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PUBLICATION RECORD

EFFECTIVE DATE	REVISION NUMBER	DESCRIPTION
09/26/2008	00	Approved new technical information bulletin to provide information to allow ORAU Team dose reconstructors to assign doses at the Sandia National Laboratory in Albuquerque, New Mexico to certain workers who have no or limited monitoring data, based on site coworker data. No changes occurred as a result of formal internal and NIOSH review. Training required: As determined by the Task Manager. Initiated by Matthew H. Smith.

Trademark Information

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ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act of 2000
IREP	Interactive RadioEpidemiological Program
LOD	limit of detection
mrem	millirem
NIOSH	National Institute for Occupational Safety and Health
ORAU	Oak Ridge Associated Universities
SNL	Sandia National Laboratories
SRDB	Site Research Database
SSN	Social Security Number
TIB	technical information bulletin
TLD	thermoluminescent dosimeter
U.S.C.	United States Code
§	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 [EEOICPA; 42 U.S.C. § 7384l(5) and (12)].

2.0 PURPOSE

The purpose of this TIB is to provide information to allow dose reconstructors to assign doses based on site coworker data to Sandia National Laboratory in Albuquerque, New Mexico (SNL) workers who have no or limited monitoring data. In addition, the data in this TIB should be used to assign dose for gaps in the dosimetry record. The data are to be used in conjunction with ORAUT-OTIB-0020, *Use of Coworker Dosimetry Data for External Dose Assignment* (ORAUT 2005).

3.0 BACKGROUND

The Oak Ridge Associated Universities (ORAU) Team is conducting a series of coworker data studies to permit dose reconstructors to complete certain cases for which external or internal monitoring data are unavailable or incomplete. Cases that do not have complete monitoring data could fall into one of several categories:

- The worker was unmonitored and, even by today's standards, did not need to be monitored (e.g., a nonradiological worker).
- The worker was unmonitored but, by today's standards, would have been monitored.
- The worker might have been monitored, but the data are not available to the dose reconstructor.
- Partial information is available, but it is insufficient to facilitate a dose reconstruction.

As described in ORAUT-OTIB-0020 (ORAUT 2005), some cases without complete monitoring data can be processed based on assumptions and methodologies that do not involve coworker data. For example, many cases in the first category can be processed by the assignment of ambient external and internal doses based on information in the relevant site technical basis documents.

As described in ORAUT-TKBS-0037, *Site Profile for Sandia National Laboratories* (ORAUT 2007a), operations at the laboratory (separate from Los Alamos) began in 1949. SNL used a variety of film dosimeters between 1949 and 1971. A two-chip thermoluminescent dosimeter (TLD) was used starting in 1971 and a multichip TLD was implemented in 1974. Exchange frequencies varied from quarterly to biweekly dependent on job duties. There does not appear to have been any significant administrative practice that would have jeopardized the integrity of the dose of record.

4.0 GENERAL APPROACH

As described in ORAUT-OTIB-0020 (ORAUT 2005), the general approach to the development of coworker data for cases without external monitoring data is to assign either 50th- or 95th-percentile doses with the intent that the assigned doses represent, but do not underestimate, the doses that would have been assigned had the worker been monitored.

5.0 APPLICATIONS AND LIMITATIONS

Some SNL workers could have worked at one or more other major sites in the DOE complex during their employment histories. Therefore, the data in this TIB must be used with caution to ensure that, for likely noncompensable cases, unmonitored external doses from multiple site employments have been overestimated. This typically requires the availability of the recorded doses or TIBs for external coworker dosimetry data for all relevant sites.

The data in this TIB address penetrating gamma radiation and nonpenetrating electron and/or low-energy photon radiation. Neutron data are not presented separately; methods for determining neutron dose are discussed in Section 7.0.

External onsite ambient dose should be applied as specified in the latest revision of ORAUT-PROC-0060*, Occupational On-Site Ambient Dose Reconstruction for DOE Sites* (ORAUT 2006).

6.0 COWORKER DATA DEVELOPMENT

Since an electronic database was not available from SNL, a Microsoft® Access® database that contains the raw dosimetry data was created by combining individual Excel® spreadsheets into one dataset. The individual Excel® spreadsheets were created by transcribing dosimetry information from documents that were captured and recorded in the Site Research Database (SRDB). Hard-copy dosimetry records were available for the periods from 1959 to 1986 and from 1992 to 1994.

The original dataset contained 254,873 records, which was culled to 236,902 records, which reduced the total number of records available for analysis by approximately 7% (see yearly distribution of records in Table 6-1). Dosimetry records that were removed from the original dataset were unremarkable (i.e., excluding these values should not affect the overall results). Records were removed from the original dataset for the following reasons:

- Illegible dates;
- Dose reported was cumulative and could not be binned into a single year;
- Dose record was of poor quality and could not be read accurately;
- The badge return date precedes the issue date; or
- The wear period was greater than 400 days.

An assumption was made that the dose could be assigned to a single year if the wear period (i.e., the number of days between the date the badge was issued and the date the badge was returned) was less than 400 days.

The annual data for each worker were prorated to account for partial years of employment based on an analysis of the length of monitored employment that was associated with the data (see Section 6.2 for further discussion of special considerations). The data were prorated so coworker doses that

Table 6-1. Distribution of SNL SRDB dosimetry records by year.

Year	# of Records	Year	# of Records	Year	# of Records
1949	1	1965	338	1981	21,199
1950	0	1966	265	1982	22,023
1951	0	1967	465	1983	23,453
1952	0	1968	318	1984	18,963
1953	0	1969	282	1985	21,999
1954	0	1970	496	1986	25,606
1955	0	1971	794	1987	0
1956	0	1972	1,477	1988	0
1957	6	1973	1,879	1989	0
1958	0	1974	1,465	1990	0
1959	72	1975	1,799	1991	4
1960	1,533	1976	2,358	1992	6,183
1961	1,055	1977	20,239	1993	1,514
1962	1,704	1978	20,299	1994	71
1963	1,122	1979	18,217		
1964	493	1980	19,210		

represent a full year of monitored employment could be derived; this permits the dose reconstructor to assign appropriate doses based on specific employment dates and job descriptions.

The dosimetry components that were developed from the data and available in the Access® database are shown in Table 6-2. Gamma was used as the primary value to represent deep dose. In the absence of a gamma value, the body dose, minus any neutron dose, was used if available. The shallow dose (i.e., open-window dose) was calculated as a precursor for the nonpenenetrating dose calculation. The skin dose was used for the shallow dose. In the absence of skin dose, the calculated deep dose was added to the nonpenetrating (NPR) dose. This step was necessary because some records listed a skin dose while others had only a NPR dose. The nonpenetrating dose was calculated by subtracting the deep dose from the shallow dose.

Table 6-2. SNL dosimetry components.

Dose component	Comment
Body	Photon penetrating dose + neutron
Skin	Penetrating + nonpenetrating dose
Extremity	~9,700 records in the database but extremity dose was not evaluated
Eye	Few records in database: ~400 records with 100 mrem or more dose
Gamma	Photon penetrating dose
Neutron	Few records in database: ~300 records with 100 mrem or more dose
NPR	Nonpenetrating dose

6.1 ADJUSTMENT FOR MISSED DOSE

According to OCAS-IG-001, *External Dose Reconstruction Implementation Guideline* (NIOSH 2007), missed doses are assigned for reported zero readings for each monitoring cycle to account for the possibility that doses were received but either not recorded by the dosimeter or not reported by the site. In addition, reported dose values less than one-half the applicable minimum detection limits are assigned as missed dose. Annual maximum potential missed doses are calculated by multiplying the number of zero or unrecorded badge readings by the reported dosimeter limit of detection (LOD) and summing the results. These values are used as the 95th percentile of a lognormal distribution to calculate the probability of causation, which is determined by the U.S. Department of Labor. Thus, in the Interactive RadioEpidemiological Program (IREP), Parameter 1 input is equal to the calculated

maximum annual missed doses multiplied by 0.5, and the Parameter 2 input is equal to 1.52. These values represent the geometric mean and geometric standard deviation, respectively, for each year of analysis.

The assignment of maximum potential missed doses for monitored workers is particularly significant for SNL workers from 1949 to 1971, when they could have been monitored biweekly. Table 6-3 lists the maximum annual missed dose by monitoring period based on information in ORAUT-TKBS-0037 (ORAUT 2007a).

Table 6-3. Missed external doses (rem) based on ORAUT-TKBS-0037 (ORAUT 2007a).

Monitoring period	Penetrating LOD (rem)	Nonpenetrating LOD (rem)	Exchange frequency[a]	Maximum potential annual missed penetrating dose (rem)	Maximum potential annual missed nonpenetrating dose (rem)
1949–1958	0.04	Not measured	Biweekly	1.04	Not applicable
1950–1971	0.04	0.04	Biweekly	1.04	1.04
1972–1990	0.02	0.038	Monthly	0.24	0.456
1990–1994	0.01	0.035	Monthly	0.12	0.42
1995–present	0.005	0.005	Monthly	0.06	0.06

a. Based on maximum potential exchange frequency in ORAUT-TKBS-0037 (ORAUT 2007a)

6.2 SPECIAL CONSIDERATIONS

Analysis of Data: 1959–1976
All dose records were treated the same and were prorated to 365 days. The data were very consistent with 98% of the records exhibiting a wear period of 300 days or greater.

Analysis of Data: 1977–1994
An identifier was created for each record which consists of Social Security Number (SSN), last name, and first name.

- This identifier was created so that all badges that were issued to an individual could be grouped together to report dose per year per individual.

- The combination of SSN, last name, and first name was chosen as the identifier because not all records had all fields but missing fields were generally consistent within a year for an individual, which yielded reliable segregation.

During this period the number of badges that were issued to an individual and the wear periods varied greatly. The number of badges varied from 1 to 222, and the "DaysPerBadge" [*(Total time a badge was issued)* ÷ *(number of badges issued in a year)*] varied from 1 to 366. Averages were 3.4 and 80.6, respectively. In cases where the "DaysPerBadge" was ≤5, it was assumed that the employee did not need to be monitored routinely and was monitored appropriately for all entries into a radiation area. These doses were <u>not</u> prorated. Only records with a "DaysPerBadge" value >5 were prorated to 365 days.

7.0 <u>COWORKER ANNUAL DOSE SUMMARIES</u>

Based on the described information and approaches, SNL coworker annual external dosimetry summaries were developed for use in the evaluation of external penetrating and nonpenetrating dose

for certain workers who were potentially exposed to workplace radiation but for whom there is no or limited monitoring data from DOE. These summaries were developed using the following steps:

Step 1. As described in Section 6.0, the reported penetrating dose was modified for each worker to account for partial years of employment. This permits the dose reconstructor to assign an appropriate prorated dose to account for partial years of employment or potential exposure.

Step 2. One-half of the maximum potential annual missed doses listed in Table 6-3 were added to the reported annual doses from Step 1 (with the exception of reported positive doses, in which case the maximum missed dose was reduced by the dose that corresponded to one badge exchange because it is not possible that all individual badge results were zero if a positive annual dose was reported).

Step 3. The 50th- and 95th-percentile annual coworker gamma doses were derived from the doses from Step 2 by ranking the data into cumulative probability curves and extracting the 50th- and 95th-percentile doses for each year.

Step 4. Table 7-1 lists the results of the coworker analysis. These percentile doses should be used for SNL workers with no or limited monitoring data through the use of the methodologies in Section 7.0 of ORAUT-OTIB-0020 (ORAUT 2005). In general, the 50th-percentile dose can be used as a best estimate of a worker's dose when professional judgment indicates that the worker was probably exposed to intermittent low levels of external radiation. The 50th-percentile dose should generally not be used for workers who were routinely exposed. For routinely exposed workers (i.e., workers who were expected to have been monitored and routinely exposed), the 95th-percentile dose should be applied. However, other options are available through the guidance in ORAUT-OTIB-0020. For instance, for cases in which routine monitoring data exist and coworker dose is used to supplement missing quarters or years, the percentile dose should be the one that is consistent with the recorded doses unless there is reason to believe that the worker's job or location in that year differed significantly from the job or location during the years dose was recorded. For workers who are unlikely to have been exposed, external onsite ambient dose should be used rather than coworker doses.

Step 5. Table 7-2 lists penetrating dose values (as described in the steps above) that have been adjusted using the guidance in Section 8.0 of ORAUT-OTIB-0052, *Parameters to Consider When Processing Claims for Construction Trade Workers* (ORAUT 2007b). This guidance is applicable for construction trade workers who meet the criteria in Section 3.0 of that TIB. Because the TIB does not provide an adjustment factor for nonpenetrating dose, this dose component is not shown in this table.

Step 6. If needed, neutron dose (for the period before the implementation of TLD dosimetry in 1971) should be calculated using the neutron-to-photon ratios in Table 6-9 of ORAUT-TKBS-0037 (ORAUT 2007a). These values would be applied to the penetrating dose values in Table 7-1 below.

Table 7-1. Annual SNL external coworker doses modified to account for missed dose (rem).

Year	Penetrating 95th percentile	Penetrating 50th percentile	Nonpenetrating 95th percentile	Nonpenetrating 50th percentile
1959	1.316	0.540	0.560	0.520
1960	0.740	0.520	0.520	0.520
1961	0.830	0.560	0.994	0.600
1962	1.031	0.590	0.796	0.540
1963	0.780	0.550	0.720	0.540
1964	1.432	0.580	0.950	0.540
1965	2.126	0.580	1.120	0.540
1966	2.027	0.600	1.828	0.645
1967	1.414	0.571	1.547	0.561
1968	2.170	0.610	1.701	0.655
1969	2.115	0.610	1.348	0.560
1970	1.603	0.580	1.875	0.570
1971	1.112	0.570	0.610	0.520
1972	0.628	0.160	0.368	0.228
1973	0.458	0.150	0.309	0.228
1974	0.440	0.140	0.289	0.228
1975	0.380	0.150	0.344	0.228
1976	0.320	0.140	0.259	0.228
1977	0.279	0.120	0.279	0.228
1978	0.229	0.120	0.259	0.228
1979	0.191	0.120	0.269	0.228
1980	0.190	0.120	0.257	0.228
1981	0.136	0.120	0.219	0.228
1982	0.150	0.120	0.229	0.228
1983	0.160	0.120	0.229	0.228
1984	0.130	0.120	0.219	0.228
1985	0.151	0.120	0.222	0.228
1986	0.154	0.120	0.228	0.228
1992	0.070	0.060	0.210	0.210
1993	0.157	0.065	0.228	0.210
1994	0.159	0.067	0.231	0.210

Table 7-2. Annual SNL external coworker doses modified in accordance with ORAUT-OTIB-0052 (rem) (ORAUT 2007b).

Year	Penetrating 95th percentile	Penetrating 50th percentile
1959	1.642	0.556
1960	0.836	0.520
1961	0.962	0.584
1962	1.243	0.626
1963	0.892	0.570
1964	1.805	0.612
1965	2.776	0.612
1966	2.638	0.640
1967	1.780	0.599
1968	2.837	0.654
1969	2.761	0.654
1970	2.044	0.612
1971	1.357	0.598
1972	0.835	0.180
1973	0.598	0.166
1974	0.572	0.152

Year	Penetrating 95th percentile	Penetrating 50th percentile
1975	0.488	0.166
1976	0.404	0.152
1977	0.347	0.120
1978	0.277	0.120
1979	0.224	0.120
1980	0.222	0.120
1981	0.146	0.120
1982	0.166	0.120
1983	0.180	0.120
1984	0.138	0.120
1985	0.167	0.120
1986	0.172	0.120
1992	0.076	0.060
1993	0.198	0.069
1994	0.201	0.072

8.0 ATTRIBUTIONS AND ANNOTATIONS

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

REFERENCES

NIOSH (National Institute for Occupational Safety and Health), 2007, *External Dose Reconstruction Implementation Guideline*, OCAS-IG-001, Rev. 3, Office of Compensation Analysis and Support, Cincinnati, Ohio, November 21.

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