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Allegheny-Ludlum Steel Company

Q.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.

Q.2 Site Description

The Allegheny-Ludlum Steel Corporation (A-L) located in Watervliet, New York, rolled solid uranium rods from billets in 1951 and 1952. The operation was on a developmental scale rather than production. The work included other metal working tasks such as straightening, lathe work, cutting with shears and stamping.

Q.2.1 Site Activities

References indicate that AWE work began at A-L in January of 1951 and continued through May of 1952. Air monitoring data and reports document the work in 1951 and 1952. Ten rolling campaigns are documented between January 20, 1951 and May 1952. During these campaigns natural uranium was rolled from ingots and billets into solid rods and slabs of various dimensions. Based upon documented quantities and estimates of quantities, approximately 180 tons of uranium was rolled between 1951 and 1952; 80 tons in 1951 and 100 tons in 1952. (RefID10885 p.23 and RefID16875, p.2). One reference refers to work occurring between December 1950 and January 1951 but since the reference is an NYOO monthly report summarizing the work at several facilities, it is Battelle's interpretation that work did not occur in 1950 at A-L but at the other facilities mentioned (RefID 10149).

Equipment used at A-L Steel and referenced in air monitoring and smear sample data sheets included a 14" rolling mill, an 18" rolling mill, an automatic mill, a Blooming mill, a finishing mill, a reversing mill, a Medart lathe, shears, straightener, bar stamper, salt bath and annealing furnace. It seems likely that the 14" and 18" mills were finishing mills and the automatic and Blooming mills were roughing mills.

Campaign Process Details

January 21, 1951: This rolling campaign occurred on a Sunday. The purpose of this campaign was to provide Birdsboro with data on the rolling characteristics of uranium for the design of a new rolling mill at Fernald. Specific aspects of the experimental process were to test the feasibility of rolling in a 2-high reversing mill, to ascertain the effect of water cooling on rods to lower metal temperature during rolling, to determine the effect of reductions and mill speeds in heating of uranium during rolling and to determine the feasibility of using guided passes in finishing stands. The quantities handled were as follows:

- 5" diameter unconditioned ingots rolled to 13/16" diameter rods
- Approximately 6-1/4 tons rolled (25 ingots)
- Approximately 3-3/4 tons rolled (15 ingots for DuPont evaluation)

No information is available regarding personal protective equipment or engineering controls. The process conditions for the September 19, 1951 campaign state that "the first small scale test to

rough roll in the 22" reversing mill using salt heating" was done on that date so it is likely that a salt bath was not used for this first January rolling campaign. Air monitoring results support this assumption. Uranium air concentrations ranged from 95 dpm/m^3 to 82,560 dpm/m^3 during the January campaign.

In addition it seems likely that there was no ventilation over the rolling mill based upon air monitoring summaries from AWE uranium fabrication sites (Harris & Kingsley, "The Industrial Hygiene of Uranium Fabrication", AMA Archives of Industrial Health, Vol. 19, 5.1959, p.80). It was noted in the latter reference that when rolls were wetted (which A-L Steel did in this first campaign), a steam cloud was produced which resulted in significant quantities of fine uranium metal fume. Airborne concentrations at the roughing mill were as high as 38,500 dpm/m^3 as a result of water deliberately dripped on the rolls, an increase of 30 times what was measured at the mills when there was no water cooling attempts. A-L Steel levels were significantly higher than this on January 21, 1951.

July 22, 1951: This campaign also occurred on a Sunday. The purpose of this campaign was to produce billets for continuous mill and to evaluate conventional oval, diamond and bulkhead pass schedule as per Allegheny-Ludlum rolls. The quantities handled were as follows:

- 12 unconditioned ingots rolled on 22" reversing mill to 2" x 2 5/8" to 2"D rounds on 18" mill (former, oval, round). Medart turned to 1.91" D.
- 12 unconditioned ingots rolled on 22" mill to 1-13/16" x 2-1/2" to 1-13/16"D rounds on 18" mill (former,oval,round) to 1.83"D rods, Medart turned to 1.73"D.
- Weight – ingot weight 6.6 tons – billets out 5.0 tons. Conventional, oval, diamond and bulkhead pass schedule not satisfactory.

No information is available regarding personal protective equipment or engineering controls. Similar to the January campaign it is likely that a salt bath was not used for this July campaign. Air monitoring results support this assumption. Uranium air concentrations ranged from 6 dpm/m^3 to 43,500 dpm/m^3.

Again, similar to the January campaign, it seems likely that there was no ventilation over the rolling mill given the air concentrations measured. There was a significant reduction in the average and maximum uranium concentrations at the mill, which could have been due to not attempting to cool the rods on this campaign.

A GA sample was collected at the straightener during this campaign. The uranium air concentration for a 220 minute sample (the longest running air sample for the campaign) was 1200 dpm/m^3. Based upon air monitoring summaries from AWE uranium fabrication sites, uranium exposures were reduced from 550 dpm/m^3 to 24 dpm/m^3 when straightener operations were ventilated. (Harris & Kingsley, "The Industrial Hygiene of Uranium Fabrication", AMA Archives of Industrial Health, Vol. 19, 5.1959, p.81) This would suggest that the straightener at Allegheny Ludlum was not ventilated.

August 11, 1951: This rolling campaign occurred on a Saturday. The purpose of this campaign was three-fold: 1) to evaluate Birdsboro designed octagonal grooves for roughing, 2) to produce billets for continuous mill and 3) to produce a few billets for Hanford. The Birdsboro designed octagonal grooves schedule failed because ingots turned over in the second groove. The remaining ingots were processed using the Allegheny-Ludlum schedule, oval, diamond, bullhead in the reversing mill and edge, oval and round in the 18" mill. The rollings were as follows:

- Three ingots rolled in octagonal groove, turned over in second groove.

- 19 ingots rolled (oval, diamond, bull-head) on 22" mill to 2-1/8" x 2-9/16" to 2.080"D on 18" mill (edge, oval, round).
- Six billets machined to 1.73"D because of excessive laps; the balance of billets machined to 1.91"D.
- Eight ingots rolled to 2-1/2" x 5" oval on 22" mill to 2.750" round on 18" mill (one pass). Machined to 2.54"D (only 5 good billets produced).
- Weight of ingots – 9 tons. Weight of billets 4 tons.

No information is available regarding personal protective equipment or engineering controls. Similar to the previous two campaigns it is likely that a salt bath was not used for this August campaign. There are no air monitoring results associated with this campaign from which to state assumptions regarding the presence or absence of ventilation at the mills or straightener.

August 23, 1951: This rolling campaign occurred on a Thursday. The purpose of this campaign was to produce billets satisfactory for Hanford's use. If satisfactory, A-L Steel Corporation would be considered for producing higher quality rods for Hanford. Specific aspects of the experimental process were to obtain preliminary information on the feasibility of rolling small sections on the 22" reversing mill. 30 conditioned ingots were to be rolled. Only 10 were rolled, however, because a satisfactory rolling schedule could not be obtained with the A-L roll pass design. The ingots were rolled as follows:

- Four ingots rolled to 1-17/32"D, turned to 1.410 to 1.360"D.
- Three ingots rolled to 2-13/16"D, turned to 1.46"D.
- Three ingots rolled to 1-9/16"D, turned to 1.46"D.

Various combinations of roll passes, square, edge and oval, were tried on the 22" reversing mill without success due to excessive lapping and seaming. See September 19 campaign for an accounting of the number of tons rolled.

No information is available regarding personal protective equipment or engineering controls. Similar to the previous two campaigns it is likely that a salt bath was not used for this August campaign. There are no air monitoring results associated with this campaign from which to state assumptions regarding the presence or absence of ventilation at the mills or straightener.

September 19, 1951: This campaign occurred on a Wednesday. This is the first documentation of the use of salt heating. The purpose of this campaign was to evaluate oval and square pass schedule as designated by Birdsboro. This schedule produced excessive laps and seams in billets – unsatisfactory for Fernald in the previous campaign. During this campaign billets were to be produced for continuous mill. In addition, approximately 6 tons of 2-5/8" square bars were to be produced for Berkeley. The quantities handled were as follows:

- 20 conditioned ingots 4-3/4"D rolled to the following:
  - 5 rolled to 2-13/16"D, machined to 2.54"D
  - 5 rolled to 2.080"D, machined to 1.91"D
  - 6 rolled to 1-17/32"D, machined to 1.465"D
  - 4 rolled to 1-17/32"D machined to 1.465"D – rolled out of salt
- 25 unconditioned ingots 5"D rolled to 2-5/8"D square for Berkeley.
- Six unconditioned ingots 4-3/4"D rolled to 2.080"D, machined to 1.91"D.

Ingot weight: 16 tons for rolling August 23 and September 19th.
Billet weight: 11 tons, 6 for Berkeley and 5 for experimental rolling.

Stated in the process descriptions was the recognition that muffle heating of ingots was not as desirable as lead or salt heating and there was a plan to build a bath furnace. It was necessary to test before building the furnace. This was the first small scale test using salt heating. The salt coating did not last for more than two or three passes. It was decided to conduct another small scale test under improved conditions (dry warm rolls, hotter preheating furnace temperature) before deciding on whether a salt bath furnace or lead bath furnace could be used.

No information is available regarding personal protective equipment or ventilation engineering controls. A salt bath was used for this campaign though the coating wore off rather quickly. There are no air monitoring results associated with this campaign from which to state assumptions regarding the presence or absence of ventilation.

October 26, 1951: This campaign occurred on a Friday. The purpose of this campaign was to evaluate a two pass schedule as designed by Birdsboro; a modified oval and square pass schedule; and a bull head and box pass schedule. In addition, they produced billets for the continuous mill (for 2,000 DuPont slugs) and billets for a CP-60 critical experiment.

The modified oval and square schedule was unsatisfactory so that schedule was abandoned. The bull head and box schedule appeared satisfactory so the ingots were processed that way. 100 ingots were rolled; 50 conditioned for experimental rolling and 50 unconditioned for the critical pile. The rolling parameters were as follows for the 25 tons rolled:

- Five ingots (conditioned) rolled on oval and square pass - unsatisfactory.
- 45 ingots (conditioned) rolled on bull head and box schedule to 1.92”D – conditioned to 1.73”D
- 50 ingots (unconditioned) rolled to 1.92”D on bull head and box schedule. (Billets not conditioned)

No information is available regarding personal protective equipment or ventilation engineering controls. It is assumed that a salt bath was used for this campaign, with more effective coating properties thereby creating a greater reduction in airborne uranium than levels in September and all previous campaigns. There are no air monitoring results associated with this campaign from which to state assumptions regarding the presence or absence of ventilation or confirm lower airborne uranium concentrations.

February 9, 1952: This rolling campaign occurred on a Saturday. Specific process information similar to some of the previous campaigns is not available for this campaign. Based upon the air sample requisition forms the Blooming (roughing) mill and the 18” finishing mill were used for rolling, and a salt bath was used for this campaign. An estimate of the amount of material worked, based upon the average of all the previous successful rollings is 13 tons, 50 ingots.

No information is available regarding personal protective equipment or ventilation engineering controls. It is assumed that a salt bath was used for this campaign, with effective coating properties thereby creating a reduction in airborne uranium. There are air monitoring results associated with this campaign which support this assumption. Average uranium concentrations at the mills were down to 80 and 103 dpm/m^3, 153 dpm/m^3 maximum.

March, April, and May 1952. There is no process information or specific dates available for these rolling campaigns. A single reference mentions them stating that a total of 918 billets were rolled. (RefID10885, p.48.) 150 ingots rolled each of the three months for a total of 92 tons is the estimated weight handled (reference: Battelle Dose Matrix workbook, 2nd tab “timeline & ton estimates”).

No information is available regarding personal protective equipment or ventilation engineering controls. It is assumed that a salt bath furnace was used for these campaigns. There are no air monitoring results associated with this campaign from which to state assumptions regarding the presence or absence of ventilation.

Q.2.2 Job Categories

Each claim will be evaluated to determine the most appropriate Job Category from the list below. The category Plant Floor High includes several specific jobs; the three categories of Plant Floor Low, Supervisor, and Clerical are for non-specific jobs.

PLANT FLOOR HIGH

- Rolling Operator (Involved directly in operations— internal exposure based on site specific data for rolling, 1951 & 1952)
- Shearing (Involved directly in operations—internal exposure equal to rolling operator for 1951; based on site specific data at the shear workstation for 1952)
- Stamping (Involved directly in operations—internal exposure equal to rolling operator for 1951; based on site specific data at the stamping workstation for 1952)
- Machining (Involved directly in operations— internal exposure for both 1951 & 1952 based on task specific machining data from TBD)

PLANT FLOOR LOW (Involved in support of operations— internal exposure based on 50% of plant floor high, rolling operator)

SUPERVISOR (Assumed to spend some time in the production areas—internal exposure based on 25% of plant floor high, rolling operator)

CLERICAL (Assumed to have minimal exposure—dose based on 2.5% of plant floor high, rolling operator)

Q.3 Occupational Medical Dose

No information regarding occupational medical dose specific to Allegheny-Ludlum Steel 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.

Q.4 Occupational Internal Dose

Air monitoring data are available from two air sampling campaigns in 1951 and one air sampling campaign in 1952. Samples were collected by the New York Operations Office (NYOO). There are no summary reports from NYOO just the field sample sheets (Ref. IDs 3803 & 9500) . Air monitoring in 1951 occurred prior to the use of a salt bath. By the 1952 monitoring, the use of a salt bath was in place and air concentrations were much lower.

The NYOO air monitoring approach focused on general area and process samples (GA & P). There were a few breathing zone samples (BZ) collected in 1951 at the rolling operations and Medart lathe. The former did not include a job title nor task description.

ROLLING OPERATIONS – PLANT FLOOR HIGH

To be favorable to the claimant, the approach taken in analyzing the air data assumed laborers could work around any of the mills, so the Plant Floor High comes from samples around the mill with the highest results. Samples within 20 feet or less from the mill were used as estimates of BZ exposures and samples greater than 20 feet were used as general area (GA) samples. The two were combined in the following equation as an estimate of the Plant Floor High daily weighted average exposure (DWA) for a worker on the plant floor around the mills:

Plant Floor High = 75% of BZ + 25% of GA

ROLLING OPERATIONS – OPERATOR, SHEAR MAN, STAMPER

Air monitoring data are available to estimate exposures for three specific job titles: Mill Operator, Shear Man and Stamper. Based upon GA samples collected in the Mill Operator's pulpit, this job has a lower exposure than jobs on the plant floor. The Mill Operator's exposure is derived from site specific data in 1951 and 1952. There are data for estimating the Shear Man and Stamper job exposures from site specific data for 1952 only.

MACHINING

Site specific air monitoring results related to machine shop activities were inadequate to estimate exposures. The Generic Metal TBD has been employed to estimate job exposures for machining operations.

These values were used to derive the inhalation values presented in Table Q.1. The values in the table present these values as a pCi per calendar day inhalation. These values were used to determine an ingestion intake in accordance with this TBD. Those values are presented as a pCi per calendar day ingestion in Table Q.2.

Q.5 Occupational External Dose

No data was found in the Site Research database related to occupational external dose during AWE work. The work performed at Allegheny-Ludlum involved rolling and machining uranium rods. Therefore, the external dose values in the TBD for rolling and machining should be used.

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

Q.6 Residual Contamination

In 1976, ORNL performed radiation surveys of surfaces in the areas where AWE operations occurred, as well as at the disposal yard where furnace liner material had been disposed. All alpha and beta-gamma radiation measurements were at background levels. Per the DOE Elimination Report, AEC personnel were on hand for the rolling operations. They carefully vacuum-cleaned areas and took radiation measurements (measurement data not available). The AEC contract called for the return of all uranium-bearing

material. No further remedial action was recommended for the site. Thus no exposure for residual contamination is assumed after 1952[2].

Q.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. Report on Residual Radioactive and Beryllium Contamination at Atomic Weapons Employer Facilities and Beryllium Vender Facilities. http://www.cdc.gov/niosh/ocas/pdfs/tbd/rescon/rcontam1206.pdf

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

Assumptions:
Operational Period Daily Weighted Average Air Concentration, Plant Floor High: 198 dpm/m^3
Residual Period Daily Weighted Average Air Concentration: 1.28 dpm/m^3
TBD GSD Default is 5
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.

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Rolling Operator	1951	Operations	72	U234	9.30E+02	3.0	Measured Air Concentrations
Rolling Operator	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Rolling Operator	1952	Operations	48	U234	6.93E+00	3.0	Measured Air Concentrations
Rolling Operator	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Operator in Pulpit -Rolling	1951	Operations	72	U234	1.15E+01	5.0	Measured Air Concentrations
Operator in Pulpit -Rolling	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Operator in Pulpit -Rolling	1952	Operations	48	U234	2.35E-01	5.0	Measured Air Concentrations
Operator in Pulpit -Rolling	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Medart Lathe Machining	1951	Operations	72	U234	2.61E+01	5.0	TBD-6000 Table 7.5
Medart Lathe Machining	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Medart Lathe Machining	1952	Operations	48	U234	1.74E+01	5.0	TBD-6000 Table 7.5
Medart Lathe Machining	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Machining - Grinder	1951	Operations	72	U234	5.84E+02	5.0	TBD-6000 Table 7.5
Machining - Grinder	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Machining - Grinder	1952	Operations	48	U234	3.90E+02	5.0	TBD-6000 Table 7.5
Machining - Grinder	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
							operations
Plant Floor High -Shearing Operator	1951	Operations	72	U234	9.30E+02	3.0	Measured Air Concentrations (1952 measurement)
Plant Floor High -Shearing Operator	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Shearing Operator	1952	Operations	48	U234	4.61E+00	3.0	Measured Air Concentrations
Plant Floor High -Shearing Operator	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Stamping Operator	1951	Operations	72	U234	9.30E+02	3.0	Measured Air Concentrations (1952 measurement)
Plant Floor High -Stamping Operator	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Stamping Operator	1952	Operations	48	U234	3.92E+00	3.0	Measured Air Concentrations
Plant Floor High -Stamping Operator	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor Low	1951	Operations	72	U234	2.33E+02	3.0	Scaled from GA measurement near rollers
Plant Floor Low	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor Low	1952	Operations	48	U234	6.93E+00	3.0	Scaled from GA measurement near rollers
Plant Floor Low	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Supervisor	1951	Operations	72	U234	4.65E+01	3.0	Scaled from GA measurement near rollers
Supervisor	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Supervisor	1952	Operations	48	U234	6.93E+00	3.0	Scaled from GA measurement near rollers
Supervisor	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Clerical	1951	Operations	72	U234	2.60E+00	3.0	Scaled from GA measurement near rollers
Clerical	1951	Residual	2128	U234	5.34E+00	3.0	Assumed deposition & resuspension of air in this year's operations
Clerical	1952	Operations	48	U234	6.93E+00	3.0	Scaled from GA measurement near rollers
Clerical	1952	Residual	2152	U234	4.03E-02	3.0	Assumed deposition & resuspension of air in this year's operations

Table Q.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

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Rolling Operator	1951	Operations	72	U234	8.66E+00	3.0	Measured Air Concentrations
Rolling Operator	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Rolling Operator	1952	Operations	48	U234	6.46E-02	3.0	Measured Air Concentrations
Rolling Operator	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Operator in Pulpit -Rolling	1951	Operations	72	U234	1.07E-01	5.0	Measured Air Concentrations
Operator in Pulpit -Rolling	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Operator in Pulpit -Rolling	1952	Operations	48	U234	2.18E-03	5.0	Measured Air Concentrations
Operator in Pulpit -Rolling	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Medart Lathe Machining	1951	Operations	72	U234	2.43E-01	5.0	TBD-6000 Table 7.5
Medart Lathe Machining	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Medart Lathe Machining	1952	Operations	48	U234	1.62E-01	5.0	TBD-6000 Table 7.5
Medart Lathe Machining	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Machining - Grinder	1951	Operations	72	U234	5.44E+00	5.0	TBD-6000 Table 7.5
Machining - Grinder	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Machining - Grinder	1952	Operations	48	U234	3.63E+00	5.0	TBD-6000 Table 7.5
Machining - Grinder	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Shearing Operator	1951	Operations	72	U234	8.66E+00	3.0	Measured Air Concentrations (1952 measurement)
Plant Floor High -Shearing Operator	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Shearing Operator	1952	Operations	48	U234	4.29E-02	3.0	Measured Air Concentrations

Job Category	Year	Operation Phase	Hr/Yr	Relevant Nuclide	Intake (pCi/d)	GSD	TBD Reference or Research Justification
Plant Floor High -Shearing Operator	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Stamping Operator	1951	Operations	72	U234	8.66E+00	3.0	Measured Air Concentrations (1952 measurement)
Plant Floor High -Stamping Operator	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor High -Stamping Operator	1952	Operations	48	U234	3.65E-02	3.0	Measured Air Concentrations
Plant Floor High -Stamping Operator	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor Low	1951	Operations	72	U234	2.17E+00	3.0	Scaled from GA measurement near rollers
Plant Floor Low	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Plant Floor Low	1952	Operations	48	U234	6.46E-02	3.0	Scaled from GA measurement near rollers
Plant Floor Low	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Supervisor	1951	Operations	72	U234	4.33E-01	3.0	Scaled from GA measurement near rollers
Supervisor	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Supervisor	1952	Operations	48	U234	6.46E-02	3.0	Scaled from GA measurement near rollers
Supervisor	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations
Clerical	1951	Operations	72	U234	2.42E-02	3.0	Scaled from GA measurement near rollers
Clerical	1951	Residual	2128	U234	4.98E-02	3.0	Assumed deposition & resuspension of air in this year's operations
Clerical	1952	Operations	48	U234	6.46E-02	3.0	Scaled from GA measurement near rollers
Clerical	1952	Residual	2152	U234	3.75E-04	3.0	Assumed deposition & resuspension of air in this year's operations

Table Q.3 EXTERNAL DOSE PATHWAYS - Whole Body

Asumptions:
Submersion Dose Conversion Factor: 2.462E-09 mrem/h/dpm/m^3
Deposition velocity: 0.0008
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
Rolling Operator	1951	Operations	72	U234	5.64E-02	5	Generic Metal TBD, Section 6.3
Rolling Operator	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Rolling Operator	1952	Operations	48	U234	3.75E-02	5	Generic Metal TBD, Section 6.3
Rolling Operator	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1951	Operations	72	U234	2.37E-06	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1952	Operations	48	U234	3.26E-08	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1951	Operations	72	U234	5.62E-02	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1952	Operations	48	U234	3.75E-02	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1951	Operations	72	U234	5.63E-02	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1952	Operations	48	U234	3.75E-02	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1951	Operations	72	U234	5.64E-02	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1952	Operations	48	U234	3.75E-02	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1951	Operations	72	U234	5.64E-02	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 High -Stamping Operator	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1952	Operations	48	U234	3.75E-02	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1951	Operations	72	U234	2.82E-02	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1952	Operations	48	U234	1.87E-02	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Supervisor	1951	Operations	72	U234	2.82E-03	5	Generic Metal TBD, Section 6.3
Supervisor	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Supervisor	1952	Operations	48	U234	1.87E-03	5	Generic Metal TBD, Section 6.3
Supervisor	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3
Clerical	1951	Operations	72	U234	5.37E-07	5	Generic Metal TBD, Section 6.3
Clerical	1951	Residual	2128	U234	3.19E-05	5	Generic Metal TBD, Section 6.3
Clerical	1952	Operations	48	U234	9.65E-07	5	Generic Metal TBD, Section 6.3
Clerical	1952	Residual	2152	U234	2.43E-07	5	Generic Metal TBD, Section 6.3

Table Q.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
Rolling Operator	1951	Operations	72	U234	2.27E+01	2.05E+00	5	Generic Metal TBD, Section 6.3
Rolling Operator	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Rolling Operator	1952	Operations	48	U234	1.51E+01	1.37E+00	5	Generic Metal TBD, Section 6.3
Rolling Operator	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1951	Operations	0	U234	0.00E+00	0.00E+00	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1952	Operations	0	U234	0.00E+00	0.00E+00	5	Generic Metal TBD, Section 6.3
Operator in Pulpit -Rolling	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1951	Operations	72	U234	2.27E+01	2.05E+00	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1952	Operations	48	U234	1.51E+01	1.37E+00	5	Generic Metal TBD, Section 6.3
Medart Lathe Machining	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1951	Operations	72	U234	2.27E+01	2.05E+00	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1952	Operations	48	U234	1.51E+01	1.37E+00	5	Generic Metal TBD, Section 6.3
Machining - Grinder	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1951	Operations	72	U234	2.27E+01	2.05E+00	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Plant Floor High -Shearing Operator	1952	Operations	48	U234	1.51E+01	1.37E+00	5	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 -Shearing Operator	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1951	Operations	72	U234	2.27E+01	2.05E+00	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1952	Operations	48	U234	1.51E+01	1.37E+00	5	Generic Metal TBD, Section 6.3
Plant Floor High -Stamping Operator	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1951	Operations	36	U234	1.13E+01	1.03E+00	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1952	Operations	24	U234	7.56E+00	6.84E-01	5	Generic Metal TBD, Section 6.3
Plant Floor Low	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Supervisor	1951	Operations	3.6	U234	1.13E+00	1.03E-01	5	Generic Metal TBD, Section 6.3
Supervisor	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Supervisor	1952	Operations	2.4	U234	7.56E-01	6.84E-02	5	Generic Metal TBD, Section 6.3
Supervisor	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3
Clerical	1951	Operations	0	U234	0.00E+00	0.00E+00	5	Generic Metal TBD, Section 6.3
Clerical	1951	Residual	2128	U234	3.19E-04	3.19E-04	5	Generic Metal TBD, Section 6.3
Clerical	1952	Operations	0	U234	0.00E+00	0.00E+00	5	Generic Metal TBD, Section 6.3
Clerical	1952	Residual	2152	U234	2.43E-06	2.43E-06	5	Generic Metal TBD, Section 6.3