

Employee Name	Employee Badge No.
_____	_____
_____	_____
_____	_____
_____	_____

Fig 6 .
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REVIEW AND APPROVAL

DISTRIBUTION:
Operations Supervisor Dosimetry Services File

RCT Supervisor

Date

REFERENCE:
70-105

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The above limits and action levels are shown in the RADCON Manual, Y/DQ-29 Document, “*Technical Basis for Workplace Air Monitoring of Airborne Radioactive Material at the Y-12 Plant,*” and Plant Procedure Y-70-105, “*Exposure Limits and Administrative Control Levels.*” The use of the most restrictive limits and action points related to Y-Class uranium compounds is justified on the basis that this use is the most conservative and consequently the safest. This policy is also the most expensive to administrate.

As Low As Reasonably Achievable (ALARA) Goals. One of the ALARA goals for 1995 was to keep the number of airborne radioactivity events to not more than ten. In fact, only two airborne events occurred. An airborne event occurs when air concentrations reach a level that might result in an employee receiving an internal exposure of 100 mrem or greater (air concentrations equal to or exceeding 40 DAC-hours). The ALARA goal for 1996 is to keep the number of airborne events to not more than five.

Records. When the Y-12 Plant laboratory completes analysis of the airborne uranium sampling filters, the data are electronically transferred to two miniframe computers located at the K-25 Plant. For maintaining data after entry, retrospective uranium air sample card data are uploaded to two mainframe computers at the K-25 Plant. These data are maintained by the Computer Services Department at the K-25 Plant and may be retrieved by requesting desired reports from that group.

Records of air sampling results are maintained in such a manner to provide a chronological historical record that meets the requirements of the American National Standards Institute (ANSI) contained in document N13.6-1972, the ANSI “*Practice for Occupational Radiation Exposure Records Systems.*” Data may be selected, compiled, and presented in many formats, as desired by the requestor.

Reports. For current reporting, an established frequency of issuance is specified by the RADCON Department. Examples of routine reports currently provided by the Computer Services Department are listed below by title.

- Uranium Air Sampling Results for year-to-date.
- Daily Uranium Air Results > Plant Action Level.
- Uranium Air Results - monthly ten highest-depleted uranium samples.
- Uranium Air Results - monthly ten highest-enriched uranium samples.

- Uranium Air Results - sorted according to average d/min/m³ and maximum d/min/m³.
- Monthly Uranium Air Results by location.
- Averages for enriched and depleted uranium with 95% confidence limits.

Some reports are provided to production operations supervisors for posting in their respective areas to inform workers of air concentration trends.

Decisions and Actions Based on Program Results. Air sampling results are utilized in making decisions regarding employee exposure potential, evaluation of operating techniques, and assessment of material containment for hoods and glove boxes. The air sampling results also are used in responding to indications of problems within an area or at an operation. These problems may then be corrected after further evaluating the air data within the area or at a specific operation of concern. An evaluation of the impact of new materials, procedures, or facilities may also be made using this information. Air data may provide information for respiratory protection requirements; however, with air samples showing such low levels as in 1995, results are seldom utilized for this purpose other than to provide continuing proof that air levels are in good control.

Air sampling data are used to assist in administrative control when evaluating the overall air monitoring programs, or within specific areas or at a specific operation. This may be accomplished by (1) providing data for graphs or charts that indicate trends; (2) generating reports that highlight those areas or locations having the highest air samples; (3) generating reports listing the ten highest sample results with locations; (4) using the data for determining appropriate sample change-out frequencies; (5) using the data to compare uranium air contamination levels with a production index; and (6) providing other sample data used by the RADCON Field Operations Section Manager in the overall administrative control of the Uranium Air Monitoring Programs.

Air sampling data generally are not used for exposure or dose estimates; however, measurements of airborne uranium can provide crude indications of exposure potential. Elevated levels of airborne uranium contamination, in a specific area or at a specific operation, would serve as an indicator that personnel, within this area or involved with the specific operation, should be monitored for possible internal uranium exposure.

Cost and Results of Programs

Size and Cost of Program. Currently, there are 568 permanently installed air samplers in 83 operating areas. There were 56,012 air samples collected by this system in 1995. The cost of maintaining the current Operational Retrospective Air Monitoring Program is \$1.4 million which is 10 percent of the overall cost of the RADCON programs.

Recent Results. Table 2 shows typical air sampling results for individual air samples for the first quarter of 1996. Table 3 shows the average results of five highest air samples in the depleted uranium areas during February 1996. The average for the last 12 months is shown for comparison.

Table 2. Uranium Air Sampling Results for Year-to-Date Area Sampler Means (Jan. 1996-Mar. 1996)

Area Sampler	No. of Samples	Average d/min/m ³	Maximum d/min/m ³	Area Sampler Description
02C A01	10	0.1	1.1	Room 154, above scales east, 9995 Lab Rm 154
02C A02	10	0.1	0.3	Room 154, above scales, west, 9995 Lab Rm 154
02C A03	10	0.1	1.4	Rm 152, above balance, 6447, 9995 Lab Rm 154
02C A04	10	0.0	0.1	Rm 152, above balance, 6414, 9995 Lab Rm 154
02C A06	10	0.0	0.1	Room 158, hood 54, dissolve and filter, 9995 Lab Room 154
02C A07	10	0.0	0.0	Room 158A, hood 41, grinding, 9995 Lab Rm 154

Table 3. Uranium Air Results: Five Highest Air Sampler Averages for Depleted Uranium Areas During Feb. 1996

Ranking	Sampler Code	d/min/m ³ Average ^{*†}		Area/Sampler Location
		Feb 96	Last 12 months	
1	58AA10	1.8	0.2	9401-5 Chip oxidation facility; FI between # 4 & #5 oxidizers
2	17BB11	1.7	0.8	9215 P-Wing
3	58AA09	1.2	0.2	9401-5 Chip oxidation facility, fl between #3 and #4 oxidizers
4	16GA37	1.1	0.8	9201-5 ARC melt 2nd fl., S. End of new salvage saw
5	18AA15	0.9	0.5	9204-4 Press area 1st floor, N.E. corner of furnace B-1015

^{*†}From comparing the results of 163 uranium samplers located in the Y-12 Plant.

Table 4 shows selected first quarter results and illustrates how these results are used to determine sample change-out frequencies in the subsequent quarters. Table 5 shows average results of all air samples taken in the plant during the third quarter of 1995 along with confidence levels with a statistical breakdown of samples greater than the PAV and DAC. Totals for the first three quarters of the year are also shown in this table.

Table 4. Area Averages for First Quarter 1996

OBS. No.	Area Code	Total Samples	Average d/min/m ³	Maximum d/min/m ³	Revised Frequency of Change-Out	Area Description
1	13E	8	11.28	154.2	Daily	9212 Rm 1008
2	13S	4	4.96	31.4	Daily	9212 E-Wing basement enclosures
4	11Q	4	1.05	3.7	Mon, Wed, Fri	9212 Receive and Ship Rm 1004
5	13C	5	0.91	7.0	Mon, Wed, Fri	9212 E-wing Basement Open

Table 5. Third Quarter and 1995 Uranium Air Results: Enriched and Depleted Averages with 95% Confidence Limits.

Areas	Quarter & Year	No. of Samples	Average d/min/m ³	95% Confidence Limits \pm dpm/m ³	Area Sample d/min/m ³			
					No. >4.4	% >4.4	No. >44	% >44
Enriched	3/95	7139	0.30	0.03	86	1	4	0
Depleted	3/95	2088	0.04	0.01	0	0	0	0
Enriched & Depleted	3/95	9227	0.25	0.02	86	1	4	0
Enriched & Depleted	1995	35181	0.37	0.01	465	1	10	0

Program Effectiveness

Evaluation. The Retrospective Uranium Air Monitoring Program appears to be more than adequate to provide the necessary information for evaluating the potential hazards of working where radioactive materials may become airborne and to assist in controlling levels of exposure to the employees. The program performs well especially when used in conjunction with other air monitoring programs, i.e., the CAM Program, the Personal Air Monitoring Program (breathing zone samples), and the Low- and High-Volume Air Monitoring Programs. These programs will be briefly described in the following discussions of the RADCON Department's special air monitoring programs.

Observations.

1. Uranium air levels in Y-12 are very low. This is judged to be the effect of a fine RADCON air contamination control program and the fact that production has been low resulting in the exposure potential also being minimized.
2. The criteria for sampling frequency are conservative. The average sampling frequency in FY1995 approached two times per week, yet less than one percent of the samples exceeded the conservative PAV of 4.4 d/min/m³ and less than 0.02 percent exceeded the equally conservative DAC of 44 d/min/m³.
3. The air DAC is based on all exposures being to Y-Class material. The urinalysis interpretation is based on exposure to Q-Class (as discussed in the Internal Radiation Monitoring Programs - *In Vitro* Report) which is more realistic for the Y-12 material as judged from the authors' many years of experience.

Conclusions.

1. With airborne uranium concentrations at the levels presently being measured by the Retrospective Uranium Air Monitoring Programs, consideration should be given to reducing the number of samples collected. This could be done in the following ways:
 - (a) Reduce frequencies at which samples are collected. Although different uranium compounds have different DACs, Y-12 has chosen the most restricted solubility class DAC (Class Y) for workplace radiological control. As noted above, approximately one percent of the samples exceeded the conservative action point. In areas where operations have been suspended or discontinued, consideration should be given to discontinuing sample changes, or only change every second or third sample.
 - (b) In some areas, operational air samplers are located at specific operations or dry boxes where work is no longer being done. These samplers could be temporarily taken out of service until operations resume.
2. Consideration should be given to using appropriate DACs for each material being handled (D-Class, W-Class, or Special-for-Y-12 Q-class) to make program decisions rather than to take the very conservative position that all Y-12 material is Y-Class, especially when very little material is actually of that class. This could greatly reduce the program size and cost.

Continuous Air Monitor Program

General Information

The Eberline Alpha-65 CAM is used at the Y-12 Plant to measure the levels of airborne radioactivity in the workplace (Figure 7). The CAM is a real-time system with audible and visible alarms to alert personnel to the presence of airborne radioactivity above predetermined levels. The CAM Program supplements the Retrospective Uranium Air Monitoring Program.

Continuous air monitoring equipment is operated in occupied areas where a person without respiratory protection might be exposed to a concentration of radioactivity in air exceeding one DAC, or where there is a need to alert potentially exposed workers to unexpected increases in the airborne radioactivity levels.

When a CAM is in operation inside an area, it normally runs 24 hours per day, seven days per week. Because CAM alpha spectrometry performance is best when filter dust loading is low, filters are changed daily because this reduces dust loading and enhances performance.

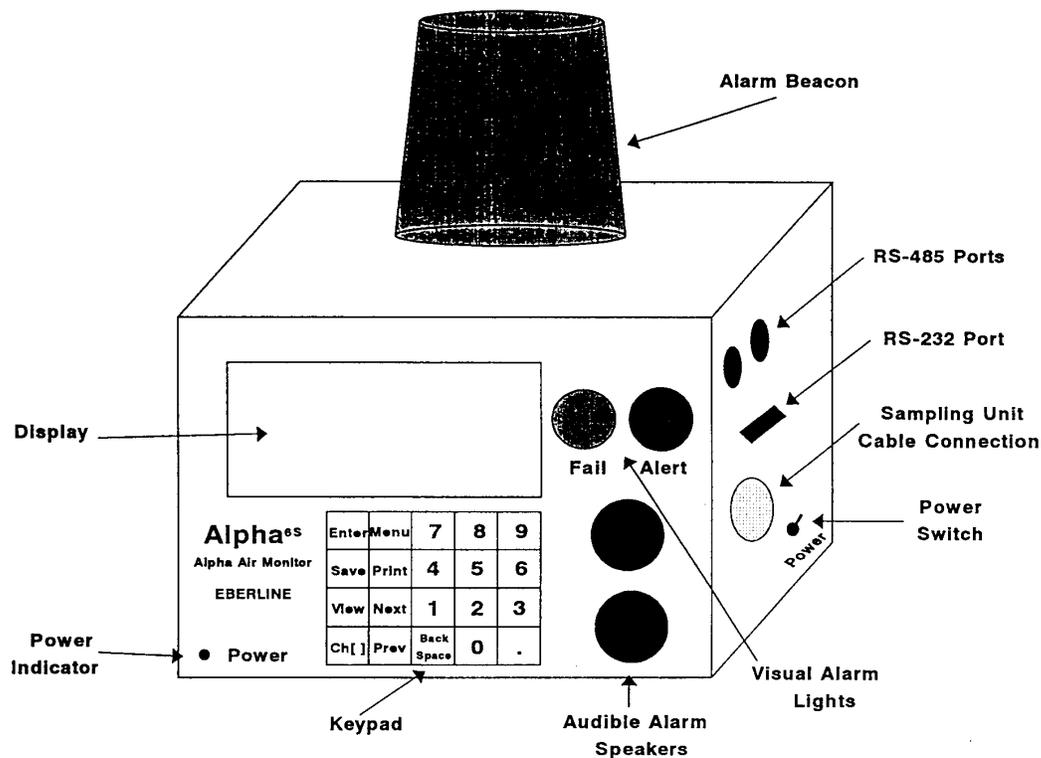


Figure 7. Eberline Alpha-65 Continuous Air Monitor

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Program Coverage

The Y-12 Plant currently has four CAM units which are used in two areas. Presently, there are 15 RCTs trained and qualified on routine CAM operation. The CAM Program Manager assists in determining locations for the installation and retirement of CAMs. CAMs cost approximately \$9,000 per unit and a RCT will spend approximately 2.5 hours per week maintaining a CAM (longer if the CAM alarms). CAM detectors are fragile and cost approximately \$550 per detector. The CAM Program Manager indicated that Y-12 replaces, on average, one detector out of five each year.

Sampling and Analysis

Under normal operation, a CAM samples air at a rate of 28.3 liters per minute. Filterable material is collected on a Millipore filter which is changed daily. For routine CAM operation, the sample filter is continuously analyzed (minute by minute) in place by the CAM's solid state Si detector. Alpha spectrometry of the CAM filter is performed continuously using a one-inch diameter solid state Si detector plated with a thin layer of gold (for detector protection). This spectrometry makes it possible to differentiate the alpha emissions originating from uranium from short-lived radon progeny alphas which are always present in ambient air.

During operation airflow is continuously measured with a mass flowmeter. A venturi flowmeter is used for calibrating the internal mass flowmeter. The CAM is calibrated annually (and after maintenance or when performance is questionable) with several electroplated alpha-emitting sources. An enriched uranium source (traceable to NIST) is used for efficiency calibration.

Filter identification is only necessary for those filters that are in place when a CAM evacuation alarm is activated. When this occurs the filter is removed from the CAM and transported to the plant laboratory for analysis. Such filters are labeled individually by the RCT responding to the CAM alarm. When a CAM filter is sent to the laboratory, it is analyzed by liquid scintillation counting.

Quality Control. For quality control, a daily operability check is performed to verify the naturally occurring ^{210}Po energy calibration. A CAM Daily Operational Check Sheet is shown in Figure 8.

Use of Results

Action Points. The CAM has two evacuation alarms enunciated by a rotating red beacon and an audible tone. An alarm is set to activate when the airborne uranium concentration (averaged for 30 minutes) exceeds 44.4 d/min/m³ (Class Y uranium DAC). An alarm also is set to activate at an eight DAC-hour value summed from the beginning of the filter change. A CAM Alarm Data Sheet is shown in Figure 10.

Form RCO-59
Revised 01/22/96

CONTINUOUS AIR MONITOR (CAM) ALARM DATA SHEET

INSTRUMENT INFORMATION			
LOCATION: _____ Building Location Code		ROOM/AREA: _____	
PROCESSOR ID: # _____		DETECTOR ID #: _____	
Confirmed Evacuation Alarm <input type="checkbox"/>		Confirmed False Alarm <input type="checkbox"/>	
OPERATIONAL DATA			
COUNT STARTED (from CAM)	Date: _____	Time: _____	
COUNT STOPPED (from CAM)	Date: _____	Time: _____	
AS FOUND CONDITIONS:			
Concentration <input type="checkbox"/>	Alert <input type="checkbox"/>	Clock <input type="checkbox"/>	P2 Comm <input type="checkbox"/>
DAC-Hrs <input type="checkbox"/>	Total CPM <input type="checkbox"/>	Counting <input type="checkbox"/>	Battery <input type="checkbox"/>
			Detector <input type="checkbox"/>
			Door <input type="checkbox"/>
			Flow Fail <input type="checkbox"/>
			Low Count <input type="checkbox"/>
214 Po PEAK CENTER CHANNEL NUMBER (should be Channel 178 ± 2): _____			
DRAW SPECTRUM BELOW		DATA COLLECTION CHECKLIST:	
		<input type="checkbox"/> A (U counts, 1 min)	
		<input type="checkbox"/> W (U counts, 20 min)	
		<input type="checkbox"/> C (U dpm/m3, 1 min)	
		<input type="checkbox"/> Q (U dpm/m3, 20 min)	
		<input type="checkbox"/> E (U DAC-hr, 1 min)	
		<input type="checkbox"/> S (U DAC-hr, 20 min)	
		<input type="checkbox"/> D (U cpm, 1 min)	
		<input type="checkbox"/> R (U cpm, 1 min)	
		SPECTRUM: Yes <input type="checkbox"/> No <input type="checkbox"/>	
		DATA TRANSFERRED TO DISKETTE:	
		Yes <input type="checkbox"/> No <input type="checkbox"/>	
Comments/Other Information/Unusual Observations: _____ _____ _____			
RCT Printed Name: _____		Date: _____	
Signature: _____		Time: _____	
Review and Approval: _____		Date: _____	
Time: _____			
DISTRIBUTION: File		REFERENCES: Y50-66-RC-151	

Fig

Figure 10. Form RCO-59

The source and justification for these action points are Y-12 document Y/DO-63, *Selection*

and Justification of Y-12 Plant Continuous Air Monitor (CAM) Alarm Settings. The action points are also consistent with the action points used in the Retrospective Air Monitoring Program. The CAM has several failure alarms that indicate problems with the unit such as “flow fail” and a “low count fail.” These are also indicated by lights and an audible tone.

Records. Routine CAM data are not typically retrieved. Daily information about the CAM performance and instrument status is recorded on a form and filed. Following a CAM evacuation alarm, data are electronically retrieved for the period of interest. This data file is maintained on the CAM Program Manager’s personal computer with a hard copy stored in the RADCON Field Office. Data can be retrieved from the appropriate filing cabinet or from the personal computer.

Other Uses of Results. Data from the CAM Program are often used to identify the portion(s) of radiological work that generate airborne uranium, or to troubleshoot equipment that inadvertently releases airborne uranium to the workplace. The instrument actually functions as an early warning device. It is used to plot airborne uranium concentrations as a function of time for a given area. Exposure or dose estimates are not assigned to personnel based on CAM data unless bioassay data are unavailable or unusable. In such cases, the CAM DAC-hour values could be useful in estimating personal dose.

Program Effectiveness

Evaluation and Observations. Although this is a relatively new program, it has great potential as a valuable radiological tool that will help control the radiation dose at ALARA levels. The program will obviously be of more use in this regard once production activities are resumed at the plant. With more and more operations coming on line since the 1994 stand down, the CAM Program will be even more useful for monitoring Y-12 operations. With the start-up of new or different operations, the CAM Program will be particularly valuable for rapidly identifying operations that produce unacceptable uranium air levels.

Conclusion. The CAM is a very important instrument to monitor airborne uranium at newly activated operations, locations, or areas. It is our understanding that a current study of operating areas is underway and that it is likely that a recommendation for the use of additional CAMs will be made.

Special Air Monitoring Programs

Personal Air Monitoring Program

Personal breathing zone samplers may be needed in some instances to monitor worker exposure, however, they are not used as a primary sampling method for radioactive materials in the Y-12 Plant. The personal breathing zone "lapel" sampler consists of a portable air filtering device that samples a known volume of air collected from the worker's breathing environment during performance of normal work activities. During sampling, a rechargeable battery-operated vacuum pump is worn near the waist of the person being monitored. A plastic hose from the pump is attached to a plastic filter cassette holding a Whatman filter approximately 1-1/2" in diameter and is clipped on the monitored employee's lapel. A Gilibrator air flow calibrator is used for setting the appropriate air flow, and the monitor is calibrated before each use.

Low-Volume Air Monitoring Program

Low-volume air sampling also is used to determine airborne radioactivity levels to assist in worker protection. The low-volume air sampling pump (Figure 11) is a portable air sampling pump that draws approximately 20 liters/min through a field monitor cassette holding a Whatman 41 paper filter. The low-volume air sampler provides a portable means for monitoring of airborne uranium contamination.

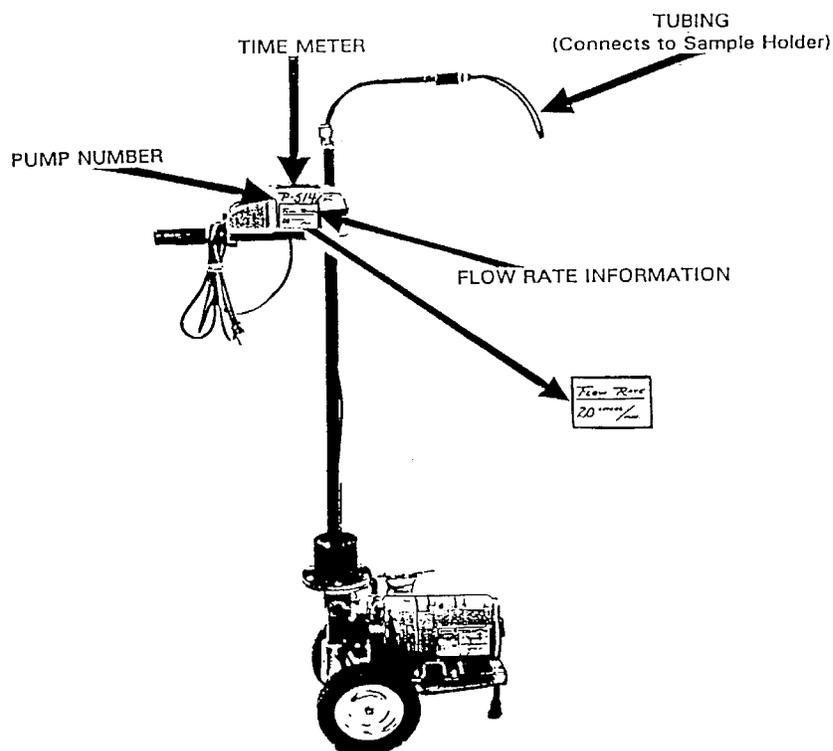


Figure 11.
Volume Air Sampling Pump

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High-Volume Air Monitoring Program

High-volume air sampling is used when airborne radioactivity concentrations need to be determined quickly. The high-volume air sampling pump (Figure 12) is a portable air sampling pump that draws approximately 400 liters/min through a Whatman 41 flat filter.

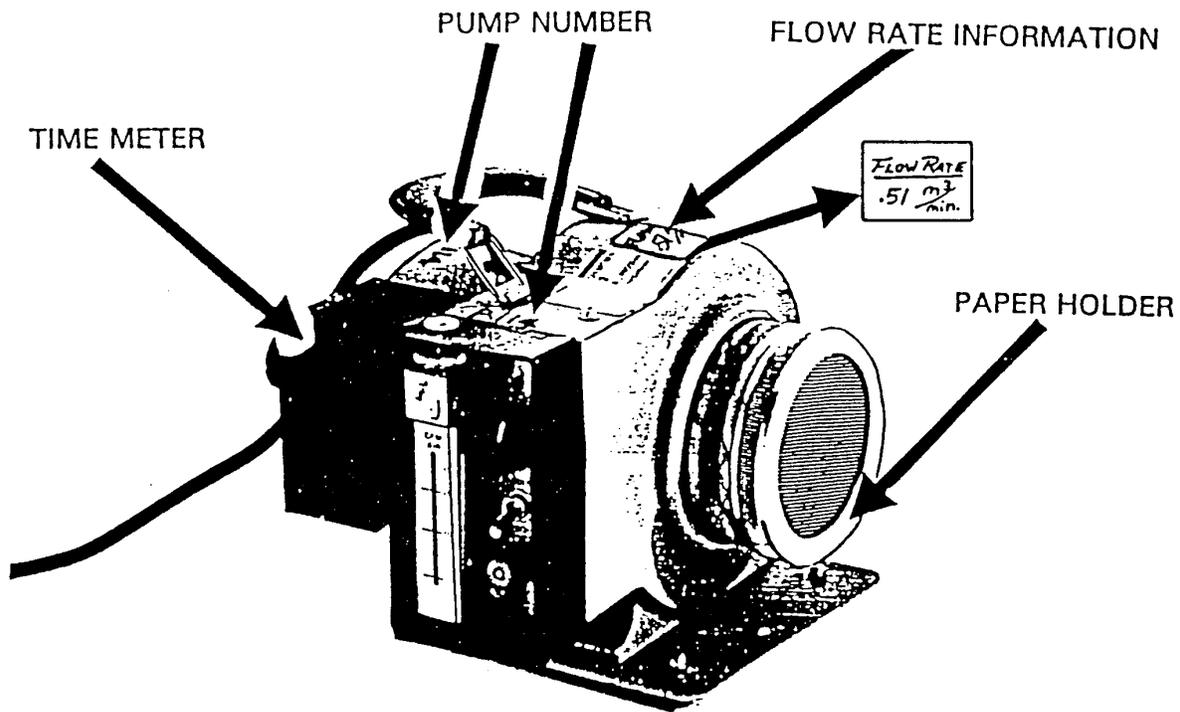


Figure 12. High-Volume Air Sampling Pump

Calibrations of the high-volume air samplers are conducted by the RADCON Department in accordance with instructions found in Departmental Procedure Y50-66-RC-309 entitled *Calibration of F & J Speciality Products Model HV-1 High Volume Air Samplers*.

Both the Low- and High- Volume Air Monitoring Programs provide quick radiation counts utilizing counting equipment available at the field office. The RADCON Field Operations Manager can notify operations supervisors in a timely fashion of recommendations or actions required. High volume air samplers are more useful for this purpose because of the larger volumes of air sampled.

RADIOLOGICAL PERSONNEL CONTAMINATION SURVEY PROGRAMS

OVERVIEW

Operated by Lockheed Martin Energy Systems (LMES), the Department of Energy's (DOE) Y-12 Plant, located in Oak Ridge, Tennessee, performs many activities involving uranium processing. Many of these processes provide opportunities for radiological contamination of operations and support personnel. In response to this potential contamination, the Y-12 Radiological Control (RADCON) Department conducts radiological survey programs to: (1) evaluate personnel contamination; (2) verify the effectiveness of plant physical design features and engineering and administrative controls; and (3) maintain employee exposure As Low As Reasonably Achievable (ALARA).

Brief Description of Programs

Personnel contamination surveillance at the Y-12 Plant is currently implemented as self-monitoring programs. Employees are responsible for monitoring themselves upon exiting any contamination control areas. RADCON Department personnel assist in decontamination of any employees who are detected as bearing radioactive contamination. RADCON personnel also perform certain special surveys for personnel contamination.

Exposure Potential

Presently, the Y-12 Plant is (1) disassembling weapons components containing uranium; (2) storing enriched uranium; (3) fabricating uranium components; and (4) maintaining a standby weapons production capability. Thus, the primary exposure potential to Y-12 employees is uranium.

Purpose of Report

The purpose of this report is to describe the (1) Personnel Contamination Survey Programs including methods used for performing surveys, (2) documentation of results, and (3) initiation of corrective actions. This report is part of a larger volume aimed at documenting all current radiological and chemical monitoring programs at Y-12 that may generate data useful for health and safety activities or studies.

PROGRAMS

Instrumentation

Radiation Monitors

The primary radiation detection instruments used in the Personnel Contamination Survey Programs are listed below.

- *Automated Personnel Contamination Monitor (PCM-2)*. This monitor detects both alpha and beta/gamma contamination and is used at the exits of most enriched uranium areas. The monitor is calibrated once per year and a performance check is made daily (Monday through Friday).
- *Automated Personnel Contamination Monitor (PCM-1B)*. This equipment is used to detect either alpha or beta/gamma contamination and is used at exits of areas involving depleted uranium to monitor for beta radiation. In some situations, this instrument is used to monitor for alpha radiation on the hands and feet. The instrument is calibrated once per year and a performance check is made daily.
- *Eberline Model RM-14S Radiation Monitor, with an Eberline Model HP-100A Gas Flow Proportional Detector*, detects both alpha and beta/gamma contamination. This instrument is on a scheduled 12-week recall program for maintenance and calibration. A performance check is performed daily, or before each use, with both an alpha and a beta source.
- *Ludlum 177-44* detects both alpha contamination (with 43-65 probe) and beta/gamma contamination (with 44-9 probe). This instrument is on a scheduled 12-week recall program for maintenance and calibration. A performance check is performed daily, or before each use, with both an alpha and beta source.

Instrument Calibration and Performance Checks

All radiation protection instrument calibrations are performed with National Institute of Standards and Technology traceable sources providing radiation levels similar to those that are found in field use. Routine performance checks are completed to ensure that instrument response is within ± 20 percent of the calibration value. Sources used to conduct the performance checks are recalled and validated on a predetermined schedule.

Quality Control (QC) Programs

The prescribed routine maintenance, calibrations, and performance checks help to assure that all monitoring instruments are operating satisfactorily. In addition, the Radiological Control Technician must complete required formal and on-the-job training before performing personnel contamination surveys. Other QC measures include the use of only radiation instruments that are within the current maintenance and calibration check period and meet daily performance tests.

Routine Personnel Surveys

Self Monitoring for Contamination

Personnel exiting Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, or Radiological Buffer Areas established for contamination control must frisk themselves immediately for contamination as required by procedures or posted instructions. This radiological frisk is accomplished at these Boundary Control Stations in one or more of the following ways:

- Use of the automated PCM-2.
- Use of the automated PCM-1B.
- Use of Personnel Monitoring Instruments (PMI) as listed below to monitor clothes and other parts of the body:
 - Eberline Model RM-14S.
 - Ludlum Model 177 with 44-9 or 43-65 probes.

No permanent record of results of these frisks is maintained. Contamination above the established limit is signaled by an audible and visual alarm. If there is a confirmed alarm for radiation levels above the action levels on either the PCM-1B or PCM-2, or if the action levels are exceeded on the PMI, the RADCON Department is notified.

Contamination Surveys by RADCON Department

The RADCON Department no longer conducts many of the personnel contamination surveys once considered routine. The form previously used for routine surveys, RCO-33 RADCON Personnel Survey for Uranium Surface Contamination (Figure 1), is still used in limited circumstances. For example, results of the personnel surface contamination check conducted prior to each *in vivo* monitoring event are entered on this form.

The form is also used in special situations when RADCON Department personnel conduct routine monitoring for short-term periods. Data entered on these forms are maintained in hard copy files only.

Nonroutine Personnel Surveys

Nonroutine RADCON surveys include responses of RADCON Department personnel to the following situations: (1) self-monitoring results indicate contamination levels above the guidelines established for personnel or clothing; (2) possible personnel contamination associated with an incident, (fires, spills, etc.); and (3) follow-up is indicated after personnel contamination has been confirmed. Such nonroutine surveys are documented on RADCON Form 32 Personnel and Clothing Radioactivity Contamination Report (Figure 2). This documentation is maintained only in hard copy form.

Guidelines for Personnel Contamination

Guidelines established for the Personnel Contamination Survey Programs are provided on Forms RCO-32 and RCO-33 (Figures 1 and 2) and are also shown in Table 1.

Table 1. Y-12 Surface Radioactivity Guidelines for Personnel and Clothing

Contamination	Fixed plus Removable (dpm/100 ^{cm})
Alpha	1,000
Beta	5,000

Form RCO-38 (Figure 3) is completed when survey results exceed Y-12 Plant guidelines.

Utilization of Results of the Programs

Results from the Personnel Contamination Survey Programs are recorded on Forms RCO-32 and RCO-33 when RADCON personnel are involved in the actual monitoring. Records of personnel monitoring through the automated PCM are maintained on an electromagnetic disk medium through the internal computer system within the PCM-1B. RADCON personnel download the information from the PCM on a regular schedule and perform reviews of the stored information periodically. Surveys performed in response to PCM alarms are documented and maintained regardless of the magnitude of the results. If contamination is confirmed, appropriate corrective actions are taken including notification to management of any personnel contamination occurrence. In the case of contamination surveys made on individuals involved in incidents, the documentation of each contamination event should be placed in the folder maintained on the relevant employee by the RADCON Department.

ALARA Objectives

The ALARA objective for 1995 was to reduce the number of skin and personal clothing contamination events by 25 percent (compared to 1994's performance) while still aggressively pursuing a goal of zero events. The 1995 goal was accomplished and a similar objective was adopted for 1996. Results of surveys performed by RADCON personnel are used to judge whether proposed goals are met.

COST AND RESULTS OF PROGRAMS

Extent and Cost of Programs

Approximately 2,500 Y-12 employees are classified as Radiation Workers because of their work assignments in Contamination, High Contamination, or Airborne Radioactivity areas. There are approximately 50 established PMI areas and 50 PCMs. There were 267 alarms from these automated monitors in 1995 to which RADCON technicians were required to respond. There are nine RADCON technicians assigned full time to caring for the instrumentation for these programs.

The cost of the Radiological Personnel Contamination Survey Programs is estimated to be approximately \$1,320,000 per year. This estimation includes the RADCON Instrumentation Technicians, the PCM, PMI stations, required portable radiation detection instruments, documentation of contamination results when guidelines are exceeded, and the time involved in self-monitoring.

Recent Results

As indicated above alarms by automated monitors, indicative of excessive contamination, are infrequent. Most of these alarm events are subsequently determined to be false mainly because of high instrument sensitivity or improper monitoring procedures.

EFFECTIVENESS OF PROGRAMS

Evaluation

The Y-12 RADCON Department's Personnel Contamination Survey Programs are judged to have adequate procedures and instrumentation for performing personnel contamination surveys, documenting results, taking corrective actions when personnel contamination (skin or clothing) is confirmed, and responding to contamination alarms from the automated PCM. The programs are very effective in identifying and quantifying, when necessary, contamination of personnel and clothing.

Observations

1. These are quite comprehensive and well-maintained surveillance programs aimed at assuring that contamination is controlled in those areas where relatively low specific activity radio nuclides are handled.
2. The programs are successful in demonstrating and documenting the absence of contamination on persons exiting potentially contaminating areas, as judged from the relatively few alarms experienced with continual surveillance by automated instrumentation.
3. The programs are well-run as demonstrated by QC programs and highly successful achievements in meeting and exceeding ALARA goals.

Conclusion

The RADCON Department should reevaluate the cost effectiveness of these programs based on the limited number of events experienced and the small contribution such contamination makes to personnel exposure.

RADIOLOGICAL AREA CONTAMINATION SURVEY PROGRAMS

OVERVIEW

Introduction

The Department of Energy's (DOE) Y-12 Plant, located in Oak Ridge, Tennessee, and operated by Lockheed Martin Energy Systems, Inc. (LMES), performs many activities involving uranium processing. Presently, the Y-12 Plant is (1) disassembling weapon components, (2) storing enriched uranium, (3) fabricating uranium, and (4) maintaining a standby weapon production capability. Thus, the primary radiation exposure potential for Y-12 employees is uranium. In addition to personnel monitoring programs for evaluating employee exposures to internal and external radiation, a number of other radiological control programs are maintained by the Y-12 Radiological Control (RADCON) Department. The Radiological Area Contamination Survey Programs are aimed at monitoring work areas and equipment for fixed and removable radiological contamination.

Purpose of Programs

The Y-12 Radiological Area Contamination Survey Programs, (fixed and removable), provide for sampling, quantifying, and assessing radiological surface contamination to help ensure that acceptable levels are not exceeded. The general purposes of the programs are to characterize and document radiological contamination levels, detect trends, and provide a basis for contamination control. Controlling radiological surface contamination helps to (1) keep exposures to radiation As Low As Reasonably Achievable (ALARA), and (2) ensure compliance with federal regulations, DOE orders, and LMES policies.

Brief Description of Programs

Comprehensive Radiological Area Contamination Survey Programs are necessary to detect changes in contamination levels and to evaluate the effectiveness of efforts to control or remove contamination from Y-12 areas. Direct instrument measurement surveys and smear surveys are used at Y-12 to evaluate surface contamination. The direct instrument survey technique measures the total amount of radioactive material contamination, fixed plus removable, on a surface. Once the total direct contamination measurement has been obtained, the tab smear survey technique is used to determine the level of removable radioactive contamination. Removable contamination is defined as radioactive material that can be removed from surfaces by nondestructive methods while fixed radiation is defined as that which cannot be removed by such methods.

Purpose of Report

The purpose of this report is to describe the goals and operation of the Radiological Area Contamination Survey Programs including methods used for performing surveys, documentation of results, and initiation of corrective actions, with particular emphasis on use of results. This report is part of a larger volume documenting currently installed monitoring programs at Y-12 that may generate data useful for health and safety activities or studies.

PROGRAMS

Direct Instrument Surveys

Direct instrument surveys measure radiological contamination in real time and are performed on any surface including material, equipment, or structures. Survey data are used to determine requirements for (1) radiological postings and boundaries, (2) optimum use of protective equipment, and (3) methods and protocols for material transfers.

Instrumentation

Brief descriptions of the instruments routinely used for direct instrument contamination surveys are listed below:

- *Ludlum Model 12 Alpha Count Ratemeter.* This is a portable, battery-operated count ratemeter using a scintillation probe to measure alpha contamination on surfaces. A factor of two, for an area less than the size of the probe, or four, for areas equal to the size of the 50 cm² probe, is used in converting the results from counts per minute (cpm) to disintegrations per minute per 100 square centimeters (dpm/100 cm²).
- *Ludlum Model 3 Beta/Gamma Count Ratemeter.* This portable battery-operated survey meter utilizes a Model 44-9 probe, with plastic cover to block alpha radiation, to detect beta/gamma radiation only. Direct contamination survey results exceeding 100 cpm above background are multiplied by a factor of 30 to calculate dpm/100 cm².
- *Eberline Model RM-14S Radiation Monitor.* The RM-14S is an AC line-operated radiation monitor with a 100 cm² probe and is used to detect alpha, beta, and gamma surface contamination radiations.

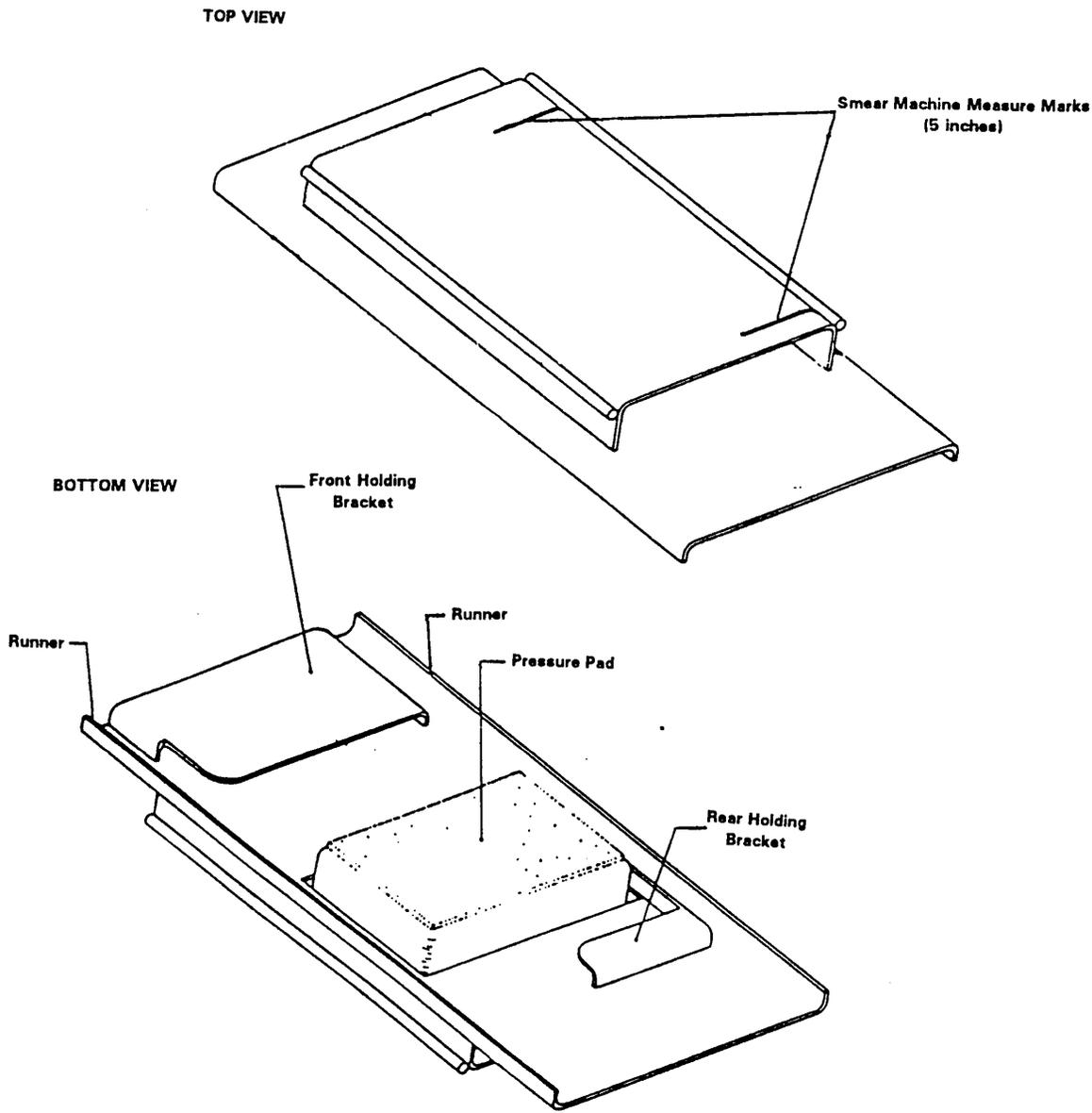


Figure 2. Smear Machine

Data obtained from smear card samples provide information on the amount of removable contamination present on the smeared surface and therefore, available to be transferred to workers or tracked out of the work area. This information also reflects the effectiveness of workers' efforts to maintain acceptable surface contamination levels. If an area is not sampled with smear cards, tab smears are used as needed.

Factors considered when determining locations for sampling with smear cards are:

1. Location
 - a. surfaces with greatest potential for contamination transfer to personnel such as surfaces of telephones, toolboxes, chairs, doorknobs, tabletops, faces of glove boxes or hoods,
 - b. areas just outside of radiological areas, or
 - c. surfaces that adequately characterize the radiological conditions of an area.
2. Type of process and/or process containment.

Tab Smears

Tab smear paper (Figure 3) is an absorbent paper usually in the form of disks that are approximately one or two inches in diameter. Typically, tab smear samples are collected at locations where the direct contamination measurements are expected to be high or where removable contamination appears likely.

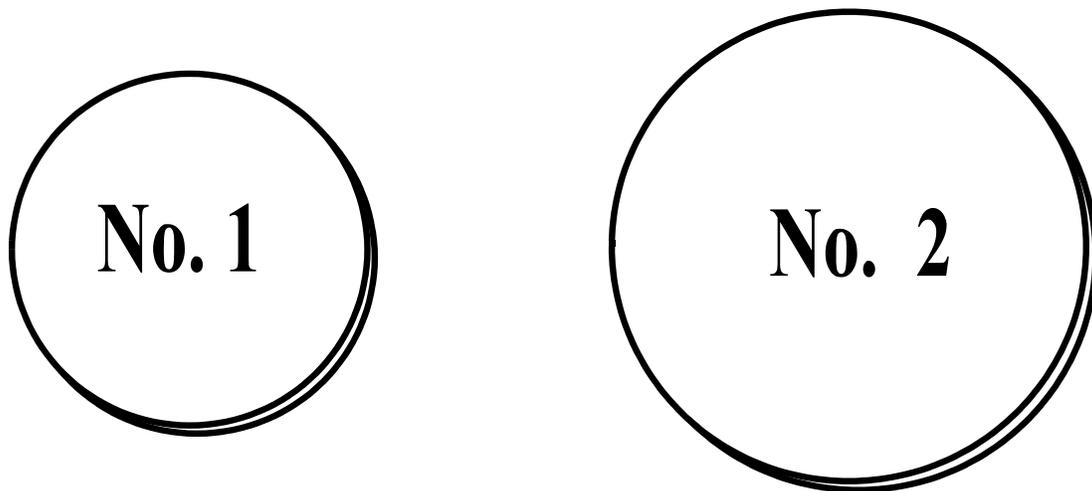


Figure 3. Tab Smears

To collect samples, tabs are wiped over an area of 100 cm² (or a 4 x 4-inch area) to measure the portion of contamination that is removable. The samples are then placed in sample holders (Figure 4) for transfer to the counting location where they are counted to determine the level of removable radiological contaminants.

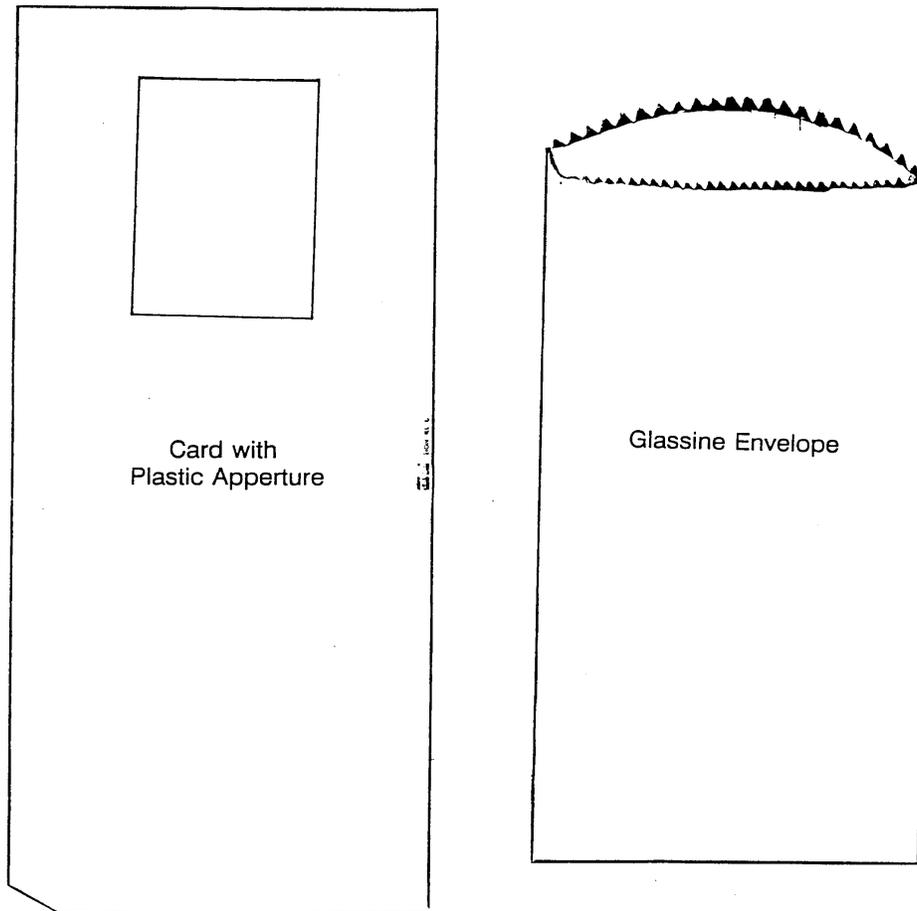


Figure 4.

Tab Smear Sample Holder

Tab smears are used to (1) determine tagging requirements for the release and transfer of possibly contaminated material and equipment; (2) assist in area characterization for determining personnel health and safety operating procedures; (3) assist in radiological posting to alert personnel to the presence of radiation and radioactive material; (4) verify that radiological area boundaries are maintained; and (5) assist in determining appropriate actions for decontamination activities. The use of tab smears provides information required for quick initiation of necessary corrective or remedial actions. Results from tab smear samples also are used in determining locations and frequencies for subsequent smear sampling. Table 1 below lists examples of various locations and the frequency at which surveys are taken for each location.

Table 1. Tab Smear Surveys - Locations and Sampling Frequencies

Location	Frequency
Step-off pads, office areas in Radiological Buffer Areas	Daily
Office areas inside Radiological Areas	Weekly
Radiological Material Areas, boundary control stations, break rooms/lunchrooms adjacent to contamination areas, high contamination areas	Weekly
Contamination Areas	Monthly
Plant entrances to portals	Quarterly

In addition to the predetermined locations listed above, other locations selected for tab smear sampling include:

1. surfaces having elevated direct contamination results;
2. locations where work activities have the potential for causing changes in the levels of removable radioactive contamination;
3. locations where work activities may modify contamination levels;
4. decontaminated surfaces with previous contamination levels exceeding acceptable levels; and
5. locations associated with leaks and/or spills.

The sampling frequencies in Table 1 only apply to the specified areas in the table. Appropriate sampling frequencies also have been established for tab smear surveys to assist in the characterization of work areas and to ensure that contamination controls are sufficient. Using the tab smear methodology, the RADCON Department can expeditiously provide results to customers and make immediate modifications to postings or entry requirements without the delay of laboratory analysis.

ANALYSIS

Card Smears

Methodology

After sampling, smear cards are packaged in plastic bags and transported to the Plant Laboratory for analysis. The cards are stacked in an automated counter which sequentially draws the bottom card through the reader. The previously keypunched information on each card is read and stored on floppy disk media in the instrument's computer. Each card is then indexed under a phoswich detector and counted for one minute and the results stored. The process is repeated until all cards have been read. The analysis information is transmitted to a processing computer where it is merged with the previously read keypunched information. Reports are generated listing the location of the sample, the date the sample was analyzed, the control criteria, the responsible RCT, and the results of the smear in dpm/100 cm².

Quality Assurance-Quality Control

Quality assurance and quality control programs are maintained to help assure useful and meaningful smear results through implementation of the following actions:

- Approved initial and continuing training are conducted to promote accuracy and consistency in the performance of removable contamination surveys.
- Calibration and performance testing of equipment are completed prior to its use.
- Counting efficiencies and background levels are determined daily. The counting efficiencies are plotted on a control chart and must be within the three standard deviations limit for the counter to be used.

Tab Smears

Methodology

After sampling, the tab smear is folded in half with the sample side inward, inserted into a sample holder, and transported to another location for radiological analysis. To perform the analysis, the tab smear is removed from the sample holder with tweezers, unfolded, then counted using one of the following instruments: (1) a Ludlum Model 12 Count Rate Meter, (2) a Ludlum Model 3 Survey Meter, (3) a Ludlum Model 2200 Scaler Rate Meter, or (4) a Ludlum Model 2929 Dual Channel Scaler. Counting results are converted to dpm/100 cm² using appropriate factors required for each instrument. Currently, counting is performed only by RADCON personnel. Until recently, the tab

smears were sent to the Plant Laboratory for a confirming recount; however, for cost-savings this confirmation step was discontinued.

Quality Control

Instruments used to count tab smears, as well as the direct reading instruments used to measure total contamination measurements (fixed plus removable), are performance tested each day the instrument is used. Should the instrument fail the performance test, it is removed from use, serviced, and recalibrated. Calibration and performance testing are performed according to operating procedures developed for each instrument type. In addition, approved initial and continuing training are developed and provided to all RCTs to promote accuracy and consistency in conducting contamination surveys.

USE OF RESULTS

Direct Readings and Tab Smears

Direct readings and tab smear results are used as bases upon which many procedural and policy decisions are made as described below.

Posting and/or Boundary Control

Results from these surveys are compared to posting criteria stated in *Posting and Entry Control* (Health and Safety Procedure Y70-117) in order to establish requirements and responsibilities for classifying radiological areas and for posting areas according to radiological conditions. The purpose of these postings, at establishing boundary control stations, is to alert personnel to the presence of radiation and radioactive materials in order to minimize exposures and prevent the spread of contamination. Form RCO-5 (Figure 5) is used for recording survey results for posting temporary radiological boundaries. Form RCO-111 (Figure 6) is used for recording survey results of permanently posted radiological areas. Figure 7 is an example of an area map which shows where direct readings and smears are taken. When decontamination efforts are required for area surfaces, survey results may be documented on either Form RCO-5 or RCO-5A (Figure 8).

DATA VALID THROUGH END OF FOLLOWING MONTH

MAX. FIXED PLUS REMOVABLE SURFACE CONTAMINATION AND DOSE RATE SURVEYS

SURVEY DATE JULY 1996

GROUP 500

9201-5 ARC MELT 2ND FL.

AREA LOC.	AREA DESCRIPTION	ALPHA DPM/100 CM**2		BETA/GAMMA DPM/100 CM**2		DOSE RATE MREM/HR AT 30 CM (2)
		MAX. FIXED PLUS REMOVABLE	REMOVABLE (1)	MAX. FIXED PLUS REMOVABLE	REMOVABLE (1)	
16G 1	FL. AT NW ENTRANCE					
16G 2	FL. N. WALKWAY AT COL. J-5.5					
16G 3	FL. BETWEEN COLS. G-6.5 & G-5.5					
16G 4	ON CONTROL PANEL FOR SAVAGE SAW					
16G 5	FL. AT CONTROL PANEL					
16G 6	FL. AT AIR SAMPLER #41					
16G 7	FL. ON STAINLESS STEEL PLATFORM					
16G 8	FL. W. SIDE OF SAVAGE SAW					
16G 9	FL. CENTER OF W. WALKWAY					
16G 10	FL. AT TOP OF W. MELT PLATFORM					
16G 11	ON CONTROL PANEL OF MELT PLATFORM					
16G 12	FL. ON SCALES					
16G 13	FL. SE ENTRANCE					
16G 14	FL. TOP OF S. PLATFORM					
16G 15	ON S. CONTROL PANEL					
16G 16	FL. ENTRANCE TO KNOCKOUT ROOM					
16G 17	FL. CENTER OF KNOCKOUT ROOM					
16G 18	FL. SW EXIT					
16G 19						
16G 20						
16G 21						
16G 22						

HEALTH PHYSICS INSTRUMENT USED (I.D.) ALPHA _____ BETA/GAMMA _____

HEALTH PHYSICS TECHNICIAN: _____ BADGE: _____

HEALTH PHYSICS AREA MONITORING SUPERVISOR _____ BADGE _____ DATE _____

Figure 5. Form RCO-5

Figure 6. FORM RCO-111

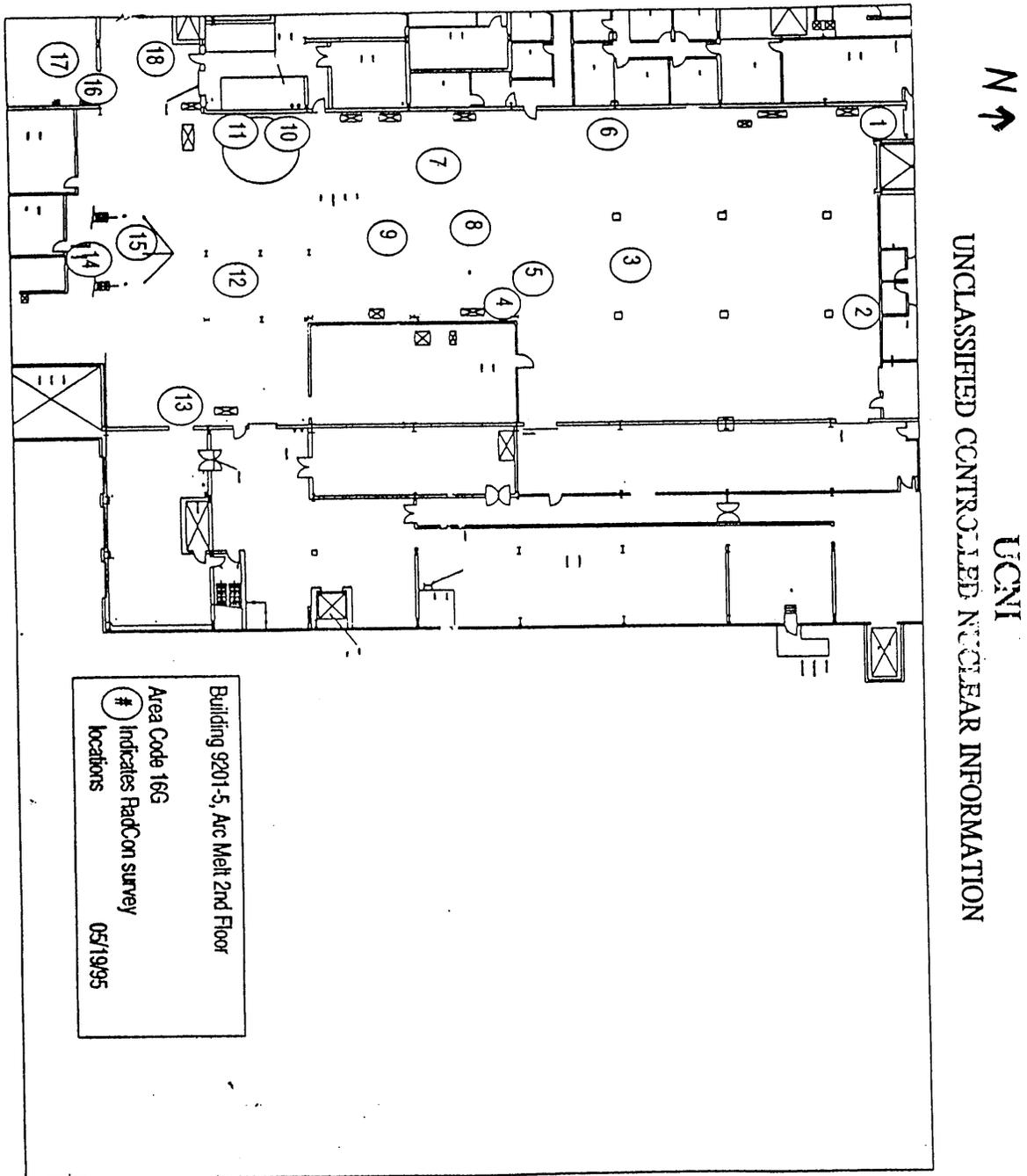


Figure 7. Area Map With Designated Sampling Locations

RADCON
SURVEY FOR URANIUM SURFACE CONTAMINATION

LOCATION: _____ DATE: _____
COMMENTS: DECON

Sample Number	DESCRIPTION	ALPHA (dpm/100 cm ²) (1)		BETA/GAMMA (dpm/100 cm ²) (1)		WORK AREA	
		Max. Fixed Plus Removable	Removable	Max. Fixed Plus Removable	Removable	Beta/Gamma mrem/hr	Neutron mrem/hr
	BEFORE						
█	AFTER						
	BEFORE						
█	AFTER						
	BEFORE						
█	AFTER						
	BEFORE						
█	AFTER						
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	BEFORE						
█	AFTER						

RadCon Instrument Used (I.D.) ALPHA _____ BETA/GAMMA _____ NEUTRON _____
RADCON TECHNICIAN: _____ BADGE: _____

(1) Y-12 SITE URANIUM SURFACE RADIOACTIVITY GUIDES IN dpm/100 cm²:

ALPHA		BETA/GAMMA		
Removable	Max Fixed Plus Removable	Removable	Max Fixed Plus Removable	
≤ 1,000	≤ 5,000	≤ 1,000	≤ 5,000	Classified as uncontaminated.
> 1,000	> 5,000	> 1,000	> 5,000	Classified as contaminated.

NOTE: The minimum detectable limit is approximately 250 dpm/100 cm² alpha and 3000 dpm/100 cm² beta/gamma fixed plus removable.

REVIEW AND APPROVAL

DISTRIBUTION:
Operations Supervisor
RCT Supervisor
File

RCT Supervisor

Date

Reference:
70-105

Figure 8. FORM RCO-5A

Transfer of Materials

Results of surface contamination surveys are compared to procedural criteria. Based on the results, either a "green tag," UCN-14B *Health Physics Material Transfer Clearance* (Figure 9), or a "yellow tag," UCN-15C *Caution Radioactive Material* (Figure 10), is issued.

 ☆ U.S. GPO: 1995-652-919			
HEALTH PHYSICS MATERIAL TRANSFER CLEARANCE			
<table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="padding: 2px;">TAG NUMBER</td> <td style="padding: 2px; text-align: center;">GT 159526</td> </tr> </table>		TAG NUMBER	GT 159526
TAG NUMBER	GT 159526		
SURVEY INFORMATION			
BUILDING	ROOM NO.		
REQUESTED BY	DIVISION		
DESCRIPTION OF MATERIAL/REMARKS			
SURFACE CONTAMINATION			
MAX. FIXED+REMOVABLE ALPHA	dpm/100cm ²	<input type="checkbox"/> <small>CHECK IF NONE DETECTED</small>	
REMOVABLE ALPHA	dpm/100cm ²	<input type="checkbox"/>	
MAX. FIXED+REMOVABLE BETA/GAMMA	dpm/100cm ²	<input type="checkbox"/>	
REMOVABLE BETA/GAMMA	dpm/100cm ²	<input type="checkbox"/>	
HEALTH PHYSICS INSTRUMENTS USED			
Alpha Instrument I.D.	Beta/Gamma Instrument I.D.		
SURVEY COMPLETED			
DATE	BY (NAME and BADGE NUMBER)		
VOID AFTER			
UCN-14B (123 7-94)			

Figure 9. FORM

UCN-14B

3-0PT

YT- 213743

**CAUTION
RADIOACTIVE MATERIAL**



SURVEY INFORMATION

BUILDING	ROOM NO.
REQUESTED BY ORIGINATOR/DIVISION	
DESCRIPTION OF MATERIAL/REMARKS	

SURFACE CONTAMINATION	dpm/100cm ²	Check if None Detected
MAX. FIXED+REMOVABLE ALPHA	dpm/100cm ²	<input type="checkbox"/>
REMOVABLE ALPHA	dpm/100cm ²	<input type="checkbox"/>
MAX. FIXED+REMOVABLE BETA/GAMMA	dpm/100cm ²	<input type="checkbox"/>
REMOVABLE BETA/GAMMA	dpm/100cm ²	<input type="checkbox"/>

EXTERNAL DOSE RATE

	Contact	1 Foot	_____ Feet
BETA/GAMMA mrad/hr at			
GAMMA mR/hr at			
NEUTRON mrem/hr at			

SPECIAL HANDLING REQUIREMENTS

Contact Health Physics prior to grinding, burning, buffing, welding, dry machining, or using impact tools on this item.

This item may have radioactive material inside.

Other:

SURVEY INSTRUMENTS USED

ALPHA INSTRUMENT I.D.	BETA/GAMMA INSTRUMENT I.D.
OTHER INSTRUMENT I.D.	

SURVEY COMPLETED

DATE	BY (Name and Badge No.)
------	-------------------------

UCN-15C (123 4-94)

Figure 10.

FORM UCN-15C

Information on these tags includes survey data, location of material, requestor's name (when known), instrument identification numbers, description of material, date of survey, and surveyor's identification. A copy of the tag remains with the material, and a record copy is maintained on file in the responsible field office. When decontamination

efforts are required for the transfer of material, survey results may be documented on either Form RCO-5 or RCO-5A.

Radiological Posting and Transfer Limits

To classify areas for radiological posting, levels of total and removable contamination are determined as described above and compared to established limits as shown in Table 2.

Table 2. Limit Values (dpm/100 cm²)

AREA POSTING		
Type of Posting	Removable	Total (Fixed and Removable)
None	<1,000	<5,000
Contamination Area	>1,000 <100,000	>5,000 < 500,000
High Contamination Area	>100,000	>500,000
OFF-SITE TRANSFER		
To Transfer	<1,000	<5,000

Job Task Survey

This type of survey includes surveys of the area, equipment, or structure(s) that workers may contact during performance of a scheduled job. Based on the scope of work, the contamination measurements, and radiological postings, the RCT will make recommendations for personnel protective equipment. The RCT will refer to requirements listed in Plant RADCON Procedures and Technical Basis Documents to assure that the personnel protective equipment recommendations are appropriate. These recommendations, along with the survey results documented on Form RCO-5, become the radiation worker protection guidance package.

Site Characterization

This type of survey is performed for both routine characterization of a work site and to return a facility to normal operations after a spill, accident, or unplanned event involving radioactive material. Results from these surveys are compared to posting criteria stated in *Posting and Entry Control* (Health and Safety Procedure Y70-117) and appropriate corrective actions or changes in posting are implemented as necessary. Site characterization survey results can be documented on Form RCO-5, RCO-5A, or RCO-5B (Figure 11) with associated maps or grid survey maps included.

Card Smears

Initiation of Cleanup Action

Card smear results are compared to Plant Action Values (PAVs) so cleanup action can be taken as needed. The PAVs are arbitrarily set by RADCON managers at a fraction of the smear levels specified in DOE 10 CFR Part 835 on the basis of professional judgement, previous smear data for particular areas, and other relevant factors. The PAVs are used in establishing frequencies for taking routine smears. Table 3 shows established PAVs and sampling frequencies for routine card smears according to the type of location. The same PAVs apply to tab smears, but the frequencies do not apply.

Table 3. Plant Action Values and Sampling Frequencies for Y-12 Routine Card Smears

Location	PAV (dpm/100 cm ²)	Frequency
Lunchrooms and break rooms	250	Weekly
All radiological work areas	2,000	Monthly
Change houses	1,000	Monthly
All other areas routinely smeared	1,000	Quarterly

Records and Reports

The Plant Laboratory's data files of card smear sample analysis results are transferred to the laboratory's VAX computer. At least once per day, the data files from the VAX are sent for final processing where the results are compiled into daily, weekly, monthly, or quarterly computerized reports. The reports provide information on the date of analysis, area surveyed, locations, the area average in units of dpm/100 cm², the PAV for the area, and the RCT identification code.

For current reporting, an established frequency is specified by the RADCON Department. The routine reports currently issued are (1) Daily Uranium (Alpha) Smear Reports; (2) Weekly Area Smear Averages; (3) Monthly Area Smear Averages; (4) Quarterly Area Smear Averages; (5) Yearly Area Smear Average (Year-to-Date); and (6) Ten Highest Year-to-Date Area Smear Averages for areas with PAVs of 250, 1,000, and 2,000 dpm/100cm².

Survey maps that contain sufficient detail to permit identification of survey locations are also maintained in the field offices and generally posted at entry to radiological areas to

inform personnel of radiological conditions. Computerized smear sampling reports are maintained on magnetic media and backed-up accordingly on the plant's mainframe computer. Tab smear results documented on survey forms are retained for a period not less than 75 years.

COST AND RECENT RESULTS

Extent and Cost of Programs

Card Smears

Currently at Y-12 there are 223 various process areas surveyed by card smear sampling on a monthly frequency and an additional 110 areas surveyed quarterly. Approximately 32,000 smear cards are processed annually. The total cost to the RADCON Department for maintaining the present Card Smear Program is \$700,000 per year.

Tab Smears

There are 100 to 125 areas surveyed monthly using tab smears and another 150 to 200 areas surveyed either daily or weekly which equates to approximately 60,000 tab smears per year. The cost of the Tab Smear Program has not been determined because of the difficulty of estimating the cost of a nonroutine program.

Recent Results

The only area survey results readily available for reporting are results from card smears. Table 4 shows results for the first six months of 1996 from areas with the ten highest year-to-date averages for each of the three PAVs used in the Y-12 Plant. No summary of tab smear results or direct reading results are presented since these results are not computerized.

Table 4. Average Area Smear Results (January - June 1996)

Area	# Months Smearied	D/Min/100 cm ² Average*	PAV	# Area Loc.	# Area Loc >PAV	% Area Loc >PAV	Area Description
58E	5	5	250	70	0.00	0.00	9616-7 Break room
58F	4	5	250	60	0.00	0.00	WETF/Tank Farm #1 Office and Break room
82C	5	5	250	55	0.00	0.00	9215 Lunchroom
95E	2	5	250	15	0.00	0.00	Sanitary Landfill Lunchroom
95L	4	5	250	32	0.00	0.00	0D-9 Break room
20Q	5	4	250	40	0.00	0.00	9215 M-Wing Lunchroom
57C	5	4	250	25	0.00	0.00	9720-28 Waste Feed Lunchroom
95O	4	4	250	40	0.00	0.00	OD-10 Break room
57G	4	3	250	22	0.00	0.00	9983-BR Health Physics Trailer
93V	3	3	250	23	0.00	0.00	9722 Lunchroom
14F	1	12	1000	4	0.00	0.00	9206 RM 14
57E	1	12	1000	5	0.00	0.00	9720-44 Sludge Handling Facility
59A	2	12	1000	8	0.00	0.00	9711-1TLD Storage Area
83U	1	12	1000	17	0.00	0.00	9206 Non-Rad Corridors and Offices
91D	2	11	1000	8	0.00	0.00	9818 Office/Control Room
81C	1	10	1000	14	0.00	0.00	9723-25 Men's Changehouse
87S	1	10	1000	7	0.00	0.00	9215 N. Office Corridors
91T	2	10	1000	10	0.00	0.00	9815 Chemical Makeup
01L	1	8	1000	11	0.00	0.00	9212 Gage Lab
91E	2	8	1000	9	0.00	0.00	9721 Office
11D	3	960	2000	87	9	10	9212 B-1 Wet Operation
19D	2	612	2000	13	1	8	9206 RM 29 Evap Denitration
11E	3	562	2000	61	2	3	9212 B-1 Dry Operation
19L	2	349	2000	14	0.00	0.00	9206 Rm 25 Incinerator
19C	1	348	2000	12	0.00	0.00	9206 Rm 28 Evap Extraction
19B	3	346	2000	33	0.00	0.00	9206 Rm 22
19E	2	312	2000	44	0.00	0.00	9206 Rm 30
19K	2	304	2000	18	0.00	0.00	9296 Rm 27
13S	3	255	2000	33	0.00	0.00	9212 E-Wing Basement Enclosures
13E	3	245	2000	55	0.00	0.00	9212 Rm 1008
1							
HP3							

*Average results of 10 highest areas for each PAV specification.
 Total areas surveyed January-June 1996 = 268.
 This is a year-to-date report and is updated each month.

Note: For the 10 highest areas where the PAV = 250 dpm/100 cm², no smears exceeded the limit and the averages ranged from 1.2 to 2% PAV. For the 10 highest areas where the PAV = 1000 dpm/100 cm², no smears exceeding the limit and averages ranged from 1 to 1.2% PAV. For the 10 highest areas where the PAV = 2000 dpm/100 cm², 12 locations (3.2%) had averages greater than the PAV, and averages ranged from 12 to 48% PAV.

EFFECTIVENESS OF PROGRAMS

Evaluation

The Area Contamination Survey Programs appear to function very well in providing information to help maintain surface contamination levels well within established limits. However, the authors had some difficulty understanding how the two smear programs were integrated to compliment each other.

Observations

1. There are two surface contamination control programs: (1) the fixed and removable surface contamination programs using direct reading radiation detection instruments and tab smears; and (2) the removable surface contamination program using card smears.
2. Results from direct reading instruments and tab smear samples appear to serve as input data upon which most radiation exposure control decisions are based.
3. A major purpose of the Card Smear Program is to determine average levels of surface contamination for reporting to supervisors on a continuing basis. Supervisors use this information to evaluate the effectiveness of currently implemented surface contamination control and cleanup programs.
4. The smear sampling levels reported in the Recent Results Section of this report indicate very low levels of removable radiological contamination especially in the areas where the PAV is 250 or 1000 dpm/100 cm². These remarkably low levels are due in part to the fine contamination control programs maintained by the Y-12 RADCON Department and Plant Supervisors, and to the small amount of production in the facility for the reported period.

Recommendations

Consideration should be given to eliminating one of the contamination control smear programs. It is our understanding that the RADCON Department has eliminated the Card Smear Program since the time this report was prepared.

PERSONNEL RESOURCES

Interviewers: C. M. West (W)
B. F. Rutherford (R)

Organizations Contacted: Radiological Control Department (RADCON)
Industrial Hygiene Department (IHD)
Analytical Services Organization (ASO)
Health Services Organization (HSO)

Person Contacted	Organization	Interviewer(s)	Subject
K.M. Bailey	RADCON	W, R	<i>In Vitro</i> Bioassay
R.S. Bogard	RADCON	W, R	RADCON Coordination
B.G. Bowers	RADCON	W, R	Field Surveys ¹
K.W. Branum	RADCON	W, R	Field Surveys ¹
A. Brynestad	RADCON	R	Procedures
R.E. Carroll	ASO	R	Analytical Operating Procedures
L.E. Cooke	IHD	W	IH in ASO facilities
T.J. Denton	RADCON	W, R	Field Surveys ¹
R.P. Ferguson	IHD	W	Other IH Programs
R.T. Ford	IHD	W	Miscellaneous IH questions
S.P. Ford	RADCON	W, R	RADCON ALARA ² Programs
B.T. Gose	RADCON	W, R	<i>In Vivo</i> Operations
R.A. Hamby	RADCON	W, R	Radiological Control Instruments
J. Hendershot	IHD	W	Overall and IHD Coordination
E.R. Hinton, Jr.	ASO	W, R	Analytical Operations
S.M. Hollenbeck	IHD	W	Asbestos, MMMF ³
J.L. Jenkins, Jr.	IHD	W	Beryllium
O.W. Jones	HSO	W, R	Medical Surveillance
W.O. Lawless	IHD	W	Mercury
L.L. Long	RADCON	R	Forms
T.W. Long	RADCON	W, R	<i>In Vivo</i>

PERSONNEL RESOURCES

Person Contacted	Organization	Interviewer(s)	Subject
F.J. Ludwig	RADCON	W, R	Field Surveys ¹
R.J. McElhaney	ASO	W, R	Analytical Procedures
V.W. Phillips	IHD	W	Lead
W.E. Porter	IHD	W	Beryllium, general
P.D. Pruitt	RADCON	R	Instruments
M.M. Reichert	ASO	W, R	Analytical Procedures
D.P. Rowan	RADCON	W, R	Miscellaneous RADCON questions
L.J. Schwanke	RADCON	W, R	External Dosimetry
P.M. Shelton	HSO	W, R	Medical Surveillance
J.L. Sherrill	IHD	W	Record System
W.A. Slishi	IHD	W	Carcinogens
J.L. Smith	RADCON	W, R	Dose History Formats
L.M. Snapp	RADCON	W, R	Internal Dosimetry
M.L. Souleyrette	RADCON	W	External Dosimetry
C.A. Steelman	RADCON	R	Instruments
J.M. Thomas	RADCON	R	Continuous Air Monitoring
¹ Field Surveys include air and surface contamination ² As Low As Reasonably Achievable ³ Man-Made Mineral Fibers			

REFERENCES

REGULATIONS, STANDARDS, PROCEDURES, AND DOCUMENTS (Listed by issuer with number, date, and title)

FEDERAL

<u>Number</u>	<u>Date</u>	<u>Title</u>
10 CFR 835	12-14-93	Occupational Radiation Protection
DOE 5480.11	12-21-88	Radiation Protection for Occupational Workers
Method 6009	08-15-89	NIOSH Manual of Analytical Methods (Mercury in Air)
Method 7400	08-15-94	NIOSH Manual of Analytical Methods (Asbestos fiber sample collection, preparation, counting and reporting)

AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)

<u>Number</u>	<u>Date</u>	<u>Title</u>
N13.6-1966 (R1922)	03-14-66	Practice for Occupational Radiation Exposure Records Systems

LOCKHEED MARTIN ENERGY SYSTEMS, INC.

Energy Systems Procedures

<u>Number</u>	<u>Date</u>	<u>Title</u>
Centralized External Dosimetry System (CEDS)	09-30-94	Technical Basis for the Centralized External Dosimetry System
CEDS 2-1-10	09-30-94	TLD Reader QC and Calibration
CEDS 2-2-20	06-30-94	Dosimeter Contamination Surveys

CEDS 3-1-500	09-30-94	Personnel Nuclear Accident Dosimetry
CEDS 3-1-505	09-30-95	Fixed Nuclear Accident Dosimetry
Energy Systems Standard ESS-IH-211	03-31-93	Worker Protection From Manmade Mineral Fibers

Radiological Control (RADCON) Procedures

Y-12 Plant

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y70-100	09-11-95	Y-12 Plant Radiological Control Program
Y70-101	08-23-95	Transfer and Management of Materials for Radiological Control
Y70-105	08-08-95	Exposure Limits and Administrative Control Levels
Y70-106	08-31-94	Temporary Dosimeters for Permanently Badged Individuals
Y70-112	06-15-90	Previous Radiation Exposure Records for New Energy Systems Employees
Y70-117	02-27-95	Posting and Entry Controls
70-118	09-25-90	Request for Radiation Exposure Records and Histories
70-119	10-30-90	Whole Body, Neutron, and Extremity Radiation Monitoring
Y70-122	02-27-95	Radiological Work Permit (RWP)
Y70-124	02-27-95	Selection and Use of Protective Clothing for Radiological Protection
Y70-130	12-15-93	Uranium Bioassay Program

Y70-133	08-31-94	Dosimetry Services for Visitors to the Y-12 Plant
70-134	05-11-95	Y-12 Plant ALARA Program for Radiological Protection

Department

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y50-66-HP-009	02-25-94	Area Monitoring Programs
Y50-66-HP-124	03-31-94	Personnel Contamination Survey Program
Y50-66-HP-133	01-31-92	Health Physics Smear Program
Y50-66-HP-134	11-30-91	Low and High Volume Air Sampling Program
Y50-66-HP-135	02-03-92	Retrospective Uranium Air Sampling Program
Y50-66-RC-142	04-10-96	Performance Testing of Radiological Control Instruments
Y50-66-RC-151	10-25-95	Operation of the Eberline Model Alpha-65 Continuous Air Monitor
Y50-66-RC-302	06-15-95	Calibration of an Eberline Model PCM-IB Personnel Contamination Monitor
Y50-66-HP-303	02-08-95	Calibration of an Eberline PCM-2 Personnel Contamination Monitor
Y50-66-HP-309	07-13-95	Calibration of F&J Specialty Products Model HV-1 High Volume Air Samples
Y50-66-HP-315	04-11-95	Calibration of a Ludlum Model 177-45 Alarm Ratemeter with a Ludlum Model 43-65 Alpha Scintillator Probe
Y50-66-HP-316	05-02-95	Calibration of a Ludlum Model 177-45 Alarm Ratemeter with a Ludlum Model 44-9 Alpha-Beta-Gamma Detector

Y50-66-RC-326	04-09-96	Calibration of an Eberline Model RM-14.5 Radiation Monitor with an Eberline Model HP-100-11 Gas Flow Proportional Detector
Y50-66-HP-404	02-15-95	Performing Internal Dose Assessments

Industrial Hygiene (IH) Procedures
Y-12 Plant

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y70-036	04-15-93	Identification of Employees Requiring Medical Surveillance
Y70-049	05-03-96	Carcinogen Control Procedure (RW.01)
Y70-200	07-14-92	Industrial Hygiene
Y70-201	02-03-92	Plant Beryllium Protection Program
Y70-204	05-10-94	Asbestos Procedure for the Y-12 Plant
Y70-214	05-20-94	Asbestos Program Surveillance and Conformance
Y70-218	02-02-95	Y-12 Mercury Protection Program
Y70-219	07-15-94	Y-12 Plant Lead Worker Protection Program
Y70-220	03-30-94	Occupational Exposure to Hazardous Chemicals in Laboratories

Department

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y50-66-IH-011	09-24-92	Personal and Area Monitoring for Chemical Contaminants
Y50-66-IH-013	04-30-93	Operational and Calibration of Dupont Model 2500 Air Sampler
Y-50-66-IH-057	08-14-91	Beryllium Smear Program
Y50-66-IH-058	08-15-91	Beryllium Airborne Monitoring Program
Y50-66-IH-069	02-03-92	Y-12 Industrial Hygiene Routine Sampling Program

Others (Health and Safety Procedures)

Y-12 Plant

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y70-026	04-30-93	Occupational Injury and Illness Record Keeping
Y70-036	04-15-93	Identification of Employees Requiring Medical Surveillance
Y70-043	01-31-96	Job Hazard Analysis
Y70-050	07-15-94	Y-12 Respiratory Protection Program
Y70-065	12-15-92	Reproductive Hazards
Y70-220		Laboratory Chemicals
Y70-375	08-09-93	Construction Contractor--Safety and Health
Y70-379	12-30-92	Construction Contractor—Site Characterization and Worker Requirements
Y70-525	10-30-91	Operations Safety Work Permit

Y70-526	07-14-95	Health and Safety Readiness Review (H&SRR)
Y70-750	02-23-95	Confined Space Entry
Y70-800	09-28-95	Safety Analysis and Review System

Analytical Services Organization (ASO) Procedures

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y/P65-0017	11-02-94	Determination of Metals on Filter Media by Inductively Coupled Plasma–Optical Emission Spectrometry (ICP-OES)
Y/P65-0019	10-31-94	Determination of Beryllium on Filter Media by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES)
Y/P65-4010	12-19-95	Determination of Free Crystalline Silica in Air by Fourier Transform Infrared Spectroscopy
Y/P65-7027	07-12-94	Activity Counting for Air and Smear Samples Using the Sharp and LB-1000 Counters
Y/P65-7028	09-20-93	Determination of Uranium on Air Monitor Filter Papers Using the Liquid Scintillation Counters
Y/P65-7173	09-02-94	Preparation of Urine Samples For Isotopic Uranium Determination - Alpha Activity Counting Method
Y/P65-7174	06-16-95	Sample Receipt and Data Management For Bioassay Samples
Y/P65-7203	In Process	Isotopic Activity Determination in Bioassay Samples - Alpha Activity Counting Method

Y/P65-7626	04-30-93	Determination of Mercury in Urine and Blood by the Cold Vapor Atomic Absorption Technique (NIOSH P & CAM 165 & 167)
Y/P65-8537	01-18-96	Determination of Airborne Fibers by Phase Contrast Microscopy
Y/P65-9509	10-15-96	ASO Quality Control Procedure

RADCON Manuals

<u>Number</u>	<u>Date</u>	<u>Title</u>
Y/DQ-29	08-02-92	Technical Basis for Workplace Air Monitoring of Airborne Radioactive Material at the Y-12 Plant
None	01-12-96	Y-12 RADCON Organization
Y/DQ-34	01-18-96	Verification and Validation of the Y-12 Lung Counting System
Y/DQ-37	March 1993	Technical Basis for Workplace Surveys of Removable Radioactive Surface Contamination at the Y-12 Plant
Y/DQ-39	03-03-92	A Model For Uranium Lung Clearance at the Y-12 Plant
Y/DQ-40	10-27-95	Technical Basis Document for the Internal Dosimetry Program at the Y-12 Plant
Y/DQ-53	Oct. 1994	Y-12 Plant Fixed Nuclear Accident Dosimeter Program
Y/DQ-61	Sept. 1995	Y-12 Radiological Control Manual
Y/DQ-63	Aug. 1995	Selection and Justification of Y-12 Plant Continuous Air Monitor (CAM) Alarm Settings
Y/DQ-64	10-24-95	Guide to Radiological Investigations

Y/DQ-68	12-27-92	Y-12 In Vivo Lung Counter Training Guide
Y/DQ-70	01-12-96	Guide to the Administration of the Y-12 In Vitro Bioassay Program

IH Manuals

<u>Number</u>	<u>Date</u>	<u>Title</u>
No number	12-05-95	Lockheed Martin Y-12 Industrial Hygiene Department IH Laboratory Information Manual (Revision 4)
No number	01-29-96	Y-12 IH Area/Personal Air Sampling
No number	01-29-96	Y-12 IH Asbestos Clearance Sampling
No number	01-29-96	Y-12 IH Smear/Wipe Sampling for Metals
No number	01-29-96	Y-12 IH Beryllium Continuous Monitoring