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Seymour Specialty Wire Company

CD.1 Introduction

This document serves as an appendix to Battelle-TBD-6000, Site Profiles for Atomic Weapons Employers that Worked Uranium and Thorium Metals. 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.

CD.2 Site Description

The Bridgeport Brass Company performed AEC contract work at its facilities in Seymour Connecticut from August 1962 through the summer of 1964. This was developmental work which included extrusion and machining and metallurgical laboratory analysis of uranium rods, as well as storage of radioactive materials. Thorium was also worked on at least two occasions. Twenty-five employees were involved in exposure monitoring programs associated with the AWE operations during the estimated 19 months.

In late 1964 all Bridgeport Brass work was consolidated at the Bridgeport Brass Reactive Metals site in Ashtabula, Ohio. From 1985 to 1992 the Seymour site operated as an employee-owned company called Seymour Specialty Wire Company. In 1992 operations ceased and the company filed for bankruptcy. The building in which AEC work was performed under Bridgeport Brass is currently being leased to an electric cable manufacturing company.

CD.2.1 Site Activities

Process Information

AWE work appears to have begun at the Seymour facility on August 30, 1962 and continued until mid-1964, sometime between April and September of that year. During that time the facility extruded uranium and machined natural, enriched and depleted uranium (NU, EU and DU) and thorium. No information is available on the total quantities handled. Air monitoring worksheets record 16 extrusions occurring during 2 days of extrusion work. The third day of extrusion air monitoring does not indicate the number of extrusions. All AWE work occurred in one location, the Ruffert Building.

There is little Seymour-specific process information on the uranium and thorium operations. Information about the machining of NU, EU and DU comes almost exclusively from HASL sample requisition forms (Reference ID 9895, pp.4, 10). No thorium quantity information is available. Information about equipment used and work areas have come exclusively from HASL sample requisition forms and environmental survey reports related to the decontamination of the site (Reference IDs 9895, 9885, 10847, 9602).

Because the Seymour facility was a Bridgeport Brass operation – specifically, the Havens Lab work relocated to this facility – referring to Bridgeport Brass operations is relevant. The Bridgeport Brass Company (BB) performed AEC Contract work at four known locations during the 1950's and 1960's; 1) Havens Lab and the Housatonic Pilot Plant in

Bridgeport, Connecticut; 2) Bridgeport Brass Plant in Adrian, Michigan; 3) Extrusion Plant/Reactive Metals in Ashtabula, Ohio; and 4) the Seymour Connecticut facility. Havens Lab in Bridgeport, Connecticut was involved in the initial work, which was primarily focused on uranium extrusion research and development. The development of an extrusion process (cold forming) for natural uranium metal occurred at the Havens Lab from November 1950 to August 27, 1962. The U.S. Atomic Energy Commission contract described the work as follows:

> Havens Laboratory conducted laboratory-scale work under AEC contract AT(30-1)-1405, effective beginning June 26, 1952, for "research on drawing uranium and related operations" (AEC 1952). The contract specifically called for the contractor to:
>
> *perform research work calculated to develop suitable and economic procedures for the following:*
>
> a. *Alpha extrusion [alpha extrusion has to do with the temperature of the metal] of uranium*
> b. *Extrusion of zirconium or zirconium alloy tubing*
> c. *Mechanical cladding of uranium with aluminum, zirconium or zirconium alloy and the development of slug and closures*
> d. *Investigation of other commercial procedures such as drawing, rolling, rocking, annealing, etc. at various temperatures pertinent to the above*
> e. *The execution of such metallographic, thermocycling and X-ray crystallography in connection with the above work necessary to evaluate and control the products in regard to their suitability for pile operation and such additional work as the Commission may require* (AEC 1952).

Havens Lab work in the 50's and early 60's included extrusion of zirconium and zirconium alloy tubing, mechanical cladding of uranium with aluminum, zirconium and zirconium alloy and the development of slugs and closures. It is not known if this type of work was continued at Seymour after the closure of Havens Lab. Reference review does support the fact that lab work, similar to that which had been done at the Havens Lab, and storage of radioactive material continued at the Seymour facility.

There are two references to the Mannesman Piercing Experiment occurring at the Seymour facility (RefID10847, p. 13, Quarterly Progress Summary April to June 1964, RL Bean Reactive Metals Ashtabula, Ohio). There are nine occasions in which process waste samples were collected. Urine samples were collected sporadically between October 1962 and February 1964.

Other available process information relates to the Dynapack extrusion process:

> "DYNAPACK extrusion has been successfully employed to produce single slug length tubes of the (a) Mark VB-) and (b) I&E sizes, relatively thin and thick walled tube types, respectively. Double slug length I&E tubes were produced in quantity under production test conditions, however a warpage problem existed." (Quarterly Progress Summary April to June 1964, RL Bean Reactive Metals Ashtabula, Ohio)

Quantities Handled

No information was found in the Havens Lab references when looking for documentation of the material transferred from Havens to Seymour. Sixteen uranium billet extrusions are documented in the HASL sample forms.

HASL Sampling Information

Seymour HASL sample requisition forms are available beginning on August 30, 1962 for a variety of samples (floor smears, urinalysis, air samples and process waste). The last set of samples was collected on March 18, 1964. The HASL contamination survey of the facility, after operations had ceased, occurred on October 7, 1964. The number of sampling occasions that occurred in the approximately two-year period of operation were 13 sets of urine samples, nine sets of process waste samples, and four days of air monitoring samples. Urine sample data are available for dose reconstructions.

The processing of thorium metal is mentioned on two HASL sample requisition forms dated 11/25/63 and 12/17/63 (Reference ID 9895, pp.4, 10). These were process waste samples: 'thorium coolant and thorium chips from Do-All' saw. There is no definite information on the beginning and ending dates of thorium processing, or any indication of the total quantity of thorium processed.

Estimating Work Days based upon Havens Lab

To estimate the amount of time AWE work was performed, it seems reasonable to refer to Bridgeport Brass Havens Laboratory and other Bridgeport Brass operations. In the summer of 1962, work at the Havens lab ceased and moved to the Seymour facility.

References to Havens Lab in the ORAU TBD assume that AEC work was full-time from the beginning of the contract, although not all work involved radioactive material. The types of supporting documents mentioned in the ORAU TBD for Havens Lab are not available for the Seymour operations. Given that Havens Lab operations are the only references available to estimate the Seymour operations frequency, and HASL sample requisition forms exist for the Seymour facility on 25 occasions, it seems reasonable to assume that operations at Seymour were similar to Havens Lab, *i.e*. work was full-time, including zirconium development work and the work with radioactive material (see ORAU TBD Bridgeport Brass Havens Lab).

The working period used for the Bridgeport Brass Havens Lab ORAU TBD is not easily determined from reading the TBD. As an approach which is favorable to the claimant, 50% time in the 22-month period from October 1, 1962, through October 31, 1964. The actual end of operations is not stated, but the last process-related samples were collected in March 1964, and a clearance survey was performed in October 1964, so this study estimated that half the work was with uranium or thorium and the other half with zirconium and aluminum.

CD.2.2 Job Categories

Each claim will be evaluated to determine the most appropriate Job Category from the list below. Because this work was developmental on a large lab/pilot scale, using the

Generic Metal TBD is not recommended. There are adequate site-specific data to estimate exposures for the anticipated job categories.

Operators (involved in operations—dose based on site-specific data)
- Extrusion Operator
- Billet Transfer (extrusion process)
- Turret Lathe Operator (machining)
- Grinder Operator (machining)

Generic Job Titles (for those who do not fit in the 4 operator categories)
- Plant Floor High (Involved directly in operations — external dose based on site-specific data, uranium internal dose based on urine bioassay data and thorium internal dose based on site specific air monitoring data)
- Plant Floor Low (Involved in support of operations— internal dose based on 50% of plant floor high above)
- Supervisor (Assumed to spend some time in the production areas—internal dose based on 25% of plant floor high above)
- Clerk (Assumed to have minimal exposure—dose based on exposure to 2.5% of plant floor high above)

Employed after AWE period
- Use the four generic job categories. For post-AWE time period up to 1991, assume exposures based on resuspension of contamination deposited during the last year of AWE operation, assuming no cleanup.
- After 1991, assume that exposure is zero, based upon FUSRAP surveys which indicate no contamination above background.

CD.3 Occupational Medical Dose

No information was available describing occupational medical doses received by workers at the Seymour facility. Information from Section 3 in the generic TBD should be used to evaluate this dose component for workers at this plant.

From the Havens Lab TBD:

4.1 OCCUPATIONALLY REQUIRED MEDICAL X-RAY

Information regarding whether or not occupationally required medical X-ray examinations were performed at Havens Laboratory and Adrian Plant is unavailable. AEC usually, but not always, required "preemployment" and periodic (annual) medical examinations of workers involved in the larger uranium processing programs. The term "preemployment" as used here, means prior to performing AEC-contracted radiological work. The typical AEC medical program included a preliminary chest x-ray examination with annual examinations thereafter. The type and frequency of x-ray examination should be based on current ORAU Team guidance. Organ doses can be obtained from the current revision of ORAUT-OTIB-0006, *Technical Information Bulletin: Dose Reconstruction from Occupationally Related Diagnostic X-Ray Procedures* (ORAUT 2003).

CD.4 Occupational Internal Dose

Intake Estimates based upon Bioassay Monitoring

Urine bioassay samples were collected from individuals and anayzed for uranium during three periods in 1962, four periods in 1963 and one period in 1964 (RefID 9885). If bioassay data is available for the claimant, the data should be used to estimate intakes using the IMBA internal dosimetry code. If bioassay data is not available an estimate favorable to the claimant may be obtained by selecting the highest recorded bioassay result for each period and using that data with IMBA. The maximum recorded excretion reported for each period and the calculated daily excretion (based on 1.4 L urine excretion per day) were as follows:

Collection Date	mg/L	mg/d
10/8/1962	5.71E-03	8.00E-03
11/19/1962	2.22E+00	3.11E+00
12/17/1962	3.50E-02	4.90E-02
2/18/1963	1.12E-02	1.57E-02
5/23/1963	5.30E-02	7.42E-02
9/30/1963	1.40E-02	1.96E-02
12/9/1963	3.40E-02	4.76E-02
2/11/1964	4.20E-02	5.88E-02

Daily intakes calculated from maximum results for each of the three years were as follows:

	Daily Intake, pCi/d	
Intake Year	Absorption Type M	Absorption Type S
1962	1.47E+02	4.86E+3
1963	2.94E+02	8.95E+03
1964	1.05E+03	3.47E+4

Intake estimates from the maximum bioassay results are expected to be favorable to the claimant because no correction has been made for uranium intake from environmental sources. The intakes should be entered into the IREP probability of causation code with a constant distribution. The selection of absorption type should be guided by whether Type M or S provides the organ dose most favorable to the claimant.

Intake Estimates based upon Air Monitoring

Site specific air sampling and bioassay data are available, and may be used to characterize the Seymour operations. Air samples were collected during four measurement campaigns. All measurements were reported in RefID 9895.

- December 10, 1962 and December 20, 1962 while extruding 3 uranium billets (12/10) and machining uranium slugs (12/10 & 12/20). On December 10, 1962 the extrusion process was performed on Mark V-B tubing. (There are articles written by Carloni at this site about this process http://www.osti.gov/energycitations/product.biblio.jsp?osti_id=4171520).

- May 28, 1963 while extruding 13 billets. Two area samples were collected at two different locations in the proximity of the press; one for 4 hours and 35 minutes (13 extrusions) and one for 2 hours (3 extrusions). Personal monitoring samples were collected as task samples on the extrusion operators and billet transfer men. All the sample times were very short, at only one minute each. No machining was sampled on this day.

- May 31, 1963 three area samples were collected at different locations in proximity of the diehead. Sample times ranged from one and a half hours to three hours. No information on the number of billets extruded was given. Personal monitoring samples were collected as task samples on the transfer men at the various steps in the process. There was no personal sample collected on the extrusion operator. All sample times were very short, ranging from 17 seconds to 58 seconds. No machining operations were sampled.

During the four air sampling campaigns described above, air sampling times ranged from seconds to 4.5 hours. When reasonable breathing zone (BZ) and general area (GA) samples are available, the two could be combined to estimate the daily weighted average exposure (DWA) as follows:

DWA= 75% BZ Average +25% GA Average

This was the approach used for calculating the Extrusion Operator DWA.

DWAs calculated in this way result in daily intake estimates for uranium that were lower than those based on bioassay data. There it is considered favorable to the claimant to use the bioassay based values for dose reconstruction.

While most exposures were assumed to involve uranium, limited thorium work was performed at the site. It was assumed that two job categories, the turret lathe machinist and the grinding machinist, were exposed to thorium for a small part of their work year. It was assumed that these jobs experienced exposure to thorium for 16 hours of their work year in 1963.

CD.5 Occupational External Dose

No data were found in the Site Research database related to occupational external dose during AWE work. The work performed at the Seymour Specialty site involved experimental work in extrusion and machining uranium and thorium. Therefore, the external dose values in the TBD for extrusion and machining should be used (Section 6.0 of TBD-6000).

Tables CD.3 and CD.4 present these values as a mrem-per-calendar-day value to be used for each calendar year listed.

CD.6 Residual Contamination

Several radiation surveys occurred as part of the decontamination process for the Ruffert Building. The first was performed by HASL in October of 1964. Several others occurred as part of the DOE FUSRAP program. Summaries of the surveys are as follows.

The initial cleanup occurred during the second or third quarter of 1964. A HASL radiation survey was completed at the site on October 21, 1964. At that time all process equipment had been removed and the site appeared clean. The survey included beta/gamma and alpha dose rate and removable alpha measurements. A value of "M" indicates a measurement was taken but the result was below the detection limit.

refID	*Survey Date*	*Survey Type*	*Location*	Beta/Gamma mrad/hr surface contact	Alpha cts/min/60 cm2	Alpha removable dpm/100 cm2
10851	Oct-64	Gamma, Beta, Alpha Dose Rate and removable alpha	Dynapack Area - General	0.01-0.03	100-250	14-20
	Oct-64		Dynapack Area - Base if Dynapack S end	0.04	400	7
	Oct-64		Dynapack Area - Base if Dynapack N end	0.05	200	M
	Oct-64		Trench at Dynapack	0.07	300	M
	Oct-64		Dynapack Area - top of electrical box	0.02	250	M
	Oct-64		Dynapack Area - steps into the area	0.02	350	M
	Oct-64		Dynapack Area - Shelf	0.03	400	M
	Oct-64		Dynapack Area - Office Ceiling	0.03	200	M
10851	Oct-64		Machine Shop - General Area - 5 randomly selected	0.04	400-900	20-70
	Oct-64		Machine Shop- Near East Wall	0.5	6500	M
	Oct-64		Machine Shop - General Area - 2 randomly selected	0.05	600 & 800	80 & 90
	Oct-64		Machine Shop- Top of shelf	M	100	M
	Oct-64		Machine Shop - Window sill	M	300	M

10851	Oct-64		Cutting & Grinding Area - General Area	0.01-0.04	100-300	30
	Oct-64		Cutting & Grinding Area - Other random location	0.01	300	20
	Oct-64		Cutting & Grinding Area - Other random location	0.06	200	50
	Oct-64		Cutting & Grinding Area - window sill	0.05	800	M
	Oct-64		Cutting & Grinding Area - window sill	0.02	200	M
10851	Oct-64		Lab Hood - N part	0.03	200	3
10851	Oct-64		Metal Storage Area - General Area	0.02-0.25	300-700	40-80
	Oct-64		Metal Storage Area - Light Fixture	M	100	60
10851	Oct-64		Metal Storage Area - Top of Rolling Door	M	300	30

In 1977, a second visit to the site under the FUSRAP program performed another survey. The survey concluded that no further action was needed. Gamma, Beta, Alpha Dose Rate 1 cm & 1 m above-surface measurements were taken.

RefID	Survey Date	Location	***Gamma μrad/hr at 1 cm above surface-MAX***	***Gamma μrad/hr at 1 m above surface MAX***	***Beta/Gamma mrad/hr at 1 cm above surface MAX***	***Alpha dpm/100 cm2 MAX***
10851	1977	Dynapack Area	50	9	0.6	300
10851	1977	Other side of Ramp just outside Extrusion Area (this is likely former uranium storage area)	30	6	0.2	M
10851	1977	Former Office Area upstairs	8	0.13	1.75	180
10851	1977	Former Office Area downstairs	<5-10	<5-10	<0.02	< Bkgd

A resurvey was completed in 1980, measuring gamma/beta dose rates at 1 cm & 1 m; direct alpha and removable contamination; and residue samples. Removable radioactive material measurements were taken in this survey. The report brought attention to a seam in the concrete floor of the former machine shop and floor drains in the former Dynapack and cutting & grinding areas. Results were compared to current acceptable surface contamination values and not found to exceed any of those limits. No remediation recommendations were included in this survey report.

Table 1. Acceptable surface contamination levels

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm²	15,000 dpm α/100 cm²	1,000 dpm α/100 cm²
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm²	300 dpm/100 cm²	20 dpm/100 cm²
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm²	3,000 dpm/100 cm²	200 dpm/100 cm²
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except SR-90 and other noted above	5,000 dpm βγ/100 cm²	15,000 dpm βγ/100 cm²	1,000 dpm βγ/100 cm²

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

[b] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

[d] The maximum contamination level applies to an area of not more than 100 cm².

[e] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

RefID	Survey Date	Locations	*Gamma μrad/hr at 1 cm above surface-MAX*	*Gamma μrad/hr general area MAX*	*Beta/Gamma mrad/hr at 1 cm above surface MAX*	*Beta/Gamma mrad/hr at 1 cm general area MAX*
16202	1980	Surface of bricks in Dynapack	15			
16202	1980	Random locations elsewhere		10		0.02
16202	1980	Former machine shop expansion joint			1.1	

			Alpha	***Alpha***	***Beta/Gamma***	**U**
			dpm/100 cm2 MAX	**removable dpm/100 cm2 MAX**	**removable dpm/100 cm2 MAX**	**U residue pCi/gm**
16202	1980	Surface of bricks in Dynapack				
16202	1980	Random locations elsewhere	<260			
16202	1980	Former machine shop expansion joint		70	150	
16202	1980	Floor Drain #1 - former Dynapack area	520			2860
16202	1980	Floor Drain #1 - former cutting & grinding area				1280
16202	1980	Floor Drain #2- former cutting & grinding area				15600

In May 1992 a team from Oak Ridge performed another survey as part of the FUSRAP program. The survey included gamma scanning over a circumscribed area around the building, gamma/beta scanning over all indoor surfaces and the collection of outdoor soil samples and dust/debris samples from random surfaces inside the building.

Radionuclides concentrations outdoors were found to exceed DOE FUSRAP program guidelines in a few isolated spots. Indoor concentrations exceeded the guidelines at numerous spots including floor drains and select locations within the building which were connected with former AW work. Remediation was undertaken in August 1992, continuing to February of 1993 and verified complete in 1994. Contaminated indoor surfaces were decontaminated and restored. Drains and drain lines were cleaned in a three-step process. A subsurface drain system (3 manholes and 165 m of drain pipe) still contained radionuclide contamination but the contamination was not removable and the cost/benefit of removing was determined to be too high, with exposure considered unlikely under present-day uses of the facility.

The radiation levels overall in the building were reported as only slightly above background. This is believed to be due to the construction materials, brick in particular. The maximum dose to a worker in the building was calculated to be 5.8 μrad/hr above background or an annual dose of 11 mrem/yr.

SUMMARY				*Beta/Gamma* removable dpm/100 cm2	*U* removable pCi/gm
10847	May-92	Dust/Debris samples	Former Dynapack Area	270-3900	190-1100
10847	May-92	Dust/Debris samples	Former Machine Shop & Cutting & Grinding Area	170-520	210-600
10847	May-92	Dust/Debris samples	Former U Storage Area	140-230	73-150
10847	May-92	Dust/Debris samples	Other Areas south and east of the 3 areas above	23-170	7-110

CD.7 References

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

2. RefID10847, p. 13, Quarterly Progress Summary April to June 1964, RL Bean Reactive Metals Ashtabula, Ohio

3. RefID9885, pp. 13,

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

Assumptions:
Operational Period Daily Weighted Average Air Concentration, Plant Floor High: 56.9 dpm/m^3
Residual Period Daily Weighted Average Air Concentration: 0.007 dpm/m^3
GSD derived from measurement data
Conversion Factor :2.22 dpm/pCi
Breathing Rate: 1.2 m^3/hour
All intakes and doses assume full-time employment for the given year.
Values represent the geometric mean of a lognormal distribution unless the GSD column indicates "constant". Those represent a constant distribution.

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Inhalation Absorption Type	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Plant Floor High	1962	Operations	1000	U234	M	1.466E+02	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1962	Operations	1000	U234	S	4.856E+03	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1963	Operations	2000	U234	M	2.945E+02	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1963	Operations	2000	U234	S	8.947E+03	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1964	Operations	800	U234	M	1.051E+03	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1964	Operations	800	U234	S	3.472E+04	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1965 -'91	Operations	2000	U235	M	2.078E-02	10.0	Resuspension of measured 1965 surface contamination
Plant Floor High	1965 -'91	Operations	2000	U235	S	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination
Machining - Turret Lathe	1963	Operations	16	Th	M/S	4.817E-02	5.0	Measured air concentrations
Machining - Grinding	1963	Operations	16	Th	M/S	9.102E-02	3.0	Measured air concentrations
Plant Floor Low	1962	Operations	1000	U234	M	7.330E+01	Constant	Scaled from Plant Floor High
Plant Floor Low	1962	Operations	1000	U234	S	2.428E+03	Constant	Scaled from Plant Floor High
Plant Floor Low	1963	Operations	2000	U234	M	1.472E+02	Constant	Scaled from Plant Floor High
Plant Floor Low	1963	Operations	2000	U234	S	4.474E+03	Constant	Scaled from Plant Floor High
Plant Floor Low	1964	Operations	800	U234	M	5.254E+02	Constant	Scaled from Plant Floor High
Plant Floor Low	1964	Operations	800	U234	S	1.736E+04	Constant	Scaled from Plant Floor High
Plant Floor Low	1965 -'91	Residual	2000	U234	M	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination
Plant Floor Low	1965 -'91	Residual	2000	U234	S	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Inhalation Absorption Type	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Supervisor	1962	Operations	1000	U234	M	7.330E+01	Constant	Scaled from Plant Floor High
Supervisor	1962	Operations	1000	U234	S	2.428E+03	Constant	Scaled from Plant Floor High
Supervisor	1963	Operations	2000	U234	M	1.472E+02	Constant	Scaled from Plant Floor High
Supervisor	1963	Operations	2000	U234	S	4.474E+03	Constant	Scaled from Plant Floor High
Supervisor	1964	Operations	800	U234	M	5.254E+02	Constant	Scaled from Plant Floor High
Supervisor	1964	Operations	800	U234	S	1.736E+04	Constant	Scaled from Plant Floor High
Supervisor	1965 -'91	Residual	2000	U234	M	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination
Supervisor	1965 -'91	Residual	2000	U234	S	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination
Clerical	1962	Operations	1000	U234	M	7.330E+00	Constant	Scaled from Plant Floor High
Clerical	1962	Operations	1000	U234	S	2.428E+02	Constant	Scaled from Plant Floor High
Clerical	1963	Operations	2000	U234	M	1.472E+01	Constant	Scaled from Plant Floor High
Clerical	1963	Operations	2000	U234	S	4.474E+02	Constant	Scaled from Plant Floor High
Clerical	1964	Operations	800	U234	M	5.254E+01	Constant	Scaled from Plant Floor High
Clerical	1964	Operations	800	U234	S	1.736E+03	Constant	Scaled from Plant Floor High
Clerical	1965 -'91	Residual	2000	U234	M	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination
Clerical	1965 -'91	Residual	2000	U234	S	2.078E-02	10.0	Based on resuspension of measured 1965 surface contamination

Table CD.2 INTERNAL DOSE PATHWAYS - Ingestion of Airborne Radionuclides

Assumptions:
Air Concentration to Intake Conversion Factor: 3.06E-05 (M^3/d)/(hr/y) - see 7.1.6 TBD-6000
Deposition velocity: 0.00075 m/s
Resuspension Factor: 1.00E-06 1/m
Values represent the geometric mean of a lognormal distribution unless the GSD column indicates “constant”. Those represent a constant distribution.

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Inhalation Absorption Type	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Plant Floor High	1962	Operations	1000	U234	M	4.68E-01	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1962	Operations	1000	U234	S	1.55E+01	Constant	Measured air concentrations
Plant Floor High	1963	Operations	2000	U234	M	1.88E+00	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1963	Operations	2000	U234	S	5.71E+01	Constant	Measured air concentrations
Plant Floor High	1964	Operations	800	U234	M	2.68E+00	Constant	Calculated from maximum urine bioassay results
Plant Floor High	1964	Operations	800	U234	S	8.86E+01	Constant	Measured air concentrations
Plant Floor High	1965 -'91	Residual	2000	U234	M	1.94E-04	3	Based on resuspension of measured 1965 surface contamination
Plant Floor High	1965 -'91	Residual	2000	U234	S	1.94E-04	10	Based on resuspension of measured 1965 surface contamination
Machining - Turret Lathe	1963	Operations	16	Th	M/S	4.49E-04	5	Measured air concentrations
Machining - Grinding	1963	Operations	16	Th	M/S	8.48E-04	3	Measured air concentrations
Plant Floor Low	1962	Operations	1000	U234	M	2.34E-01	Constant	Scaled from Plant Floor High
Plant Floor Low	1962	Operations	1000	U234	S	7.74E+00	Constant	Scaled from Plant Floor High
Plant Floor Low	1963	Operations	2000	U234	M	9.39E-01	Constant	Scaled from Plant Floor High
Plant Floor Low	1963	Operations	2000	U234	S	2.85E+01	Constant	Scaled from Plant Floor High
Plant Floor Low	1964	Operations	800	U234	M	1.34E+00	Constant	Scaled from Plant Floor High
Plant Floor Low	1964	Operations	800	U234	S	4.43E+01	Constant	Scaled from Plant Floor High
Plant Floor Low	1965 -'91	Residual	2000	U234	M	1.94E-04	4	Based on resuspension of measured 1965 surface contamination
Plant Floor Low	1965 -'91	Residual	2000	U234	S	1.94E-04	10	Based on resuspension of measured 1965 surface contamination
Supervisor	1962	Operations	1000	U234	M	2.34E-01	Constant	Scaled from Plant Floor High

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Inhalation Absorption Type	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Supervisor	1962	Operations	1000	U234	S	7.74E+00	Constant	Scaled from Plant Floor High
Supervisor	1963	Operations	2000	U234	M	9.39E-01	Constant	Scaled from Plant Floor High
Supervisor	1963	Operations	2000	U234	S	2.85E+01	Constant	Scaled from Plant Floor High
Supervisor	1964	Operations	800	U234	M	1.34E+00	Constant	Scaled from Plant Floor High
Supervisor	1964	Operations	800	U234	S	4.43E+01	Constant	Scaled from Plant Floor High
Supervisor	1965 -'91	Residual	2000	U234	M	1.94E-04	5	Based on resuspension of measured 1965 surface contamination
Supervisor	1965 -'91	Residual	2000	U234	S	1.94E-04	10	Based on resuspension of measured 1965 surface contamination
Clerical	1962	Operations	1000	U234	M	2.34E-02	Constant	Scaled from Plant Floor High
Clerical	1962	Operations	1000	U234	S	7.74E-01	Constant	Scaled from Plant Floor High
Clerical	1963	Operations	2000	U234	M	9.39E-02	Constant	Scaled from Plant Floor High
Clerical	1963	Operations	2000	U234	S	2.85E+00	Constant	Scaled from Plant Floor High
Clerical	1964	Operations	800	U234	M	1.34E-01	Constant	Scaled from Plant Floor High
Clerical	1964	Operations	800	U234	S	4.43E+00	Constant	Scaled from Plant Floor High
Clerical	1965 -'91	Residual	2000	U234	M	1.94E-04	3	Based on resuspension of measured 1965 surface contamination
Clerical	1965 -'91	Residual	2000	U234	S	1.94E-04	10	Based on resuspension of measured 1965 surface contamination

Table CD.3 EXTERNAL DOSE PATHWAYS - Whole Body

Assumptions:
Submersion Dose Conversion Factor: 2.462E-09 mrem/h/dpm/m^3
Deposition velocity: 0.00075 m/s
Contaminated Surface Dose Conversion Factor: 5.615E-10 mrem/h/dpm/m^2
All external dose from estimated exposure to uranium slugs
Residual period: Assume no handling of U metal - only exposure is from residual contamination on floor and in air

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	External Whole Body (mR/d)	GSD	TBD Reference or Research Justification
Extrusion Operator	1962	Operations	500	U234	3.90E-01	5	Generic Metal TBD, Section 6.3
Extrusion Operator	1963	Operations	1000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Extrusion Operator	1964	Operations	800	U234	6.25E-01	5	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1962	Operations	500	U234	3.90E-01	5	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1963	Operations	1000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1964	Operations	800	U234	6.25E-01	5	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1962	Operations	500	U234	3.90E-01	5	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1963	Operations	1000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1963	Operations	16	Th	3.21E-01	5	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1964	Operations	800	U234	6.25E-01	5	Generic Metal TBD, Section 6.3
Machining - Grinding	1962	Operations	500	U234	3.90E-01	5	Generic Metal TBD, Section 6.3
Machining - Grinding	1963	Operations	1000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Machining - Grinding	1963	Operations	16	Th	3.21E-01	5	Generic Metal TBD, Section 6.3
Machining - Grinding	1964	Operations	800	U234	6.25E-01	5	Generic Metal TBD, Section 6.3
Plant Floor High	1962	Operations	1000	U234	1.26E-02	5	Generic Metal TBD, Section 6.3
Plant Floor High	1963	Operations	2000	U234	7.82E-01	5	Generic Metal TBD, Section 6.3
Plant Floor High	1964	Operations	800	U234	1.56E+00	5	Generic Metal TBD, Section 6.3
Plant Floor High	1965 -'91	Residual	2000	U234	3.39E-06	5	Generic Metal TBD, Section 6.3

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	External Whole Body (mR/d)	GSD	TBD Reference or Research Justification
Plant Floor Low	1962	Operations	1000	U234	1.56E+00	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1963	Operations	2000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1964	Operations	800	U234	1.56E+00	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1965 -'91	Residual	2000	U234	1.76E-06	5	Generic Metal TBD, Section 6.3
Supervisor	1962	Operations	1000	U234	1.56E+00	5	Generic Metal TBD, Section 6.3
Supervisor	1963	Operations	2000	U234	7.81E-01	5	Generic Metal TBD, Section 6.3
Supervisor	1964	Operations	800	U234	1.56E+00	5	Generic Metal TBD, Section 6.3
Supervisor	1965 -'91	Residual	2000	U234	1.76E-06	5	Generic Metal TBD, Section 6.3
Clerical	1962	Operations	1000	U234	7.04E-06	5	Generic Metal TBD, Section 6.3
Clerical	1963	Operations	2000	U234	5.66E-05	5	Generic Metal TBD, Section 6.3
Clerical	1964	Operations	800	U234	3.23E-05	5	Generic Metal TBD, Section 6.3
Clerical	1965 -'91	Residual	2000	U234	2.80E-07	5	Generic Metal TBD, Section 6.3

Table CD.4 EXTERNAL DOSE PATHWAYS - Skin

Assumptions:
All assumptions from TBD-6000 Section 6.3
Operational Period: Non-penetrating dose to skin 115 mR/hour (hands and forearms) 10.4 mR/hour (other)
Plant Floor High: Assume hands in contact with metal 50% of time. Other skin is 100% of dose rate at 1-ft, 20.8 mrem/h
Plant Floor Low: 50% of Plant Floor High
Supervisor: assume 10% of Plant Floor Low for time in contact with metal
Clerical: assume no handling of U metal.
Residual Period: Non-penetrating dose to skin 3.9E-06 mr/hour
Assume no handling of U metal.
Assume 10x the photon whole body dose rate

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Hands & Forearms (mR/d)	Other Skin (mR/d)	GSD	TBD Reference or Research Justification
Extrusion Operator	1962	Operations	500	U234	1.58E+02	1.425E+01	5.000E+00	Generic Metal TBD, Section 6.3
Extrusion Operator	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Extrusion Operator	1964	Operations	800	U234	2.52E+02	2.279E+01	5.000E+00	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1962	Operations	500	U234	1.58E+02	1.425E+01	5.000E+00	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Extrusion Billet Transfer	1964	Operations	800	U234	2.52E+02	2.279E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1962	Operations	500	U234	1.58E+02	1.425E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1963	Operations	16	Th	3.38E+00	1.607E+00	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Turret Lathe	1964	Operations	800	U234	2.52E+02	2.279E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Grinding	1962	Operations	500	U234	1.58E+02	1.425E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Grinding	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Grinding	1963	Operations	16	Th	3.38E+00	1.607E+00	5.000E+00	Generic Metal TBD, Section 6.3
Machining - Grinding	1964	Operations	800	U234	2.52E+02	2.279E+01	5.000E+00	Generic Metal TBD, Section 6.3

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Hands & Forearms (mR/d)	Other Skin (mR/d)	GSD	TBD Reference or Research Justification
Plant Floor High	1962	Operations	16	U234	5.04E+00	4.559E-01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor High	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor High	1964	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor High	1965 -'91	Residual	2000	U234	1.17E-06	1.166E-06	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor Low	1962	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor Low	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor Low	1964	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Plant Floor Low	1965 -'91	Residual	2000	U234	1.17E-06	1.166E-06	5.000E+00	Generic Metal TBD, Section 6.3
Supervisor	1962	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Supervisor	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Supervisor	1964	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Supervisor	1965 -'91	Residual	2000	U234	1.17E-06	1.166E-06	5.000E+00	Generic Metal TBD, Section 6.3
Clerical	1962	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Clerical	1963	Operations	1000	U234	3.15E+02	2.849E+01	5.000E+00	Generic Metal TBD, Section 6.3
Clerical	1964	Operations	2000	U234	6.30E+02	5.699E+01	5.000E+00	Generic Metal TBD, Section 6.3
Clerical	1965 -'91	Residual	2000	U234	1.17E-06	1.166E-06	5.000E+00	Generic Metal TBD, Section 6.3