ORAU Team **Dose Reconstruction Project for NIOSH** Technical Information Bulletin – External Coworker Dosimetry Data for the X-10 Site	Document Number: ORAUT-OTIB-0021 Effective Date: 12/29/2004 Revision No.: 00 Controlled Copy No.: _____ Page 1 of 8
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RECORD OF ISSUE/REVISIONS

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Draft	11/30/2004	00-A	New technical information bulletin to provide information to allow ORAU Team dose reconstructors to assign doses to workers at the X-10 site who have no or limited monitoring data, based on site coworker data. Initiated by Steven E. Merwin.
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12/29/2004	12/29/2004	00	First approved issue. Initiated by Steven E. Merwin.

1.0 PURPOSE

The purpose of this Technical Information Bulletin (TIB) is to provide information to allow ORAU Team dose reconstructors to assign doses to workers at the X-10 site who have no or limited monitoring data, based on site coworker data. The data in this TIB are to be used in conjunction with ORAUT-OTIB-0020, "Use of Coworker Dosimetry Data for External Dose Assignment."[1]

2.0 BACKGROUND

The ORAU Team is conducting a series of coworker data studies to permit dose reconstructors to complete cases for which external and/or internal monitoring data are unavailable or incomplete. Such cases may fall into one of several categories, including:

- the worker was unmonitored and, even by today's standards, did not need to be monitored (e.g., a non-radiological worker).
- the worker was unmonitored, but by today's standards would have been monitored.
- the worker may have been monitored but the data are not available to the dose reconstructor.
- the worker may have partial information, but the available information is insufficient to permit a dose reconstruction to occur.

As described in the X-10 External Dosimetry TBD,[2] most workers with a potential for radiation exposure at the X-10 site wore radiation dosimetry badges, especially after 1950. Also, the data provided to NIOSH in conjunction with this program are largely complete and sufficient for external dose reconstruction. Therefore, the coworker data provided in this TIB are expected to be of limited use for individuals who worked exclusively at the X-10 site. However, the specific work history is unknown for some individuals with no monitoring data who worked at more than one site within the Oak Ridge complex, and the data presented in this TIB will be a key component of dose reconstructions for some of those workers.

3.0 GENERAL APPROACH

As described in ORAUT-OTIB-0020,[1] the general approach to applying coworker data for cases without external monitoring data involves two phases. The first phase (Phase I) permits cases to be processed when a "best and final" estimate of dose is not required for claim determination. The second phase (Phase II) of the external coworker data approach facilitates the assignment of "best and final estimates" of dose, when necessary. This initial revision of this TIB provides coworker external dosimetry summary statistics applicable to Phase I dose reconstructions; coworker dose distributions applicable to Phase II dose reconstructions will be made available in a subsequent revision.

4.0 APPLICATIONS AND LIMITATIONS

1. Revision 0 of this document provides site coworker data and information that may be used only for cases not requiring best estimate calculations. Such cases include clearly non-compensable cases for which a higher external dose can be assigned than was likely to have been actually received, or clearly compensable cases for which a lower external dose can be assigned than was likely to have been actually received. Revision 1 of this document will provide dose distributions

and additional information based on the data presented herein to permit the processing of cases requiring a best estimate analysis.

2. At the Oak Ridge complex, many workers were employed at more than one of the major Oak Ridge sites (K-25, X-10 and Y-12). For some cases, employment information is provided in NOCTS as a multiple site listing such as "K-25/Y-12/X-10," and the available information such as the DOE dosimetry records and claimant interview are insufficient to determine the actual work location(s), especially on an annual basis. Similarly, workers may have worked at more than one major site at different locations across the DOE complex during their employment history. Thus, the data presented herein must be used with caution to ensure that for clearly non-compensable and compensable cases, unmonitored external doses from multiple site employment have been overestimated and underestimated, respectively.

3. Summary statistics based on X-10 dosimetry data presented in this TIB do not extend beyond 1985 because reliable data were not available at the time this TIB was drafted. However, the absence of these data (and the subsequent development of dose distributions) should not interfere with the processing of most X-10 cases having a lack of external dosimetry data, since in recent years the monitoring practices at X-10 (and the other Oak Ridge sites) were sufficiently robust to ensure that essentially all workers with a potential for external radiation exposure were monitored. Coworker dosimetry data beyond the year 1985 will be presented in a subsequent revision to this TIB should the need arise and sufficient reliable data become available.

4. The data presented in this TIB address penetrating radiation from gamma radiation and non-penetrating radiation from beta radiation (and potentially low-energy photons). Neutron data are not presented. However, the locations within the X-10 site at which neutron exposures were possible are limited, and neutron doses were monitored separately for most workers having a potential for neutron exposure.[2] Therefore, it is not anticipated that the lack of coworker neutron dosimetry data in this TIB will negatively impact X-10 dose reconstructions. Coworker dosimetry data for neutron exposures will be presented in a subsequent revision to this TIB should the need arise and sufficient reliable data become available.

5.0 REFERENCES

1. ORAU Team, ORAUT-OTIB-0020, Use of Coworker Dosimetry Data for External Dose Assignment.

2. ORAU Team, ORAUT-TKBS-0012-6, Technical Basis Document for the Oak Ridge National Laboratory – Occupational External Dose.

3. NIOSH (National Institute for Occupational Safety and Health), External Dose Reconstruction Implementation Guideline, Rev. 0, OCAS-IG-001, Office of Compensation Analysis and Support, Cincinnati, Ohio, 2002.

6.0 X-10 COWORKER DATA DEVELOPMENT

Dosimetry data for monitored X-10 workers maintained by the Comprehensive Epidemiologic Data Resource (CEDR) maintained by DOE were selected for this evaluation. However, for the year 1966, data maintained by the ORAU Center for Epidemiologic Research (CER) were selected because CEDR data were not available for that year.

The CEDR data evaluated represented quarterly or annual gamma and non-penetrating ("skin") dosimetry data maintained by the X-10 site, which pertain to the shielded and open-window dosimetry readings and exclude neutron doses. Starting in 1961, the CEDR data are identified by quarter. Since the site implemented a quarterly badge exchange cycle for essentially all workers starting in the third quarter of 1956, these CEDR data represent directly the X-10 site monitoring results. Prior to 1961, the CEDR data for X-10 typically include from one to three monitoring results each year for an individual. This is as indication that the result represents annual summaries of the quarterly or weekly (which was the typical exchange frequency prior to the third quarter of 1956) dosimetry data. The fact that two or three results are associated with some individuals is an indication that dosimetry results from Oak Ridge sites other than X-10 (e.g., K-25 and Y-12) were included. It does not appear possible based on either the CEDR or CER data to separate the doses associated with the individual Oak Ridge sites prior to 1961; thus, these data should be used with caution by the dose reconstructors.

The validity of the CEDR data (and CER data for 1966) was confirmed by comparing a random sampling of the data to claimant dosimetry data submitted by the site as part of the EEOICPA Subtitle B program. A review of data for ten claimants covering 253 worker-years of employment at X-10 indicated generally good agreement between the two data sets. Specifically, the annual penetrating doses extracted from the two data sets matched perfectly in 92% and 74% of the 253 annual results for gamma and non-penetrating doses, respectively. Importantly, when the data did not match, the CEDR data were higher more than half of the time, suggesting that relying on the CEDR data for coworker dose reconstruction would not result in a negative bias against the claimants. Additionally, part of the mismatches were apparently attributable to quarterly doses that overlapped two calendar years being assigned two different years in the two data sets. Also, some of the instances in which the CEDR annual doses were less than the annual doses extracted from the EEOICPA claimant data were attributable to an occasional missing quarter of CEDR data; however, these instances do not result in an underestimation of coworker dose because of the extrapolation approach described in Section 7.0 below. Overall, the CEDR data (and CER data for 1966) are considered to be acceptable for the development of coworker doses for the X-10 site.

Adjustment for Missed Dose

According to the External Dose Reconstruction Implementation Guideline,[3] missed doses are to be assigned for null dosimeter readings to account for the possibility that doses were received but not recorded by the dosimeter or reported by the site. Annual missed doses are calculated by multiplying the number of null badge readings by the dosimeter limit of detection (LOD) and summing the results; these values are used as the 95th percentile of a lognormal distribution for the purpose of calculating probability of causation. Thus, in IREP the calculated missed doses are multiplied by 0.5 and entered in Parameter 1, and a value of 1.52 is entered in Parameter 2, to represent the geometric mean and geometric standard deviation, respectively.

The assignment of missed doses for monitored workers is particularly significant for X-10 claimants, because there is historically a high percentage of null dosimeter results for this site. By the 1980s more than 90% of quarterly penetrating dose readings and reported annual doses were zero. By comparison, in the late 1950s, less than one-third of the quarterly results were zero. This is largely due to the site monitoring practices and the increasing robustness of radiological controls over time (starting in 1951, all regular workers wore a combination dosimeter and security badge regardless of work area - the transition to this system was completed by 1953).

Because X-10 claimants with null monitoring data are assigned missed dose, including those claimants who likely had no potential for external radiation exposure during their employment, the

assignment of doses to workers with no monitoring data based on coworker data must also account for the assignment of missed dose.

Table 1 lists the maximum annual missed dose by era and type of radiation (penetrating gamma and non-penetrating) based on information presented in the site TBD.[2] Although the TBD indicates that some workers may have been on a dosimeter exchange cycle that was less or more frequent than the typical cycle, the great majority of workers were on the typical schedule so the values provided in Table 1 are deemed appropriate for the adjustment of reported coworker doses to account for missed dose.

Table 1. Missed external doses based on X-10 external TBD.

Period	Penetrating LOD (rem)	Non-penetrating LOD (rem)[a,b]	Exchange frequency	Maximum annual missed dose (rem)	
				Penetrating	Non-penetrating
June 1944- June 1956	0.03	0.03	Weekly	1.560	1.560
July 1956 – 1974	0.03	0.03	Quarterly	0.120	0.120
1975 – present	0.01	0.01	Quarterly	0.040	0.040

a. Non-penetrating LODs are based on the TBD statement that "for assigning missed shallow dose, dose reconstructors should apply the deep dose values…unless there is reason to suspect exposure to a field consisting primarily of low-energy electrons."[2]

b. The listed LODs are not reliable for low-energy beta particles. The X-10 TBD[2] should be reviewed to identify potential exposure scenarios involving low-energy beta particles to determine whether the scenarios may apply to particular claimants. Note that cancer location is an important consideration, because beta particles with a low enough energy to render the tabulated LODs unreliable would deliver little dose through clothing.

Other Considerations

Certain aspects of the external dosimetry practices at the X-10 site documented in the TBD[2] were considered in the analysis of the site data. These include:

- In some cases, values less than the dosimeter LOD were reported by the site. For example, values as low as 10 or 20 mR were reported even though the LOD was considered to be 30 mrem (or 30 mR).

- Prior to 1951, dosimeter use was not expressly required for all workers – badges were typically provided only for people who entered the restricted area, and the badges were worn based on an "honor system" rather than a strict requirement. A review of claimant data indicates that most such workers actually wore the badges when provided.

As described in Section 7.0 below, a claimant-favorable approach was adopted in the development of coworker dose summaries, and this approach should account for any underestimate of doses to radiological workers at the X-10 site based on the considerations described above.

7.0 X-10 COWORKER ANNUAL DOSE SUMMARIES

Based on the information and approaches described above, X-10 coworker annual external dosimetry summaries were developed for use in the evaluation of external dose for claimants potentially exposed to workplace radiation, but with no monitoring data provided by DOE. These summaries were developed using the following steps:

1. As described in Section 6.0 above, the penetrating and "skin" doses available from CEDR (CER for 1966) were converted to annual data by summing the reported quarterly data (1961 and later) or summing the annual results that apparently cover the major Oak Ridge sites. Consistent with the guidelines in ORAUT-OTIB-0020,[1] doses for individuals with less than four quarters of data for a particular year were converted to annual doses by extrapolating (i.e., one quarterly result was

multiplied by 4; two quarterly results were multiplied by 2; and three quarterly results were multiplied by 1.333). Prior to 1961, reported doses were not extrapolated since the reported values apparently represented doses received during the entire year.

2. The 50th, 95th and 99th percentile annual penetrating and skin doses were derived for two scenarios: excluding and including reported zeroes.

3. The 50th, 95th and 99th percentile doses based on the exclusion of zeroes were used as the basis for the coworker data set, since these are representative of radiological worker doses which are the principal focus of the coworker studies. However, to ensure claimant favorability, the percentile doses with zero results included were evaluated, and if the addition of one-half of the maximum annual missed doses (listed in Table 1) to these percentile doses resulted in values exceeding the percentile doses based on the exclusion of zeroes, the latter were replaced with the former.

4. The results are presented in Table 2 below. These percentile doses should be used for selected X-10 workers with no or limited monitoring data using the methodologies outlined in Section 7.0 of ORAUT-OTIB-0020.[1] Should these data prove insufficient for the completion of dose reconstructions, "best estimate" coworker dose distributions should be used as documented in Section 8.0 below and in accordance with Section 8.0 of ORAUT-OTIB-0020.[1]

Table 2. Annual X-10 external coworker doses modified to account for missed dose (rem).

Year	Gamma 99th%	Gamma 95th%	Gamma 50th%	Non-pen 99th%	Non-pen 95th%	Non-pen 50th%
1943	1.762	1.370	0.780	0.000	0.000	0.000
1944	3.861	2.810	0.915	0.507	0.235	0.025
1945	2.950	1.465	0.780	4.559	1.325	0.000
1946	2.501	1.373	0.780	6.947	3.895	0.000
1947	3.363	1.329	0.780	5.286	2.030	0.000
1948	2.564	1.290	0.780	4.593	0.835	0.030
1949	3.999	2.542	0.780	4.595	2.340	0.000
1950	3.113	1.604	0.780	3.967	2.003	0.000
1951	4.356	2.585	0.780	5.163	2.970	0.000
1952	6.131	3.750	0.780	5.303	2.881	0.040
1953	5.081	2.539	0.800	4.821	2.632	0.045
1954	5.508	2.206	0.780	8.202	3.244	0.070
1955	4.686	2.541	0.820	8.119	4.649	0.073
1956	4.550	2.161	0.500	3.996	1.592	0.040
1957	5.463	2.035	0.180	4.303	1.796	0.195
1958	3.156	1.610	0.320	3.249	1.087	0.195
1959	3.600	1.788	0.270	3.456	1.329	0.090
1960	2.879	1.304	0.110	2.401	0.936	0.055
1961	2.020	0.980	0.100	1.344	0.430	0.030
1962	2.268	1.020	0.110	1.479	0.570	0.043
1963	2.030	1.006	0.120	1.200	0.415	0.030
1964	2.067	0.904	0.090	1.397	0.502	0.030
1965	2.371	1.220	0.080	1.729	0.766	0.060
1966	2.816	1.230	0.080	3.824	0.740	0.070
1967	2.828	1.360	0.110	2.240	0.923	0.080
1968	2.669	1.302	0.100	2.506	0.663	0.060
1969	2.302	1.192	0.110	2.043	0.593	0.050

1970	1.850	1.029	0.100	2.190	0.581	0.060
1971	2.109	1.100	0.090	1.939	0.565	0.060
1972	2.435	1.386	0.100	4.156	0.746	0.060
1973	2.238	1.210	0.080	2.246	0.370	0.050
1974	1.485	0.750	0.060	1.123	0.188	0.020
1975	2.080	1.188	0.090	2.283	0.470	0.020
1976	1.992	1.121	0.060	0.544	0.140	0.010
1977	2.356	0.980	0.060	0.324	0.190	0.010
1978	1.901	1.021	0.100	0.550	0.315	0.010
1979	1.977	1.194	0.100	0.749	0.377	0.015
1980	2.312	1.269	0.080	3.124	0.583	0.010
1981	1.954	1.176	0.160	1.626	0.986	0.050
1982	1.612	1.030	0.180	2.074	0.620	0.080
1983	1.829	1.237	0.250	2.190	0.796	0.055
1984	1.740	0.949	0.175	1.699	0.519	0.060
1985	1.300	0.940	0.170	1.400	0.330	0.080

Dose to organs impacted only by penetrating radiation (e.g., organs other than the skin, breast and testes) are calculated based only on the "Gamma" columns in Table 2 combined with the appropriate organ dose conversion factors (DCFs).[3] Doses to the skin, breast and testes (and any other cancer location potentially impacted by non-penetrating radiation) are determined based on both the "Gamma" and "Non-penetrating" columns; gamma doses are assigned as photons with energy ranges consistent with information in the external dosimetry TBD for the X-10 site,[2] and non-penetrating doses are assigned as electrons >15 keV (or <30 keV photons if appropriate) with corrections applied to account for clothing attenuation or other relevant considerations. This approach explains why the occasional "zero" values in Table 2 for non-penetrating dose will not result in a dose of zero being assigned to an organ such as the skin. For example, the 50-th percentile dose to the skin in 1943 would be assigned entirely as 0.780 rem of photons.

The "zero" values for non-penetrating dose result from occurrences when the calculated missed doses (as described in Step 3 above) are used as the basis for the gamma and non-penetrating coworker doses; since the LODs are the same for both types of radiation (see Table 1), the subtraction of the two values results in a net non-penetrating dose of zero. This approach does not result in an underestimation of dose because there cannot be missed dose for both penetrating and non-penetrating radiations at the LOD simultaneously without the open-window element recording a positive value (e.g., if the LOD is 30 mrem for both elements and a penetrating dose of 30 mrem is received in addition to a non-penetrating dose of 30 mrem), the open-window reading would effectively be twice the LOD, or 60 mrem). Additionally, assigning beta dose as gamma dose in IREP has no negative effect because the radiation effectiveness factors are the same for >15 keV electrons and >250 keV photons, and are higher for both <30 keV photons and 30-250 keV photons.

8.0 X-10 COWORKER ANNUAL DOSE DISTRIBUTIONS

Reserved