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Supersedes: None

Approval: Signature on file Date: 3/13/2008
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RECORD OF ISSUE/REVISIONS

ISSUE AUTHORIZATION DATE	EFFECTIVE DATE	REV. NO.	DESCRIPTION
3/14/2008	3/14/2008	0	Appendix to Battelle-TBD-6001 describing the use of the TBD for claims at United Nuclear Corp.

D.1 Introduction

This document serves as an appendix to Battelle-TBD-6001, Site Profiles for Atomic Weapons Employers that Refined Uranium and Thorium. This appendix describes the results of document research specific to this site. Where specific information is lacking, research into similar facilities described in the body of this Site Profile is used.

D.2 Site Description

Throughout its history, United Nuclear Corporation 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[1].

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 (UNC) 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[1].

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 1959 and 1969[2]. Therefore, all sources of radiation exposure during this time period must be accounted for, including that from commercial and naval reactor work. After 1969 only radiation dose caused by contamination remaining from weapons related work must be accounted for (residual contamination)[3].

D.3 Occupational Medical Dose

No documentation regarding occupational medical dose specific to United Nuclear Corporation was found. Information to be used in dose reconstructions for which no specific information is available is provided in ORAUT-OTIB-0006, the dose reconstruction project technical information bulletin covering diagnostic x-ray procedures.

D.4 Occupational External Dose

Occupational external dose information was found as reported in an AEC inspection report for license renewal at the site in 1960[4]. The average badge results for beta radiation were reported as 80-90 mrep in a monthly badge program. The maximum result was 240 mrep. The maximum gamma badge reading recorded was 15 mrem for the monthly program. These results were for workers in the production areas. Readings were lower for all other monitored workers which were listed as pilot plant, laboratory, and maintenance personnel. Due to the limited information available, operators will be assumed to have been exposed to the maximum monthly reading every month. Operators include all personnel routinely operating uranium processing equipment or handling uranium materials. Also, mrep was a unit used to distinguish beta dose from gamma dose. This dose estimate assumes the two to be identical.

Laboratory personnel as well as Supervisors, maintenance personnel, guards and others that may have routinely entered the production areas but not routinely operated uranium processing equipment or directly handled uranium will be assumed to have been continuously exposed to the distribution of monthly readings. The distribution was determined by assuming the readings are lognormally distributed and the Geometric Mean of the gamma readings is half the maximum reading. The maximum reading is taken to be the 95^{th} percentile of the distribution. The average beta reading of 90 mrep was considered the Geometric Mean for the beta dose distribution with the maximum reading again taken as the 95^{th} percentile.

Office personnel and others that did not routinely enter the production areas will be assumed to have been exposed to a lower value. This lower value was calculated by determining the external dose rate if airborne uranium was allowed to concentrate on the floor as discussed in section D.6. Therefore, the external dose for this group of workers is the same as that to all workers during the residual contamination period.

The values for Operators and Office personnel represent bounding estimates since operators are assumed to be continuously exposed to the maximum recorded value and Office personnel are assumed to be continuously exposed to the maximum contamination. As such, these values should be considered a constant; that is, no

distribution parameters should be assigned them. External dose for the Supervisor group is a lognormal distribution. Tables D.2 and D.3 present these values as mrem per year for each job category as well as the appropriate parameters to describe the distributions.

D.5 Occupational Internal Dose

There is a considerable amount of air monitoring data available for uranium dust for 1959-1960[5]. The data consists of weekly air sample averages by person along with urinalysis taken approximately quarterly on the same people. There is also more urinalysis data available in 1962 through 1964[6, 7]. The later data is listed by job categories (operators, technicians, engineers, foremen and guards) while the early data is not.

Urinalysis samples starting in late 1962 revealed some operators had higher intakes than previously believed based on air sampling[8]. 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 "others" 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 12/31/1969 (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 Table D.1. 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 same criteria used in the external dose section of this appendix should be applied here to categorize a person as operator, supervisor, or other. The geometric mean of the supervisor intake will be used for people categorized as other. 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.

These assumed intakes were compared with a sampling of the individuals for which both air sample data and urinalysis data exist[5]. The geometric mean of the assumed intakes underpredicted urinalysis results for the people with higher sample results but overpredicted those with lower results. This indicates good agreement with the distribution. However, the calculated intakes in Table D.1 for type S material were considerably higher than the air sample results for these people. 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.

D.6 Residual Contamination

Residual contamination from weapons related work may have been present at United Nuclear after weapons work ended in 1969. Only exposure from weapons related work is addressed after 1969 even though additional exposure from non-weapons related work may have been received[3].

In order to estimate this residual contamination, the highest intake rate from table D.1 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 exposure an individual for 2000 hours per year. Both external exposure and intakes from resuspension were calculated based on this value.

A letter to the AEC[5] 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 contaminats. 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.

D.7 References

1. RefID 30008 (pp. 16-17) Westinghouse, 2003, *Hematite Former Fuel Cycle Facility Decommissioning, Historical Site Assessment,* May 20, 2003

2. DOE Office of Health, Safety and Security, EEOICPA web site. http://www.hss.energy.gov/healthsafety/fwsp/advocacy/faclist/findfacility.cfm

3. NIOSH, 2007, *Radiation exposures covered for Dose Reconstructions under Part B of the Energy Eemployees Occupational Illness Compensation Program Act Rev. 0,* OCAS-IG-003, National Institute for Occupational Safety and Health, Office of Compensation Analysis and Support, Cincinnati, Ohio.

4. RefID 3944 (p. 51) Atomic Energy Commission, 1960, *Compliance Inspection Report of Mallinckrodt Nuclear Corporation,* January 12 through 14, 1960

5. RefID 17606 Frank Zeitlin, United Nuclear Corporation, 1960, *Letter to H. L. Price, U. S. Atomic Energy Commission,* December 16, 1960

6. RefID 11713 United Nuclear Corporation, *Various urine sample results between 1962 and 1964,* 1962 through 1964.

7. RefID 11714 United Nuclear Corporation, *Various urine sample results between 1962 and 1964,* 1962 through 1964.

8. RefID 11724 (pp. 22-25) J. A. Lindberg, United Nuclear Corporation, 1963, *Letter to Charles Keller, U. S. Atomic Energy Commission,* October 28, 1963

Table D.1 INTERNAL DOSE PATHWAYS - Inhalation of Airborne Radionuclides

Assumptions:
Intakes are in dpm per calendar day.
Dose entered into IREP as alpha radiation
Intake value is the geometric mean of a lognormal distribution except where GSD is listed as constant. Those intake values are constants (no distribution)

Job Category	Year	Operation Phase	Relevant Nuclide	Solubility Type	Intake (dpm/d)	GSD	TBD Reference or Research Justification
Operators	1/1/1959 - 6/13/1963	Operations	U234	S	12590	3.29	Air sample data
Supervisors	1/1/1959 - 6/13/1963	Operations	U234	S	4784	3.0	Air sample data
Other	1/1/1959 - 6/13/1963	Operations	U234	S	4784	Constant	Air sample data
Operators	6/14/1963 - 12/31/1969	Operations	U234	S	7662	3.0	Air sample data
Supervisors	6/14/1963 - 12/31/1969	Operations	U234	S	2311	3.0	Air sample data
Other	6/14/1963 - 12/31/1969	Operations	U234	S	2311	Constant	Air sample data
Operators	1/1/1959 - 6/13/1963	Operations	U234	M	871.9	3.29	Air sample data
Supervisors	1/1/1959 - 6/13/1963	Operations	U234	M	331.2	3.0	Air sample data
Other	1/1/1959 - 6/13/1963	Operations	U234	M	331.2	Constant	Air sample data
Operators	6/14/1963 - 12/31/1969	Operations	U234	M	560.2	3.0	Air sample data
Supervisors	6/14/1963 - 12/31/1969	Operations	U234	M	169	3.0	Air sample data
Other	6/14/1963 - 12/31/1969	Operations	U234	M	169	Constant	Air sample data
All	After 1/1/1970	Residual	U234	S	10.34	Constant	Air sample data
All	After 1/1/1970	Residual	U234	M	0.72	Constant	Air sample data

Table D.2 EXTERNAL DOSE PATHWAYS - Whole Body

Based on monthly film badge results and 12 months per year of work.
Doses are entered into IREP as Photons 30 – 250 kev
Values are either constant (no distribution) or the Geometric Mean of a lognormal distribution as indicated.

Job Category	Year	Operation Phase	Whole body (mr/yr)	Distribution	TBD Reference or Research Justification
Operators	1/1/1959 – 12/31/1969	Operations	180	Constant	Film badge data
Supervisors	1/1/1959 – 12/31/1969	Operations	90	Lognormal (GSD = 1.524)	Film badge data
Others	1/1/1959 – 12/31/1969	Operations	11.6	Constant	Film badge data
All	After 1/1/1970	Residual	11.6	Constant	Film badge data

Table D.3 EXTERNAL DOSE PATHWAYS - Skin

Assumptions:
Based on monthly film badge results and 12 months per year of work.
Doses are entered into IREP as Electron >15 kev
These doses are in addition to the Whole Body doses in Table D.2
Values are either constant (no distribution) or the Geometric Mean of a lognormal distribution as indicated.

Job Category	Year	Operation Phase	Skin (mr/yr)	Distribution	TBD Reference or Research Justification
Operators	1/1/1959 – 12/31/1969	Operations	2880	Constant	Film badge data
Supervisors	1/1/1959 – 12/31/1969	Operations	1080	Lognormal (GSD = 1.815)	Film badge data
Others	1/1/1959 – 12/31/1969	Operations	186	Constant	Film badge data
All	After 1/1/1970	Residual	186	Constant	Film badge data