



### PUBLICATION RECORD

| EFFECTIVE DATE | REVISION NUMBER | DESCRIPTION  |
|----------------|-----------------|--|
| 01/06/2004     | 00              | New document for the Y-12 National Security Complex – Y-12 Site Profile. First approved issue. Initiated by William E. Murray.   |
| 11/24/2004     | 00 PC-1         | <p>Deletes acronyms and abbreviations for DOL IREP, and OWCP on page 3. Revises information on page 4 to incorporate changes from DOL and NIOSH Office of General Counsel (OGC). First approved page change revision. Initiated by William E. Murray.</p> <p>Approval:</p> <p><u>Signature on File</u> <span style="float: right;">10/26/2004</span><br/>William E. Murray, TBD Team Leader</p> <p><u>Signature on File</u> <span style="float: right;">10/26/2004</span><br/>Judson L. Kenoyer, Task 3 Manager</p> <p><u>Signature on File</u> <span style="float: right;">11/04/2004</span><br/>Richard E. Toohey, Project Director</p> <p><u>Signature on File</u> <span style="float: right;">11/24/2004</span><br/>James W. Neton, Associate Director for Science</p>                     |
| 10/11/2005     | 00 PC-2         | <p>Page change initiated to incorporate recent direction from NIOSH to include details for the definition of a DOE facility on pages 4 and 5. No sections were deleted. Second approved page change revision. Retraining is not required. Initiated by William E. Murray.</p> <p>Approval:</p> <p><u>Signature on File</u> <span style="float: right;">10/06/2005</span><br/>William E. Murray, TBD Team Leader</p> <p><u>Signature on File</u> <span style="float: right;">10/04/2005</span><br/>Judson L. Kenoyer, Task 3 Manager</p> <p><u>Signature on File</u> <span style="float: right;">10/04/2005</span><br/>Richard E. Toohey, Project Director</p> <p><u>Signature on File</u> <span style="float: right;">10/11/2005</span><br/>James W. Neton, Associate Director for Science</p> |
| 10/24/2006     | 01              | Approved Rev 01 initiated to incorporate Y-12 National Security Complex Special Exposure Cohort class descriptions in a new section. Text was added or modified on pages 5 and 6. Headings and citations were added for the Technical Basis Documents. A Reference section was added with the TBD references. The Acronyms and Abbreviations page was adjusted per usage. No sections were deleted. Constitutes a total rewrite of the document. Incorporates formal internal and NIOSH review comments. This revision results in no change to the assigned dose and no PER is required. Training required: As determined by the Task Manager. Initiated by William E. Murray.   |

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**ACRONYMS AND ABBREVIATIONS**

DOE U.S. Department of Energy

EEOICPA Energy Employees Occupational Illness Compensation Program Act of 2000

HEU highly enriched uranium

HHS U.S. Department of Health and Human Services

MED Manhattan Engineering District

NIOSH National Institute for Occupational Safety and Health

ORAU Oak Ridge Associated Universities

POC probability of causation

TBD technical basis document

U.S.C. United States Code

Y-12 Y-12 National Security Complex

µm micrometer

§ section or sections

## 1.1 PURPOSE

Technical basis documents and site profile documents are not official determinations made by the National Institute for Occupational Safety and Health (NIOSH) but are rather general working documents that provide historic background information and guidance to assist in the preparation of dose reconstructions for particular sites or categories of sites. The documents will be revised in the event additional relevant information is obtained about the affected site(s). These documents may be used to assist NIOSH staff in the completion of the individual work required for each dose reconstruction.

In this document the word “facility” is used as a general term for an area, building, or group of buildings that served a specific purpose at a site. It does not necessarily connote an “atomic weapons employer facility” or a “Department of Energy [DOE] facility” as defined in the Energy Employees Occupational Illness Compensation Program Act [EEOICPA; 42 U.S.C. § 7384l(5) and (12)]. EEOICPA defines a DOE facility as “any building, structure, or premise, including the grounds upon which such building, structure, or premise is located ... in which operations are, or have been, conducted by, or on behalf of, the Department of Energy (except for buildings, structures, premises, grounds, or operations ... pertaining to the Naval Nuclear Propulsion Program)” [42 U.S.C. § 7384l(12)]. Accordingly, except for the exclusion for the Naval Nuclear Propulsion Program noted above, any facility that performs or performed DOE operations of any nature whatsoever is a DOE facility encompassed by EEOICPA.

For employees of DOE or its contractors with cancer, the DOE facility definition only determines eligibility for a dose reconstruction, which is a prerequisite to a compensation decision (except for members of the Special Exposure Cohort). The compensation decision for cancer claimants is based on a section of the statute entitled “Exposure in the Performance of Duty.” That provision [42 U.S.C. § 7384n(b)] says that an individual with cancer “shall be determined to have sustained that cancer in the performance of duty for purposes of the compensation program if, and only if, the cancer ... was at least as likely as not related to employment at the facility [where the employee worked], as determined in accordance with the POC [probability of causation<sup>1</sup>] guidelines established under subsection (c) ...” [42 U.S.C. § 7384n(b)]. Neither the statute nor the POC guidelines (nor the dose reconstruction regulation) define “performance of duty” for DOE employees with a covered cancer or restrict the “duty” to nuclear weapons work.

As noted above, the statute includes a definition of a DOE facility that excludes “buildings, structures, premises, grounds, or operations covered by Executive Order No. 12344, dated February 1, 1982 (42 U.S.C. 7158 note), pertaining to the Naval Nuclear Propulsion Program” [42 U.S.C. § 7384l(12)]. While this definition contains an exclusion with respect to the Naval Nuclear Propulsion Program, the section of EEOICPA that deals with the compensation decision for covered employees with cancer [i.e., 42 U.S.C. § 7384n(b), entitled “Exposure in the Performance of Duty”] does not contain such an exclusion. Therefore, the statute requires NIOSH to include all occupationally derived radiation exposures at covered facilities in its dose reconstructions for employees at DOE facilities, including radiation exposures related to the Naval Nuclear Propulsion Program. As a result, all internal and external dosimetry monitoring results are considered valid for use in dose reconstruction. No efforts are made to determine the eligibility of any fraction of total measured exposure for inclusion in dose reconstruction. NIOSH, however, does not consider the following exposures to be occupationally derived:

- Radiation from naturally occurring radon present in conventional structures

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<sup>1</sup> The U.S. Department of Labor is ultimately responsible under the EEOICPA for determining the POC.

- Radiation from diagnostic X-rays received in the treatment of work-related injuries

NIOSH is supported by the Oak Ridge Associated Universities (ORAU) Team in conducting dose reconstructions under EEOICPA. This Site Profile represents a specific support mechanism to the ORAU Team about documentation of historical practices at the Y-12 National Security Complex, referred to as Y-12. This Site Profile can be used to evaluate both internal and external doses for both monitored and unmonitored workers and can serve as a supplement to, or substitute for, individual monitoring data. The document provides a Site Profile of Y-12 that contains technical basis information that the ORAU Team can use to evaluate the total occupational radiation dose for EEOICPA claimants.

The document also provides supporting technical data to evaluate the total Y-12 occupational radiation dose that can reasonably be associated with the worker's radiation exposure. This dose results from exposure to external and internal radiation sources in Y-12 facilities; to Y-12 occupationally required medical X-ray examinations, and to onsite environmental releases. Techniques are also included to estimate the dose that could have occurred while the worker was not monitored or inadequately monitored, dose that could have been missed due to analytical detection limits, or dose to workers whose monitoring records are incomplete (i.e., missed dose). Over the years new and more reliable scientific methods and protection measures have been developed. The methods needed to account for these changes are also identified in this document.

This Site Profile can be a tool when performing dose reconstructions for Y-12 workers. The Integrated Modules for Bioassay Analysis computer program is a tool useful for internal dose calculations. Information on measurement uncertainties is an integral component of the NIOSH approach. This document describes how to evaluate uncertainty associated with exposure at Y-12 and the Y-12 dosimetry records.

## **1.2 SCOPE**

The Site Profile is divided into six TBDs: This Introduction, Site Description, Occupational Medical Dose, Occupational Environmental Dose, Occupational Internal Dose, and Occupational External Dosimetry. After this Introduction, each TBD has an accompanying attachment that provides critical data for the specialists reconstructing the doses.

### **Site Description**

The Site Description TBD (ORAUT 2005) presents a brief description of the facilities and processes used at Y-12 to develop nuclear weapons and weapons components since the early 1940s. Y-12 is in the eastern section of the Oak Ridge Reservation in Oak Ridge, Tennessee. The plant occupies 811 acres and consists of 531 buildings with more than 7.5 million square feet of floor space. Construction of Y-12 was initiated in late 1942 and completed in 1943 as part of the Manhattan Engineering District (MED). Prior to completion, the operating contractor, the Tennessee Eastman Company, moved people in to start operations. The first building to begin operations was the Calutron pilot plant and training building in the fall of 1943.

Despite technical problems, this first-of-a-kind electromagnetic isotope separation (Calutron) plant, succeeded in its mission. In about 2 years, the uranium fuel was separated for the Hiroshima nuclear weapon. The gaseous diffusion process at the K-25 Site was the MED's backup for enriching uranium. Because this process was workable and much less costly, Y-12 was shutdown in December 1946, and employment was cut drastically.

The Y-12 Plant eventually became one of 12 production facilities with a unique role. From 1947 to 1992, its missions were to produce the key components of nuclear weapons and the test devices needed for the expanding nuclear weapons stockpile and to safeguard the nation's highly enriched uranium (HEU) stockpile. Other tasks included the production of the enriched lithium urgently needed for the thermonuclear program in the 1950s and 1960s. Y-12 successfully carried out these missions in developing state-of-the-art technologies demanded by new weapons designs over almost 50 years.

From 1992 to the present, the Nation's stockpile of nuclear weapons was reduced by 90%. The number of operational buildings at Y-12 was reduced, and the Plant's manufacturing technology was transferred to industry where allowed. By the end of 1992, 50 research and development agreements were negotiated between Y-12 and governmental and commercial entities. Informally termed "Work for Others," challenging problems were successfully solved for other Federal agencies. Ongoing missions include storing HEU for DOE, disassembling weapons components to study aging and other effects, producing a small number of nuclear weapons parts and assemblies, decontaminating and decommissioning unused buildings, and conducting major efforts in environmental and waste management.

### **Occupational Medical Dose**

The Occupational Medical Dose TBD (ORAUT 2006a) provides information about the dose that individual workers received from chest X-rays taken as a condition of employment. These included chest X-rays taken during preemployment (preplacement), periodic, and termination physical examinations. All workers received chest X-rays prior to employment or placement and at termination from 1943 through the present. However, the frequency of periodic chest X-rays varied over time and with the worker's age.

Both the X-ray equipment and the techniques used for taking X-rays have changed over the years. These factors have been considered in determining the dose that a worker received from the X-ray. When there was a doubt about the technique used, the assumptions which are most favorable to claimants have been made to ensure that the worker's dose has not been underestimated. The technique parameters considered include tube current and voltage, exposure time, filtration, source-to-skin distance, the view (posterior-anterior or lateral), and any other factor that could affect the dose received by the worker.

The doses to other exposed organs from the chest X-rays have also been calculated. The calculated dose takes into account the uncertainty associated with each of the parameters mentioned above. The doses received by the various organs in the body are presented in the tables for convenient reference by the dose reconstructors.

### **Occupational Environmental Dose**

The Occupational Environmental Dose TBD (ORAUT 2006b) applies to workers who were not monitored for external or internal radiation exposure. The occupational environmental dose received by unmonitored workers is limited to exposures received while outside buildings and within the perimeter of the Y-12 Plant. Buildings and other operational units occupy the vast majority of the land area at Y-12. The two exposure pathways identified are inhalation of uranium in ambient air from operational releases and direct external radiation from radionuclides in soils and outdoor surfaces, as well as shine from buildings and operational units.

Other radionuclides have been used at Y-12, but the primary source of airborne radioactive material has been uranium from operations that have occurred over the years. Due to the complexity of the terrain surrounding Y-12 and the release mechanisms from the production facilities compounded by the limited dispersion distances, traditional dispersion and transport models were considered

unsuitable. An empirical approach based on the limited ambient air-monitoring data was used to estimate  $^{234/235}\text{U}$  and  $^{238}\text{U}$  air concentrations for all years. This approach used the annual release estimates independently reconstructed by previous studies to generate annual air concentrations for four locations within Y-12. Annual intakes were then calculated for  $^{234/235}\text{U}$  and  $^{238}\text{U}$ .

There are two potential sources of external exposures received by workers at the Y-12 facility: Exposures from the deposition of radionuclides released as a consequence of facility operations and exposures received from radiation emanating from buildings and storage areas. External exposures were estimated using the results of a comprehensive radiological scoping survey. The analysis of the results from the scoping survey was used to generate a statistical range of exposure values.

### Occupational Internal Dose

The Occupational Internal Dose TBD (ORAUT 2006c) discusses the internal dosimetry program. Uranium isotopes in various chemical and physical forms have been the primary contributors to the workers' internal radiation doses, but other radionuclides were also handled and recycled uranium introduced other radionuclides. At times the processed uranium compounds might have contained impurities with radiological health implications, but the primary focus on internal dose control has been on uranium compounds and alloys over a wide range of  $^{235}\text{U}$  enrichment.

Uranium compounds handled at Y-12 range from highly soluble to very insoluble. Several particle size studies in uranium process areas have been conducted. For different processes, particle sizes ranged from less than 1 to over 10  $\mu\text{m}$ . A positive correlation was reported between uranium octoxide particle size and process temperature.

During and immediately after World War II, a uranium urinalysis program based on fluorometry was used in conjunction with medical examinations to monitor for kidney damage from exposure to soluble uranium compounds. In 1950, production workers were placed on a uranium urinalysis program to estimate internal exposure. The program was expanded to include certain maintenance workers in 1954. At present, workers with a potential for internal exposures in excess of 100 mrem/year committed effective dose equivalent are required to participate in the urinalysis program. Until 1989, routine urinalysis focused on enriched, normal, and depleted uranium, tritium, and plutonium. Analyses for other radionuclides were performed on an as-needed basis. Where available, the TBD provides laboratory detection limits for all urinary bioassay methods over time. Fecal samples were used in follow-up investigations when urinalysis or *in vivo* measurements indicated the likelihood of a substantial intake. Fecal sampling was discontinued several times in the past, but was reinstated in 1998 due to changes in workplace exposure conditions. If a work area has predominantly insoluble airborne uranium, current workers with a moderate to high exposure potential submit urine and fecal samples. The detection limit for fecal analysis is provided.

Whole-body counting was not routinely practiced at Y-12. The primary *in vivo* detection method was chest counting, which was put into routine use in 1961. Chest counting was done for  $^{235}\text{U}$ ,  $^{238}\text{U}$ , thorium (inferred from  $^{228}\text{Ac}$  and/or  $^{212}\text{Pb}$ ),  $^{237}\text{Np}$ ,  $^{60}\text{Co}$ , and  $^{95}\text{Zr}$ . Reported detection limits are provided.

### Occupational External Dosimetry

The Occupational External Dosimetry TBD (ORAUT 2006d) discusses the program for measuring skin and whole-body doses to the workers. The methods for evaluating external doses to workers have evolved over the years as new techniques and equipment have been developed. The dose reconstruction parameters, Y-12 practices and policies, and dosimeter types and technology for measuring the dose from the different types of radiation are discussed in this section. Attention is given to the evaluation of measured doses due to beta, gamma, and neutron radiations. Test results



are tabulated for various dosimeters exposed under different exposure geometries to different radiation energies.

Sources of bias, workplace radiation field characteristics, responses of the different beta/gamma and neutron dosimeters in the workplace fields, and the adjustments to the recorded dose measured by these dosimeters during specific years are discussed in detail. There are sources of potential dose that could be missed because of the limitations of dosimetry systems and the methods of reporting low doses. This missed dose is discussed as a function of facility location, dosimeter type, year, and energy range. The uncertainty in both photon and neutron doses are discussed and standard error is given over time for various dosimeters. The complexities and uncertainties in applying organ dose conversion factors to the adjusted dose of record are discussed. The use of the parameters presented in Section 6.0 is discussed in Attachment F to aid the dose reconstructor in preparing dose reconstructions for long-term Y-12 workers.

### **1.3 SPECIAL EXPOSURE COHORTS**

#### **1.3.1 March 1943 to December 1947**

Based on the findings and recommendations of NIOSH and the Advisory Board on Radiation and Worker Health, the Secretary of the U.S. Department of Health and Human Services (HHS) has determined that, for the period from March 1943 to December 1947, the only radiological exposures at Y-12 for which doses can be reconstructed are those that resulted from occupational medical X-rays. As a consequence, internal exposures are not reconstructed for those years.

Beginning from 1948, the occupational environmental internal dose from uranium can be calculated using the data provided in *Y-12 National Security Complex – Occupational Environmental Dose* (ORAUT 2006b).

#### **1.3.2 January 1948 to December 1957**

Based on the findings and recommendations of NIOSH and the Advisory Board on Radiation and Worker Health, the Secretary of the HHS has determined that, for the period from January 1948 to December 1957, there is insufficient bioassay or air-sampling data to reconstruct:

1. Internal thorium dose for employees who worked in buildings where thorium operations took place (Buildings 9201-3, 9202, 9204-1, 9204-3, 9206, and 9212).
2. Internal dose for cyclotron workers (employees who worked in Building 9201-2). These workers might have accumulated substantial chronic exposures through episodic intakes of a variety of radionuclides that were produced during the cyclotron operation period.

NIOSH determined that it is possible to reconstruct or bound occupationally required medical doses and external gamma, beta, and neutron doses. NIOSH also found that sufficient bioassay data from January 1948 to December 1957 are available for reconstruction of internal doses for workers:

1. With potential for exposure to uranium or recycled uranium contaminants ( $^{238}\text{Pu}$  and  $^{239}\text{Pu}$  in lesser quantities,  $^{237}\text{Np}$ , and  $^{99}\text{Tc}$ )
2. Involved in plutonium operations when plutonium was enriched with the calutrons.

**REFERENCES**

- ORAUT (Oak Ridge Associated Universities Team), 2005a, *Technical Basis Document for the Y-12 National Security Complex – Site Description*, ORAUT-TKBS-0014-2, Rev. 01 PC-1, Oak Ridge, Tennessee, October 11.
- ORAUT (Oak Ridge Associated Universities Team), 2006a, *Technical Basis Document for the Y-12 National Security Complex – Occupational Medical Dose*, ORAUT-TKBS-0014-3, Rev. 00 PC-3, Oak Ridge, Tennessee, April 18.
- ORAUT (Oak Ridge Associated Universities Team), 2006b, *Y-12 National Security Complex – Occupational Environmental Dose*, ORAUT-TKBS-0014-4, Rev. 01, Oak Ridge, Tennessee, July 20.
- ORAUT (Oak Ridge Associated Universities Team), 2006c, *Y-12 National Security Complex – Occupational Internal Dose*, ORAUT-TKBS-0008-5, Rev. 02, Oak Ridge, Tennessee, August 3.
- ORAUT (Oak Ridge Associated Universities Team), 2006d, *Technical Basis Document for the Y-12 National Security Complex – Occupational External Dose*, ORAUT-TKBS-0008-6, Rev. 00 PC-3, Oak Ridge, Tennessee, May 11.