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PUBLICATION RECORD

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05/12/2006	00	New technical information bulletin to provide information to allow ORAU Team dose reconstructors to assign doses at the Rocky Flats Plant to certain workers who have no or limited monitoring data, based on site coworker data. First approved issue. Training required: As determined by the Task Manager. Initiated by Matthew H. Smith.

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ACRONYMS AND ABBREVIATIONS

DOE	U.S. Department of Energy
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
LOD	limit of detection
NDRP	Neutron Dose Reconstruction Project
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH-OCAS Claims Tracking System
OCAS	Office of Compensation Analysis and Support
ORAU	Oak Ridge Associated Universities
RFP	Rocky Flats Plant
TIB	technical information bulletin
TLD	thermoluminescent dosimeter
U.S.C.	United States Code
yr	year
§	section

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 working documents that provide historical 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. TIBs may be used to assist the 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 [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 [probability of causation] guidelines established under subsection (c) …." [42 U.S.C. § 7384n(b)]. Neither the statute nor the probability of causation 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 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;
- radiation from diagnostic X-rays received in the treatment of work-related injuries.

2.0 PURPOSE

The purpose of this TIB is to provide information to allow Oak Ridge Associated Universities (ORAU) Team dose reconstructors to assign doses to Rocky Flats Plant (RFP) workers who have no or limited monitoring data, based on site coworker data. The data in this TIB are to be used in conjunction with *Use of Coworker Dosimetry Data for External Dose Assignment* (ORAUT 2005a).

3.0 BACKGROUND

The 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 not having 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 (2005a), some cases without complete monitoring data can be processed based on assumptions and methodologies that do not involve coworker data. For example, many cases falling in the first category can be processed by assigning ambient external and internal doses based on information in the relevant site technical basis documents.

As described in *Technical Basis Document for the Rocky Flats Plant – Occupational External Dosimetry* (ORAUT 2004), operations at the site began in 1951. RFP used a variety of film dosimetry designs between 1951 and 1969. A combination film and thermoluminescent dosimeter (TLD) was used starting in 1969 until a full TLD was implemented in 1971. Use of dosimetry at RFP expanded as production operations increased. In 1964, the dosimetry package was incorporated into the security badge, which better ensured that each worker wore a dosimeter (ORAUT 2004). Exchange frequencies varied from quarterly to weekly, depending on job duties. There does not appear to be any significant administrative practice that would have jeopardized the integrity of the dose of record.

4.0 GENERAL APPROACH

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

5.0 APPLICATIONS AND LIMITATIONS

Some RFP workers could have worked at one or more other major sites within the DOE complex during their employment history. 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 will typically require the availability of the respective site recorded doses or TIBs for external coworker dosimetry data for all relevant sites.

The data in this TIB address penetrating radiation from gamma and neutron radiation and nonpenetrating radiation from electron and/or low-energy photon radiation. Neutron data are not presented separately; therefore, methods for determining neutron dose are discussed in Section 7.0. ORAUT (2004) and the following two documents should be used as the basis for assigning neutron doses, when relevant:

- *Use of Rocky Flats Neutron Dose Reconstruction Project Data in Dose Reconstructions* (ORAUT 2005b)
- *Technical Basis Document for the Neutron Dose Reconstruction Project* (Falk et al. 2005)

External onsite ambient dose should be applied as specified in the latest revision of ORAUT-PROC-0060*, External On-Site Ambient Dose Reconstruction for DOE Sites* (ORAUT 2005c).

6.0 COWORKER DATA DEVELOPMENT

Dosimetry data for monitored RFP workers contained in the Health Information System (HIS20) were selected for this evaluation. The HIS20 system was the last one used at RFP for the retention of occupational radiation exposure data. The information in this system contains data that have been transferred from previous electronic systems and hard-copy health physics files. In addition, HIS20 now contains the results of the Neutron Dose Reconstruction Project (Falk et al. 2005).

The annual data for each worker reported between 1952 and 2005 were prorated to account for partial years of employment based on an analysis of the length of monitored employment associated with the data (see “Special Considerations” for further discussion). The data were prorated so coworker doses representing 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 validity of the data used for coworker dose development was confirmed by selecting a sampling of beta-gamma film badge worksheets (handwritten records) and comparing them to data for penetrating radiation listed in the HIS20 database.

Each beta-gamma worksheet contains film badge results for numerous workers for a given building and quarter. For each worker-year, four sheets are combined to comprise the annual beta-gamma dose record. Thirty such worker-years were examined and compared to data for the same worker-year.

Of the 30 worker-years compiled (representing data for 30 individuals), 22 (73%) were complete, in that all quarterly data were found, and the total annual dose was in agreement. For 5 worker-years (17%), one quarter of data was missing, but the annual total calculated with that missing quarter agreed with the HIS20 database. For 3 worker-years (10%), some quarterly data were missing or blank and the annual totals did not agree with the HIS20 database. In all three of those instances, the HIS20 database annual values were higher than the data extracted from the beta-gamma worksheets.

6.1 ADJUSTMENT FOR MISSED DOSE

According to *External Dose Reconstruction Implementation Guideline* (NIOSH 2002), missed doses are assigned for zero or unrecorded 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. 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), the 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 RFP workers from 1954 to 1962 when they could have been monitored weekly. Table 6-1 lists the maximum annual missed dose by monitoring period based on information in ORAUT (2004).

Table 6-1. Missed external doses based on ORAUT (2004).

Monitoring period	Penetrating LOD (rem)	Nonpenetrating LOD (rem)[a]	Exchange frequency	Maximum potential annual missed penetrating dose (rem)	Maximum potential annual missed nonpenetrating dose (rem)
1952–1953	0.04	0.05	Semimonthly[b]	0.960	1.200
1954–1962	0.04	0.05	Weekly[b]	2.080	2.600
1963–1964	0.04	0.05	Semimonthly[b]	0.960	1.200
1965–1966	0.04	0.05	Monthly[b]	0.480	0.600
1967–1968	0.04	0.05	Semimonthly[b]	0.960	1.200
1969–1976	0.02	0.03	Semimonthly[b]	0.480	0.720
1977–1992	0.02	0.03	Monthly[c]	0.240	0.360
1993–2005	0.01	0.02	Monthly[c]	0.120	0.240

a. Based on analysis of nonpenetrating LODs for other DOE sites in OTIB-0017 (ORAUT 2005d). Specific RFP data for nonpenetrating LOD is not available at this time.
b. Based on maximum potential exchange frequency as shown in ORAUT (2004).
c. The exchange frequency was not defined in ORAUT (2004). It is based on a review of claim data evaluated under the EEOICPA Subtitle B program.

6.2 SPECIAL CONSIDERATIONS

Certain aspects of the external dosimetry practices at the RFP documented in ORAUT (2004) were considered in the analysis of the site data. These include:

- Conservatively determined default dosimeter exchange frequencies were used. Not all RFP employees would have had dosimetry exchanged at these upper-bound frequencies.

- During the process of prorating HIS20 dose to account for partial years of employment, it was discovered that artificially short or long wear periods had been entered into the HIS20 database. These artificial periods were entered because only one date (usually the end date) was available in the electronic data from previous database systems. To avoid skewing the overall dataset with artificially high or low prorated dose, data with a wear period less than or equal to 0.1 yr or greater than 1.25 yr were excluded from the analysis described in Section 7.0.

- Inclusion of Neutron Dose Reconstruction Project (NDRP) data in the HIS20 dataset led to the development of tables of data for penetrating and nonpenetrating dose that include and exclude the NDRP values. This was done to provide a method to separate a neutron dose component from 1952 to 1969. To determine neutron dose for 1970 to 2005, a neutron-to-photon ratio method defined in OTIB-0050 can be used (ORAUT 2005b).

- OTIB-0027 should be used to choose the proper method for processing penetrating and nonpenetrating data to determine low-energy (less-than-30-keV) photon dose or electron (greater-than-15-keV) dose components as needed (ORAUT 2005e).

As described in Section 7.0, a claimant-favorable approach was adopted in the development of coworker dose summaries, and this approach is intended to account for any underestimate of doses to radiological workers at the RFP based on these considerations.

7.0 COWORKER ANNUAL DOSE SUMMARIES

Based on the information and approaches described, RFP coworker annual external dosimetry summaries were developed for use in the evaluation of external gamma dose for certain workers potentially exposed to workplace radiation, but with no or limited monitoring data from DOE. These summaries were developed using the following steps:

Step 1. As described in Section 6.0, for data between 1952 and 2005, the reported penetrating dose, which represented annual summary data, was modified for each worker to account for partial years of employment. This adjustment was made by analyzing the dosimetry wear dates supplied in the HIS20 database. For example, if in a particular calendar year the average employment period for all RFP employees in the NIOSH-OCAS Claims Tracking System (NOCTS) was 11 months, the reported annual doses were multiplied by 12/11 (1.09). 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 6-1 were added to the reported annual doses from Step 1 (except reported positive doses, in which case the maximum missed dose was reduced by the dose corresponding 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 calculated in Step 2 by ranking the data into cumulative probability curves and extracting the 50th- and 95th-percentile doses for each year.

Step 4. Tables 7-1 and 7-2 list the results of the coworker analysis including and excluding NDRP data respectively. These percentile doses should be used for selected RFP workers with no or limited monitoring data using the methodologies outlined in Section 7.0 of ORAUT (2005a). In general, the 50th-percentile dose can be used as a best estimate of a worker's dose when professional judgment indicates the worker was likely exposed to intermittent low levels of external radiation. The 50th-percentile dose should not be used for workers who were routinely exposed. For routinely exposed workers (i.e., workers who were expected to have been monitored), the 95th-percentile dose should be applied. For workers who are unlikely to have been exposed, external onsite ambient dose should be used rather than coworker doses.

Step 5. Workers exposed to neutrons from work in plutonium facilities from 1952 to 1969 were, in general, included in the NDRP study. Therefore, the neutron dose component for 1952 to 1969 should be calculated by subtracting (at the chosen 95th or 50th percentile) the penetrating non-NDRP dose (Table 7.2) from the penetrating dose including NDRP data (Table 7-1). The results for penetrating dose in Table 7-2 represent the gamma component of penetrating dose for 1952 to 1969. To separate the neutron and gamma components of the

penetrating dose for 1970 to 2005, the neutron-to-photon ratio method defined in OTIB-0050 should be used (ORAUT 2005b). It should be noted that the NDRP data includes an estimate of missed neutron dose (addressed as notional dose by the NDRP project), therefore, no adjustments are needed for missed neutron dose for the period 1952 to 1969. Likewise, for the period 1970 to 2005, missed neutron dose is accounted for when the applicable neutron to photon ratio is applied to the data in Table 7-1.

Step 6. In instances where non-penetrating dose is considered for the period 1952-1969, Table 7-1 values should be used for workers at plutonium facilities (i.e. non-penetrating dose is due to low-energy photons). For workers at non-plutonium facilities (i.e. non-penetrating dose is due to electrons), the non-penetrating values in Table 7-2 should be used.

Table 7-1. Annual RFP external coworker doses (including NDRP data) modified to account for missed dose (rem).

Year	Penetrating 95th percentile	Penetrating 50th percentile	Nonpenetrating 95th percentile	Nonpenetrating 50th percentile	Number of Monitored Workers
1952	5.018	2.505	5.133	2.620	42
1953	4.190	0.751	4.553	0.892	319
1954	3.233	1.095	3.600	1.361	353
1955	4.411	1.165	5.266	1.431	529
1956	4.461	1.135	5.617	1.415	781
1957	5.136	1.177	6.004	1.454	918
1958	6.015	1.253	7.553	1.584	1062
1959	7.186	1.581	8.002	1.908	1063
1960	7.121	1.293	7.728	1.645	1284
1961	7.850	1.527	8.201	1.923	1638
1962	6.523	1.542	7.062	1.828	2003
1963	5.955	0.940	6.232	1.104	2176
1964	4.875	0.648	5.012	0.799	2834
1965	3.533	0.511	3.663	0.598	2826
1966	4.767	0.592	4.976	0.679	2888
1967	4.379	0.627	4.735	0.761	2902
1968	3.276	0.578	3.591	0.714	3101
1969	2.702	0.327	2.919	0.450	3471
1970	2.301	0.307	2.460	0.423	3308
1971	1.938	0.384	2.096	0.500	3398
1972	1.853	0.377	1.995	0.494	3282
1973	1.697	0.380	1.848	0.497	3020
1974	1.881	0.497	2.047	0.612	2687
1975	1.329	0.401	1.525	0.516	2489
1976	0.826	0.248	1.030	0.364	**2424**
1977	0.589	0.122	0.699	0.177	3740
1978	0.698	0.120	0.830	0.180	4176
1979	0.906	0.122	1.074	0.180	3893
1980	0.743	0.120	0.889	0.168	3752
1981	0.853	0.110	1.008	0.180	4060
1982	0.990	0.121	1.174	0.166	4851
1983	1.212	0.134	1.440	0.193	5360
1984	1.204	0.141	1.551	0.200	5673
1985	1.302	0.142	1.584	0.203	6140
1986	1.365	0.183	1.860	0.301	4942
1987	1.510	0.259	2.265	0.457	2583
1988	1.236	0.199	1.614	0.373	2778
1989	0.550	0.115	0.733	0.180	5296
1990	0.288	0.130	0.435	0.201	3369
1991	0.337	0.154	0.471	0.228	5641
1992	0.267	0.150	0.421	0.235	5831
1993	0.207	0.080	0.296	0.150	5313
1994	0.179	0.084	0.242	0.142	4839
1995	0.200	0.080	0.275	0.137	4130
1996	0.274	0.105	0.357	0.168	3454
1997	0.352	0.085	0.420	0.145	3718
1998	0.275	0.073	0.337	0.130	3470
1999	0.192	0.072	0.256	0.127	3655
2000	0.164	0.060	0.224	0.120	3576
2001	0.160	0.060	0.223	0.120	3443
2002	0.157	0.060	0.215	0.120	3502
2003	0.127	0.060	0.194	0.120	3373
2004	0.097	0.060	0.164	0.120	2758
2005	0.175	0.071	0.234	0.129	955

Table 7-2. Annual RFP external coworker doses (excluding NDRP data) modified to account for missed dose (rem).

Year	Penetrating 95th percentile	Penetrating 50th percentile	Nonpenetrating 95th percentile	Nonpenetrating 50th percentile	Number of Monitored Workers
1952	1.004	0.853	1.119	0.968	2
1953	1.829	0.690	2.151	0.818	295
1954	1.858	1.075	2.747	1.340	343
1955	2.572	1.145	3.203	1.411	507
1956	2.551	1.095	3.334	1.370	696
1957	2.956	1.135	3.879	1.405	872
1958	3.907	1.155	5.314	1.445	1011
1959	4.757	1.256	5.684	1.573	1029
1960	3.877	1.108	4.586	1.415	1242
1961	4.204	1.250	4.760	1.581	1593
1962	4.264	1.248	4.864	1.538	1942
1963	3.558	0.646	3.941	0.798	2097
1964	2.337	0.545	2.520	0.675	2775
1965	2.548	0.416	2.717	0.498	2781
1966	4.362	0.541	4.565	0.620	2846
1967	4.231	0.571	4.565	0.702	2871
1968	2.674	0.536	3.026	0.660	3063
1969	1.787	0.278	2.113	0.395	3390

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