DOE Review Release 03/27/2009

Document Title: **Potential Missed Dose to Nuclear Weapons Assemblers at the Y-12 Plant During the Period from 1958 to 1990**	Document Number: Revision: Effective Date: Type of Document Supersedes:	ORAUT-OTIB-0074 00 03/13/2009 OTIB None

Subject Expert(s): George D. Kerr, William G. Tankersley

Site Expert(s): N/A

Approval:	Signature on File George D. Kerr, Document Owner	Approval Date:	03/06/2009
Concurrence:	Signature on File John M. Byrne, Task 3 Manager	Concurrence Date:	03/05/2009
Concurrence:	Signature on File Edward F. Maher, Task 5 Manager	Concurrence Date:	03/05/2009
Concurrence:	Signature on File Kate Kimpan, Project Director	Concurrence Date:	03/11/2009
Approval:	Signature on File James W. Neton, Associate Director for Science	Approval Date:	03/13/2009

☒ New ☐ Total Rewrite ☐ Revision ☐ Page Change

FOR DOCUMENTS MARKED AS A TOTAL REWRITE, REVISION, OR PAGE CHANGE, REPLACE THE PRIOR REVISION AND DISCARD / DESTROY ALL COPIES OF THE PRIOR REVISION.

PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
03/13/2009	00	New technical information bulletin that provides bounding estimates of potential missed radiation doses to weapons assemblers who worked in the dry room of Building 9204-2 at the Oak Ridge Y-12 Plant during the period from 1958 to 1990. Incorporates formal internal review comments. No changes occurred as a result of formal NIOSH review. Training required: As determined by the Task Manager. Initiated by George D. Kerr.

TABLE OF CONTENTS

SECTION **TITLE** **PAGE**

LIST OF TABLES

TABLE **TITLE** **PAGE**

ACRONYMS AND ABBREVIATIONS

d	day
DOE	U.S. Department of Energy
ft	foot
hr	hour
IREP	Interactive RadioEpidemiological Program
keV	kiloelectron volts
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
OCAS	Office of Compensation Analysis and Support
ORAU	Oak Ridge Associated Universities
qtr	quarter
RPG	radiation protection guideline
SRDB Ref ID	Site Research Database Reference Identification (number)
TIB	technical information bulletin
U.S.C.	United States Code
wk	week
Y-12	Y-12 Plant, now the Y-12 National Security Complex
yr	year
§	section or sections

1.0 INTRODUCTION

Technical information bulletins (TIBs) 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 at particular sites or categories of sites. They will be revised in the event additional relevant information is obtained about the affected site(s). TIBs may be used to assist NIOSH staff in the completion of individual dose reconstructions.

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 of 2000 [42 U.S.C. § 7384l(5) and (12)].

2.0 PURPOSE

The purpose of this TIB is to provide information on potential missed dose to nuclear weapons assemblers at the Y-12 Plant during the period from 1958 to 1990. The information that was used in the preparation of this TIB was obtained primarily from interviews of several former weapons assemblers and a former supervisor of weapons assemblers at the Y-12 Plant (Tankersley 2006, 2009).

3.0 BACKGROUND INFORMATION

The Y-12 National Security Complex, formerly the Y-12 Plant, performs missions that are vital to DOE (TAPP 2003; Alspaugh 2001). Every nuclear weapon in the current U.S. stockpile contains components that were manufactured at the Y-12 facility (Alspaugh 2001). Y-12 also serves as the nation’s assembly and disassembly plant for nuclear secondary components (Alspaugh 2001).

There are two basic types of nuclear weapons. The first type produces explosive energy through nuclear fission alone. These weapons are commonly called *fission bombs, atomic bombs*, or *A-bombs*. The second basic type produces most of the explosive energy through nuclear fusion. These weapons are commonly known as *thermonuclear bombs, hydrogen bombs*, or *H-bombs.* Thermonuclear weapons depend on a fission stage to initiate the explosive release of fusion energy. The fission stage is called the *primary*, and the fusion stage of the weapon is called the *secondary*. The secondary stages in thermonuclear weapons were installed at Y-12, and the partially assembled weapons were shipped off the site for further installation of the primaries.

Weapons component assembly and disassembly were performed primarily in Buildings 9204-2 and 9204-2E (ORAUT 2007a; Wilcox 2001). Dry boxes with glove ports were used by Y-12 workers during the assembly of the earliest thermonuclear weapons (Wilcox 2001). These dry boxes were later replaced by a dry room with moisture levels controlled to within parts per million range (Wilcox 2001). Personnel inside the dry room wore airtight ventilated suits similar to those worn by astronauts to prevent body moisture from damaging weapons components during assembly of secondary stages (Wilcox 2001). The interviews with former assembly personnel indicate that the dry room at Y-12 was built in late 1958 or early 1959 (exact date uncertain) in Building 9204-2 (Tankersley 2006, 2009).

The following bulleted items provide other information that was obtained in the interviews of several former weapons assemblers and a former supervisor of weapons assemblers at the Y-12 Plant (Tankersley 2006).

- Dry room work was cumbersome at best, and an attempt was made to minimize the time in the ventilated suits. The total time spent in the suits was typically less than or equal to approximately 4 hr/d.
- The ventilated suit was rather heavy. It was made of plastic or rubber and had a weight similar to that of muslin. Personnel who were wearing ventilated suits took off outer clothing down to their underwear.
- Film badges and extremity dosimeters were not worn during assembly operations because they would be damaged by the profuse sweating by personnel while suited. The airflow in the dry room was quite high, but the dry room was not air conditioned.
- There were usually two to three individuals in the dry room at any one time. Much of the work was hands on, but individuals who were not involved in the assembly would step back until they were needed, then move up to carry out their part of the assembly.
- No one took unnecessary exposures during assembly. Health physicists stayed in the dry room and made constant surveys of the exposure and dose rates. Assemblers were not overly concerned because the penetrating whole-body doses were determined to be small.
- Time in a dry room without a film badge was about 15 to 20 hr/wk. The number of hours within 3 ft of a device under construction was approximately 10 hr/wk, and the time in direct contact with a device was about 1 to 2 minutes per assembly.

The dose rates below are taken from actual measurements made on secondary stages handled at the Y-12 facility during the period of interest (Kerr 2007). The set of measurements giving the largest dose rates is used here to provide bounding values for the potential missed dose to assemblers. These dose rates at various distances are as follows:

Distance	**Photons (mrem/hr)**	**Beta particles (mrem/hr)**
Contact	8	197
1 ft	1	7
3 ft	0.1	0.6

For dose reconstruction, estimates of the radiation doses to the extremities are necessary as well as estimates of the doses to the whole body and skin of the whole body. The beta doses to the body, face, and extremities must be corrected for shielding by the ventilated suit, clear plastic headpiece, and gloves the assemblers wore (Table 3-1). Transmission factors of various clothing items for the very energetic beta particles from uranium are summarized in Table 3.1. These data were taken from two recent reports on radiological protection for workers at uranium facilities (Rich et al. 1988; DOE 2004). The application of certain selected transmission values from Table 3-1 in the estimation of missed dose to nuclear weapon assemblers at the Y-12 Plant is discussed in Section 4.0.

Table 3-1. Transmission factors of various clothing for uranium beta particles.

Clothing	Transmission factor	Reference
Face shield	0.41	Rich et al. 1988
Vinyl surgeon's gloves	0.95	DOE 2004
Latex surgeon's gloves	0.87	DOE 2004
Two pairs of gloves plus liner	0.60	Rich et al. 1988
Lead-loaded, 10-mil lead equivalent	0.77	DOE 2004
Lead-loaded, 30-mil lead equivalent	0.13	DOE 2004
Pylox (vinyl) gloves	0.62	DOE 2004
Leather, medium weight	0.62	DOE 2004
White cotton gloves	0.89	DOE 2004
Two pairs of coveralls plus paper liner	0.80	Rich et al. 1988
Tyvek coveralls	0.98	DOE 2004
Durafab paper laboratory coat	0.96	DOE 2004
Laboratory coat (65% Dacron and 35% cotton)	0.91	Rich et al. 1988; DOE 2004

4.0 MISSED DOSE ESTIMATES

The dose rates at various distances from the secondary stage in the previous section of this report were used in the following estimates of potential missed dose to assemblers while working in the dry room at the Y-12 facility during the period from 1958 to 1990. It was assumed that the model individual spent a total of 10 hr/wk within 3 ft of the device under assembly. It is further assumed that 5 hr/wk of the total of 10 hr/wk were spent at 1 ft from a device during hands-on work. The 1 to 2 minutes during assembly that were spent in nearly direct contact with a device during hands-on work contributed insignificantly to the total missed dose.

Use of the above assumptions resulted in a potential missed penetrating dose to the whole body from photons equal to:

$$(0.1 \text{ mrem/hr})(5 \text{ hr/wk}) + (1 \text{ mrem/hr})(5 \text{ hr/wk}),$$

which is 5.5 mrem/wk, 72 mrem/qtr, or 290 mrem/yr (Table 4-1). These estimates are also used as the photon radiation dose to the head and face (Table 4-1).

Table 4-1. Estimates of potential missed dose (mrem) to weapons assemblers at the Y-12 Plant, 1958 to 1990.[a]

Dose equivalent component	Dose equivalent Weekly	Quarterly	Yearly
Photon radiation dose to whole body	5.5	72	290
Beta radiation dose to skin of whole body	32	420	1,700
Photon radiation dose to head and face	5.5	72	290
Beta radiation dose to skin of head and face	16	210	840
Photon radiation dose to hands	40	520	2,100
Beta radiation dose to skin of hands	740	9,600	39,000

a. Dose estimates greater than 100 mrem are rounded to two significant figures.

For the nonpenetrating dose to the whole body from beta particles, a transmission factor of 0.85 was assumed for the ventilated suit, which is the approximate average value of the transmission factors of 0.80 for two pairs of coveralls plus a paper liner and 0.91 for a laboratory coat (Table 3-1). Therefore, the potential missed nonpenetrating dose from beta particles to the skin of the whole body would be:

$$0.85 \times [(0.6 \text{ mrem/hr})(5 \text{ hr/wk}) + (7 \text{ mrem/hr})(5 \text{ hr/wk})],$$

which is 32 mrem/wk, 420 mrem/qtr, or 1.7 rem/yr (Table 4-1).

For the nonpenetrating dose to the skin of the head and face from beta particles, a transmission factor of 0.41 for a face shield in Table 3.1 was assumed to be applicable to the clear plastic headpiece of the airtight ventilated suit worn by the assemblers. Therefore, the potential missed nonpenetrating dose from beta particles to the skin of the head and face would be:

$$0.41 \times [(0.6 \text{ mrem/hr})(5 \text{ hr/wk}) + (7 \text{ mrem/hr})(5 \text{ hr/wk})],$$

which is 16 mrem/wk, 210 mrem/qtr, or 840 mrem/yr (Table 4-1).

The Y-12 radiation protection guideline (RPG) for the dose to the whole body from photons was 5 rem/yr, and the RPG for the dose to the skin of the whole body and the face from both photons and beta particles ranged from a low of 15 rem/yr to a high of 50 rem/yr during this period (ORAUT 2007b). The total missed dose to the skin of the whole body or the head and face is the sum of the penetrating and nonpenetrating doses in Table 4.1 from photons and beta particles, respectively.

The potential missed dose to the hands or extremities from photons from direct contact with a device during hands-on work is estimated to be:

$$(8 \text{ mrem/hr})(5 \text{ hr/wk}),$$

which is 40 mrem/wk, 520 mrem/qtr, or 2.1 rem/yr. For the dose to the hands from beta particles, a transmission factor of 0.75 was assumed for the gloves assemblers wore, which is the approximate average value of the transmission factors for Pylox or leather gloves and 0.91 for white cotton gloves (Table 3-1). Therefore, the potential missed dose to the hands from beta particles would be:

$$0.75 \times (197 \text{ mrem/hr})(5 \text{ hr/wk}),$$

which is 739 mrem/wk, 9.6 rem/qtr, or 39 rem/yr (Table 4-1). The total missed dose to the hands (extremities) from photons and beta particles would be approximately 41 rem/yr, which compares to RPGs for the extremities of 75 rem/yr before 1988 and 50 rem/yr starting in 1988 (ORAUT 2007b).

The nuclear weapon assemblers at the Y-12 Plant wore a film badge dosimeter when they were not working in the dry room. Thus, the dose estimates given here are only estimates of missed dose while the assemblers were working in the dry room and were not wearing their film badge dosimeters. The exposure geometry for the missed dose estimates presented here should be treated as an anterior-posterior (AP) or front-to-back irradiation of the body. The beta particles should be considered to have energies greater than 15 keV and the photons should be considered to have energies ranging from 30 to 250 keV (ORAUT 2006, Table 6.3.4.1-1). Because the missed dose estimates for an assembler who worked in the dry room without wearing a film badge dosimeter are bounding estimates or best estimates based on the available information, they should be entered as constant values into the calculations using the NIOSH-Interactive RadioEpidemiological Program (NIOSH-IREP). NIOSH-IREP is a web-based computer program that estimates the probability that an individual's cancer was caused by his or her radiation exposure. Discussions of NIOSH-IREP can be found in a number of technical documents posted on NIOSH's Office of Compensation Analysis and Support (OCAS) web site at www.cdc.gov/niosh/ocas.

5.0 ATTRIBUTIONS AND ANNOTATIONS

All information requiring identification was addressed via references integrated into the reference section of this document.

REFERENCES

Alspaugh, D., 2001, *Overview of the DYMCAS, the Y-12 Material Control and Accountability System*, Y/SW-0077, BWXT Y-12, Y-12 National Security Complex, Oak Ridge, Tennessee, July. [SRDB Ref ID: 47091]

DOE (U.S. Department of Energy), 2004, *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities*, DOE-STD-1136-2004, Washington, D.C. [SRDB Ref ID: 18881]

Kerr, G. D., 2007, "Bounding Dose Rates for Weapon Assemblers Working in the Y-12 Dry Room," documented communication with M. H. Chew, (M. L. Chew and Associates), Kerr Consulting, Knoxville, Tennessee, February 27. [SRDB Ref ID: 31375]

ORAUT (Oak Ridge Associated Universities Team), 2006, *Technical Basis Document for the Y-12 National Security Complex – Occupational External Dosimetry*, ORAUT-TKBS-0014-6, Rev. 00 PC-3, Oak Ridge, Tennessee, May 11.

ORAUT (Oak Ridge Associated Universities Team), 2007a, *Y-12 National Security Complex – Site Description*, ORAUT-TKBS-0014-2, Rev. 02, Oak Ridge, Tennessee, November 8.

ORAUT (Oak Ridge Associated Universities Team), 2007b, *Historical Evaluation of the Film Badge Dosimetry Program at the Y-12 Plant in Oak Ridge, Tennessee: Part 3 – Beta Radiation*, ORAUT-OTIB-0046, Rev. 00, Oak Ridge, Tennessee, June 22.

Rich, B. L., S. L. Hinnefeld, C. R. Lagerquist, W. G. Mansfield, L. H. Munson, E. R., Wagner, and E. J. Vallario, 1988, *Health Physics Manual of Good Practices for Uranium Facilities*, EGG-2530, EG&G Idaho, Idaho National Engineering Laboratory, Idaho Falls, Idaho, June. [SRDB Ref ID: 1781]

Tankersley, W. G., 2006, "Y-12 Assembly/Disassembly Conferences and Telephone Conversations" documented communications with G. D. Kerr (Oak Ridge Associated Universities) March 16, 2006 through March 23, 2006, Oak Ridge Associated Universities Team, Oak Ridge, Tennessee. [SRBD Ref ID: 57448]

Tankersley, W. G., 2009, "Dry Room Locations at the Y-12 Plant from 1958 to 1990" documented communications with G. D. Kerr (Oak Ridge Associated Universities) January 27, 2009, Oak Ridge Associated Universities Team, Oak Ridge, Tennessee. [SRDB Ref ID: 58676]

TAPP (Thomas and Associates Preservation Planners), 2003, *Y-12 National Security Complex National Historic Preservation Act Historic Preservation Plan*, Y/TS-1983, Y-12 National Security Complex, Oak Ridge, Tennessee. [SRDB Ref ID: 19331]

Wilcox, W. J. Jr., 2001, *An Overview of the History of Y-12 – 1942-1992: A Chronology of Some Noteworthy Events and Memoirs*, American Museum of Science and Energy, Oak Ridge, Tennessee, August. [SRDB Ref ID: 9609]