Division of Compensation Analysis and Support Technical Basis Document for the United Nuclear Corporation Hematite, Missouri		Document Number: DCAS-TKBS-0008 Effective Date: 03/21/2011 Revision No.: 0 Page 1 of 15
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TABLE OF CONTENTS

LIST OF TABLES

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1.0 Introduction

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 at particular sites or categories of sites. They 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 [AWE] 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. § 7384I(5) and (12)]. EEOICPA, as amended, provides for employees who worked at an AWE facility during the contract period and/or during the residual period.

Under EEOICPA, employment at an AWE facility is categorized as either (1) during the DOE contract period (i.e., when the AWE was processing or producing material that emitted radiation and was used in the production of an atomic weapon), or (2) during the residual contamination period (i.e., periods that NIOSH has determined there is the potential for significant residual contamination after the period in which weapons-related production occurred). For contract period employment, all occupationally derived radiation exposures received at covered facilities must be included in dose reconstructions. This includes radiation exposure related to the Naval Nuclear Propulsion Program and any radiation exposure received from the production of commercial radioactive products that were concurrently manufactured by the AWE facility during the covered period. NIOSH does not consider the following exposures to be occupationally derived (NIOSH 2010):

- Background radiation, including radiation from naturally occurring radon present in conventional structures
- Radiation from X-rays received in the diagnosis of injuries or illnesses or for therapeutic reasons

For employment during the residual contamination period, only the radiation exposures defined in 42 U.S.C. § 7384n(c)(4) [i.e., radiation doses received from DOE-related work] must be included in dose reconstructions. Doses from medical X-rays are not reconstructed during the residual contamination period (NIOSH 2007). It should be noted that under subparagraph A of 42 U.S.C. § 7384n(c)(4), radiation associated with the Naval Nuclear Propulsion Program is specifically excluded from the employee's radiation dose. This exclusion only applies to those AWE employees who worked during the residual contamination period. Also, under subparagraph B of 42 U.S.C. § 7384n(c)(4), radiation from a source not covered by subparagraph A that is not distinguishable through reliable documentation from radiation that is covered by subparagraph A is considered part of the employee's radiation dose. This site profile covers only exposures resulting from nuclear weapons-related work. Exposures resulting from non-weapons-related work, if applicable, will be covered elsewhere.

The following information from the Department of Energy's Office of Health, Safety and Security EEOICPA Find Facilities webpage defines the EEOICPA covered periods for the United Nuclear Corporation.

Site:	United Nuclear Corporation
Location:	Hematite, Missouri
Covered Period:	1958-1973, Residual Radiation 1974-October 2009

This document contains a summary of the description of the site as well as the Atomic Energy Commission activities performed there, and provides the technical basis to be used to evaluate the occupational radiation doses for EEOICPA claims.

2.0 Site Description and Operational History

Throughout its history, United Nuclear Corporation (UNC) located in Hematite, Missouri, manufactured uranium metal and uranium compounds from natural and enriched uranium for use as nuclear fuel. The fuel was manufactured for use by the federal government and government contractors and by commercial and research reactors. Research and development was also conducted at the plant as well as uranium scrap recovery (Westinghouse 2003).

Mallinckrodt Chemical Works built the plant which became operational in July 1956. The plant initially produced uranium products for use in the naval nuclear fuel program. Ownership transferred to United Nuclear Corporation in May of 1961. In 1970 the operator became Gulf United Nuclear Fuels Corporation, which was a joint venture between UNC and Gulf Nuclear Corporation. The facility was closed in 1973 and sold to Combustion Engineering in May of 1974. In 1989 Asea Brown Boveri (ABB) began operating the facility as ABB Combustion Engineering. In April of 2000, Westinghouse purchased the nuclear operations of ABB which included the Hematite facility (Westinghouse 2003).

Most of the operations at the facility involved manufacturing reactor fuel for the naval nuclear program or commercial reactors rather than weapons work. However, the Department of Energy has determined that the facility performed uranium scrap recovery operations for the weapons program between 1958 and 1973 (DOE 2009). Therefore, all sources of radiation exposure during this time period must be accounted for, including that from commercial and naval reactor work. After 1973 only radiation dose caused by contamination remaining from weapons related work must be accounted for (residual contamination) (NIOSH 2010a).

3.0 Internal Dose

Bioassay and air monitoring data from UNC identified the potential for internal radiation exposures to workers. The primary source of this exposure was deposition of alpha-emitting materials via inhalation and ingestion of airborne uranium and thorium (and progeny).

3.1 Uranium Intakes

There is urinalysis data for workers at UNC available for most years from 1958 through 1973. If bioassay data is available for the employee, the data should be used to estimate intakes. For unmonitored workers, a co-worker intake estimate was developed.

The urinalysis data, however, generally does not separate people into job categories. A subset of this data that does separate people into job categories was used to estimate intakes. For this exposure estimate, the workers were broken up into three categories; Operators, Supervisor/Laborers, and Others. The “Operator” category is for personnel that routinely handled uranium or operated uranium processing equipment. The “Supervisor/Laborer” category is for personnel that were routinely in the uranium handling areas and handled uranium or uranium processing equipment, but not on a routine basis. Examples of people fitting this category are foreman, guards, maintenance personnel, and janitors. Laboratory technicians and chemists also fit this category because they routinely handled uranium, but not in production quantities. The “Other” category is for personnel that did not routinely enter the uranium production areas. Examples of personnel fitting this category are office personnel and store room attendants.

Coworker internal dose from uranium urinalysis samples, starting in late 1962, revealed some “Operators” had higher intakes than previously believed based on air sampling (NIOSH 2010b). Several improvements were made and the samples were reduced by mid 1963. Therefore, the urinalysis results were broken into four categories. The categories were “Operators” prior to June 1963 and after June 1963, as well as “non-operators” prior to June 1963 and after. All the samples in each group were used to determine parameters of a lognormal distribution of urine samples. From these distributions, intake rates were determined assuming first type M solubility material and then type S material for each of the four categories. In determining the intakes, a constant chronic intake was assumed from 1/1/1958 (the first day of the covered work) to 6/13/1963 (the day before the sample date showing a significant decrease in results). The second period assumed a constant chronic intake from 6/14/1963 to 12/31/1973 (the last day of the contract period).

The resulting intakes are the geometric mean of a lognormal distribution. The intake rates along with the geometric standard deviations (GSD) are listed in Tables 1 and 2 below. When the calculated GSD was less than three, the value of 3.0 was substituted in order to account for the uncertainty in the biokinetic models used in dose estimation. The geometric mean of the “Supervisor/Laborer” intake will be used for people categorized as “Others”. Since this category is reserved for people that do not routinely enter the production areas, this value represents a bounding estimate and should be considered to be a constant.

This intake estimate was compared to the larger data set. The larger data set was analyzed on an annual basis to determine the parameters of a lognormal distribution. The geometric mean for each year was compared to the urine concentrations predicted from the United Nuclear intake calculations.

The predicted urine concentrations for "Operators" overestimated most annual results for both type M and type S intakes. The predicted concentrations for "Supervisors/Laborers" were at the low end of the annual results for both solubility types. This is consistent with data that has known job categories. Results from the "Operators" are consistently higher than those from the "Supervisors/Laborers" and "Others" job categories. Since the original intake estimate was able to separate "Operators" from "Others" and appears to be consistent with additional data, the original intake estimate, as described below, will be used.

These assumed intakes were next compared with a sampling of the individuals for which both air sample data and urinalysis data exist (ORAUT 2006a). The geometric mean of the assumed intakes under-predicted urinalysis results for the people with higher sample results but over-predicted those with lower results. This indicates good agreement with the distribution. However, the calculated intakes in Tables 1 and 2 below, for type S material were considerably higher than the air sample results for these personnel. The intakes calculated for type M material did, however, match the air sample values reasonably well. The reports containing these values imply the most significant difficulty they had in controlling intakes involved the metal reduction area. This area would contain both type M and type S material and it is likely the highest urinalysis results came from type M exposures. However, it is not possible to determine if the urine sample results from 1962-1964 involved only type M material or less soluble type S material. Therefore, since both were available at the site, intakes rates for both were determined and the dose reconstructor should apply the more favorable of the two.

Table 1: Daily Intakes of Uranium (Solubility Type S)

Job Category	Years	Operation Phase	Radionuclide	Inhalation (dpm/day)	GSD
Operators	1/01/58 - 6/13/63	Operations	U-234	12590	3.29
Supervisors/Laborers				4784	3.0
Others				4784	Constant
Operators	6/14/63-12/31/73			7662	3.0
Supervisors/Laborers				2311	3.0
Others				2311	Constant

Table 2: Daily Intakes of Uranium (Solubility Type M)

Job Category	Years	Operation Phase	Radionuclide	Inhalation (dpm/day)	GSD
Operators	1/01/58 - 6/13/63	Operations	U-234	871.9	3.29
Supervisors/Laborers				331.2	3.0
Others				331.2	Constant
Operators	6/14/63-12/31/73			560.2	3.0
Supervisors/Laborers				169	3.0
Others				169	Constant

3.2 Internal Dose from Uranium Using Bioassay Results

Beginning in 1958, UNC operating personnel submitted urinalysis samples on a three- to six-month basis dependent on specific work assignments. Sample analysis incorporated gross activity counting methods to determine uranium activity levels. UNC evaluated bioassays by different analytical protocols, including enriched and fluorometric uranium techniques. Total uranium concentrations were measured and reported with a minimum detectable concentration (MDC) of 10 dpm per liter.

3.3 Thorium Intakes

Approximately nine tons of natural thorium was on site during the covered period for a single, specific project conducted in 1964 in the Pellet Plant (NIOSH 2010b). Thorium dioxide powder was blended with uranium dioxide powder to produce Th-U fuel pellets to be used in fuel assemblies for breeder reactors (NIOSH 2010b). Each pellet consisted of a mixture of 97 % ThO_2 and 3% UO_2, compressed and sintered (heated) in a furnace. A total of 210 air samples, designated specifically as “ThO_2” (thorium dioxide), were collected throughout the Pellet Plant project in 1964 and the results were reported in uCi/ml. These samples were used to determine parameters of a lognormal distribution. From this distribution, intake rates were determined. “Operators” who routinely handled thorium or operated thorium processing equipment will be assigned the 95th percentile of this distribution. “Supervisors/Laborers” and other personnel who routinely entered the processing area but did not routinely handle thorium will be assigned the full distribution of intakes. “Others”, personnel who did not routinely enter the area, will be assigned the geometric mean of the distribution.

The Technical Information Bulletin, “Estimation of Ingestion Intakes” (NIOSH 2004) was also utilized to determine additional internal intake due to ingestion with the f1 value the same as that used for inhalation. The intake rates along with the geometric standard deviations (GSD) are listed in Table 3 below. For internal dose estimates, the thorium will be considered to be type M or S solubility, whichever produces the highest dose. No thorium intakes will be assigned after 1964 since indications are that a cleanup of residual thorium dioxide was conducted following the project.

Table 3: Daily Intakes of Thorium (Solubility Type M or S)

Job Category	Years	Operation Phase	Radionuclide	Inhalation (dpm/day)	Ingestion (dpm/day)	GSD
Operators	1964	Operations	Th-232	4130	126	Constant
Supervisors/Laborers	1964			165	5.02	7.09
Others	1964			165	5.02	Constant

3.4 In Vivo

Direct (in vivo) whole-body counting (WBC) was conducted during the years 1963, 1964, and 1965 for several workers, using total body counters available at the Y-12 plant in Tennessee (NOSH 2010b). Emphasis was placed primarily on several workers who had received elevated internal exposures in the Red Room (exceeding 10 C.F.R. pt. 20 limits). The analysis was performed to assay the amount (micrograms) of U-235 in the workers' lungs. Other employees were also assayed for uranium at Y-12 during these years but not on a consistent basis. In vivo WBC was also conducted during the years 1968-1973. UNC contracted Helgeson Nuclear Services, Inc., to conduct WBC for evidence of U-235 intakes (NIOSH 2010b).

3.5 Internal Dose from Residual Contamination

Residual contamination from weapons related work may have been present at United Nuclear after weapons work ended in 1973. Only exposure from weapons related work is addressed after 1973 even though additional exposure from non-weapons related work may have been received (NIOSH 2010a).

In order to estimate this residual contamination, the highest intake rate from Table 3 above was converted to an air concentration and assumed to settle to the floor and accumulate for an entire year. The surface contamination resulting from this was then assumed to expose an individual for 2000 hours per year. The internal intake rates along with the geometric standard deviations (GSD) are listed in Tables 4 and 5 below.

A letter to the AEC (UNC 1960) describes some of the measures taken in 1960 to reduce airborne concentrations. These measures included wet mopping at frequent intervals not only the floors but overhead piping and duct work. It also describes various type of ventilation used to remove airborne contaminants. Therefore, the assumption that all the airborne contamination settled out and was never removed is considered a bounding estimate and will be used as a constant in dose estimates.

Table 4: Daily Intakes from Residual Contamination (Solubility Type S)

Job Category	Years	Operation Phase	Radionuclide	Inhalation (dpm/day)	GSD
All	1/01/74-7/31/06	Residual	U-234	10.34	Constant

Table 5: Daily Intakes from Residual Contamination (Solubility Type M)

Job Category	Years	Operation Phase	Radionuclide	Inhalation (dpm/day)	GSD
All	1/01/74-7/31/06	Residual	U-234	0.72	Constant

4.0 External Dose

Personnel photon exposures at UNC were directly related to work with enriched uranium, primarily from operations in the Red Room, Blue Room, Green Room, and Item Plant. These processes are known to have been a routine component of plant operations during the entire covered period from 1958-1973 based on a review of plant radiation safety manuals and procedures, plant correspondence and operations logs, and film badge results. Uranium in various forms and compounds was used. Accordingly, external exposures to photon radiation would have resulted from radionuclides in the uranium decay chain. Exposure to beta sources at UNC would have resulted principally from uranium decay products and was likely encountered during routine scrap recovery operations and other production activities at the site. Potential exposure to neutrons would have resulted from operations with enriched uranium.

4.1 Co-worker Gamma and Beta Dose

Dosimetry data for monitored workers at United Nuclear Corporation were evaluated. According to the 1962 UNC Health Physics Manual all personnel assigned to the plant were issued a film badge upon entry to the facility. The available personnel monitoring data include data that represent the maximally-exposed work group and work scenario over the operational period. Film badge data was available for the operational years (1958-1973). Data for 1958 through 1960 exists only in reports summarizing exposures. Dose estimates based on coworker exposures were developed for use in the evaluation of external dose for certain claimants potentially exposed to workplace radiation, but with no or limited monitoring data. The Limit of Detection (LOD) is 40 mrem for beta and 40 mrem for gamma in accordance with NIOSH technical information bulletins and procedures (ORAUT 2005b, 2006a, 2006b).

The external dosimetry data for 1958 indicates there was a combination of weekly and monthly exchanges (NIOSH 2010b). The average reported dose received during 1958 was 80 mrad beta and 36 mrad gamma. The maximum reported dose received was 2525 mrad beta and 380 mrad gamma (for 6 months) (NIOSH 2010b). A yearly missed dose based on 20 mr (LOD/2) per week was added to the average values to derive a geometric mean (GM) for both the beta dose and the gamma dose. The yearly missed dose was also added to the maximum values (adjusted to an annual dose) to produce values at the 95th percentile.

During 1959 all weekly exchanges were changed to monthly exchanges. The data for 1959 indicates the maximum beta dose received was 240 mrem in a month. The average beta was 90 mrem in a month. The maximum gamma was 15 mrem in a month (NIOSH 2010b). Since it is not clear when in 1959 the exchange frequency changed, missed dose was assigned based on a weekly exchange frequency for the entire year. Missed dose was added to the maximum recorded values and used to represent the 95th percentile dose. Missed dose was added to the average beta dose and used to represent the GM beta dose. The GM gamma dose was assigned based on the GM beta dose adjusted using the average beta to gamma ratio between 1961 and 1965.

The data for 1960 is limited. One report indicated the maximum gamma dose received prior to 1961 was 100 mrem in a week (NIOSH 2010b) while the typical reading was below 50 mrem. The maximum value was assumed to occur every week and assigned as the 95th percentile. The typical reading was also assumed to occur every week and assigned as the GM. A beta to gamma ratio based on 1961 to 1965 data was used to derive the annual beta doses.

The data for 1961 through 1965 was reported as separate beta and gamma readings. This data was used to assign gamma and beta dose for each year at the GM and the 95th percentile.

For 1966 through 1973 only the total dose (combining beta and gamma) was reported. Using the 1961 through 1965 data, a ratio of beta to gamma was calculated for each of those years, and the average of that ratio was applied to the 1966 through 1973 data to derive annual beta and gamma dose at the GM and the 95th percentile.

For this exposure estimate, the workers were broken up into three categories; Operators, Supervisor/Laborers, and Others. The "Operator" category is for personnel that routinely handled uranium or operated uranium processing equipment. The "Supervisor/Laborer" category is for personnel that were routinely in the uranium handling areas and handled uranium or uranium processing equipment, but not on a routine basis. Examples of people fitting this category are foreman, guards, maintenance personnel, and janitors. Laboratory technicians and chemists also fit this category because they routinely handled uranium, but not in production quantities. The "Other" category is for personnel that did not routinely enter the uranium production areas. Examples of personnel fitting this category are office personnel and store room attendants.

"Operators" are assigned the 95th percentile of the annual dose. "Supervisors/Laborers" are assigned the full distribution of doses. The "Others" category is assigned the 50th percentile of the distribution. The annual external dose values to be applied each year for unmonitored workers are listed in Tables 6 and 7 below.

Table 6: Annual Whole Body External Dose

Operation Phase	Year	Others (rem/year)[(a)]	Operators (rem/year)[(a)]	GSD	Supervisors (rem/year)[(a)]	GSD
Operations	1958	1.016	1.74	Constant	1.016	1.390
	1959	0.680	1.16		0.680	1.384
	1960	0.620	1.240		0.620	1.524
	1961	0.346	0.550		0.346	1.325
	1962	0.511	1.349		0.511	1.805
	1963	0.467	1.070		0.467	1.655
	1964	0.538	1.255		0.538	1.674
	1965	0.769	3.494		0.769	2.509
	1966	0.181	0.382		0.181	1.576
	1967	0.160	0.271		0.160	1.376
	1968	0.177	0.386		0.177	1.605
	1969	0.181	0.371		0.181	1.546
	1970	0.179	0.514		0.179	1.897
	1971	0.134	0.176		0.134	1.179
	1972	0.151	0.390		0.151	1.779
	1973	0.172	0.385		0.172	1.633

(a) Applied as Photons 30-250 keV. Whole body photon doses are to be converted to organ doses using the Exposure to Organ Dose Conversion Factors (US DHHS 2007).

Table 7: Annual Shallow External Dose

Operation Phase	Year	Others (rem/year)(a)	Operators (rem/year)(a)	GSD	Supervisors (rem/year)(a)	GSD
Operations	1958	1.060	6.030	Constant	1.060	2.877
	1959	2.060	3.860		2.060	1.465
	1960	1.880	3.760		1.880	1.524
	1961	0.840	3.169		0.840	2.242
	1962	2.166	10.902		2.166	2.671
	1963	3.276	9.670		3.276	1.931
	1964	2.566	7.413		2.566	1.906
	1965	0.904	3.102		0.904	2.115
	1966	0.548	1.158		0.548	1.576
	1967	0.485	0.820		0.485	1.376
	1968	0.537	1.170		0.537	1.605
	1969	0.549	1.123		0.549	1.546
	1970	0.543	1.556		0.543	1.897
	1971	0.407	0.534		0.407	1.179
	1972	0.458	1.181		0.458	1.779
	1973	0.520	1.166		0.520	1.633

(a) Applied as Electrons > 15 keV.

4.2 Co-worker Neutron Dose

A routine external monitoring program for neutron exposure did not exist at UNC, but there was a potential for personnel neutron exposures from the uranium-enrichment operations (NIOSH 2010b). The site received and processed uranium compounds containing fluorine and oxygen. The site was authorized by the AEC to receive enriched uranium hexafluoride and typically requested quantities of 50 to 100 kilograms (kg) on a quarterly basis with enrichments ranging from approximately 20% to 93%.

The maximum amount of 20% enriched uranium handled at any one time is assumed to be 100 kg (2010b). The maximum amount of 93% enriched uranium being handled at any one time is assumed to be 50 kg due to criticality concerns. Conversion factors from ORAUT-OTIB-0024 (ORAUT 2005a) for naturally enriched uranium without progeny were used to estimate the neutron dose rate. The conversion factors were adjusted based on the specific activity of naturally enriched uranium compared to the specific activity of 20% and 93% enriched uranium.

“Operators” are assumed to have worked within 1 foot of the enriched uranium fluoride ½ the time (1000 hours per year). “Supervisors/Laborers” are assumed to have worked within 3 feet of the enriched uranium fluoride ½ the time (1000 hours per year). Both are assumed to have worked with 20% enriched uranium and 93% enriched uranium for equal amounts of time. “Others” were assumed to have received an annual dose equal to half the “Supervisors/Laborers” dose. Annual dose values are listed in Table 8. These values represent a bounding estimate and should be considered a constant.

Table 8: Annual Neutron External Dose

Operation Phase	Years	Others (rem/year)[a]	Operators (rem/year)[a]	Supervisors (rem/year)[a]	GSD
Operations	1958-1973	0.114	2.06	0.228	Constant

(a) Applied as Neutrons 100 keV - 2 MeV.

4.3 Measured Dose

If external dosimetry data is available for the employee the data should be used to reconstruct external dose received. The external dosimetry data was reported as a mix of monthly and yearly exposures. For dose reconstruction purposes, unless otherwise indicated, exchange frequencies are considered to be weekly for 1958 and 1959, and monthly for all other years.

4.3.1 Photons

Dose Reconstructors should include an uncertainty factor of 1.3 multiplied by the measured photon dose, assume a constant distribution, and utilize the Exposure (R) to Organ Dose (HT) dose conversion factors from IG-001 (NIOSH 2007). The photon radiation should be considered 50% in the 30-250 keV energy range and 50% in the greater than 250 keV energy range.

4.3.2 Electrons

From 1961 through 1965 beta and photon exposures were measured separately. Beginning in 1966 the photon dose and the beta dose were reported as a sum of the beta and photon dose. For combined doses, 25% should be considered photon dose and 75% considered beta dose. This is based on the ratio of photon to beta dose from the 1961-1965 data. The guidance contained in ORAUT-OTIB-0017 (ORAUT 2005b) for assignment of skin dose from penetrating and non-penetrating radiation should be followed. The non-penetrating radiation is predominantly in the E >15 keV energy range.

4.4 Missed Dose

Missed dose applies to workers who were monitored but had results below the Limit of Detection (LOD) of their personal radiation monitor. An acceptable, favorable to claimant estimate of missed dose is one-half the LOD multiplied by the number of zero dose results for dose results below one-half the LOD. A GSD of 1.52 should be applied to missed dose. For summary data, recorded dose should be assumed to have occurred during only one monitoring period and missed dose assigned for the remaining periods.

4.5 External Dose from Residual Contamination

Residual contamination from weapons related work may have been present at United Nuclear after weapons work ended in 1973. Only exposure from weapons related work is addressed after 1973 even though additional exposure from non-weapons related work may have been received (NIOSH 2010a).

In order to estimate this residual contamination the highest intake rate from Table 1 above was converted to an air concentration and assumed to settle to the floor and accumulate for an entire year. The surface contamination resulting from this was then assumed to expose an individual for 2000 hours per year. Annual dose values are listed in Tables 9 and 10 below. These values represent a bounding estimate and should be considered a constant.

Table 9: Annual Whole Body External Dose from Residual Contamination

Operation Phase	Years	Whole Body (mrem/year)[(a)]	Job Category	GSD
Residual	1/01/74 - 7/31/06	11.6	All	Constant

(a) Applied as Photons 30-250 keV. Whole body photon doses are to be converted to organ doses using the Exposure to Organ Dose Conversion Factors (US DHHS 2007).

Table 10: Annual Shallow External Dose from Residual Contamination

Operation Phase	Years	Shallow Dose (mrem/year)[(a)]	Job Category	GSD
Residual	1/01/74-7/31/06	186	All	Constant

(a) Applied as Electrons > 15 keV.

5.0 Occupational Medical Dose

No documentation specific to UNC regarding occupational medical dose was found. Information to be used in dose reconstructions, for which no specific information is available, is provided in ORAUT-OTIB-0006, Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures (ORAUT 2005c). The assumed frequency in this document is pre-employment, annual, and termination PA chest X-rays which will be assigned between the years 1958 and 1973. Annual organ doses are entered into the NIOSH-IREP program as the annual dose due to an acute exposure to photons (E=30-250 keV). The distribution is assumed to be normal with a standard deviation of 30%.

6.0 References

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