Overview of NIOSH Exposure Records and Dose Reconstruction Methodology in the 1942-1947 era

Timothy D. Taulbee, PhD, CHP
Associate Director for Science
National Institute for Occupational Safety and Health (NIOSH)
Division of Compensation Analysis and Support (DCAS)

National Academies of Sciences, Engineering, and Medicine: Feasibility of Assessing Veteran Health Effects of Manhattan Project (1942-1947) Related Waste Meeting
March 7, 2024

Overview

- NIOSH Dose Reconstruction Program
  - *www.cdc.gov/niosh/ocas*
- Exposure Records (1942-1947)
- Dose Reconstruction Methodology under EEOICPA
- NASEM Committee Questions

NIOSH Dose Reconstruction Program

NIOSH Dose Reconstruction Program - EEOICPA

- NIOSH created the Division of Compensation Analysis and Support (DCAS) in 2001 to estimate work related radiation exposure (dose reconstruction) for certain workers with cancer who filed claims under Part B of the *Energy Employees Occupational Illness Compensation Program Act of 2000 (the Act/EEOICPA).*
- Part B is a portion of the Act that provides compensation of $150,000 and medical benefits to employees (or their survivors) for illness caused by exposure to radiation, beryllium, and silica during their employment at DOE, its contractor, or subcontractor facilities.

Radiation Dose Reconstruction for Energy Employees

- Department of Labor (DOL) is the lead agency for processing claims and establishes employment at a covered facility (as defined by DOL and DOE)
- NIOSH only reconstructs doses of energy employees who file cancer claims with the DOL under Part B of EEOICPA
- DOL assess other toxic exposures at these facilities through Part E of EEOICPA
- Covered period varies for each covered facility
  - Hanford: August 1942 – present
  - Oak Ridge (X-10): March 1943 - Present
  - Los Alamos: August 1942 – present
  - Mallinckrodt: August 1942 – 1962, 1995 (remediation)
  - Dayton Project: July 1943 – 1950

Major Components of NIOSH Radiation Dose Reconstructions

- Organ Dose from External Sources
  - Dosimeter Badges (Film, TLD), Exposure Rate Survey Measurements, Source Terms
- Organ Dose from Internal Sources
  - Bioassay (Urinalysis, Whole Body Counts), Dust Studies (Air Samples)
- Organ Dose from Medical Sources
  - X-rays and Photofluorography (PFG used for mass screening for TB)
- Organ Dose from Environmental Sources
  - Survey records very limited environmental air monitoring in the 1942 - 1947 time period

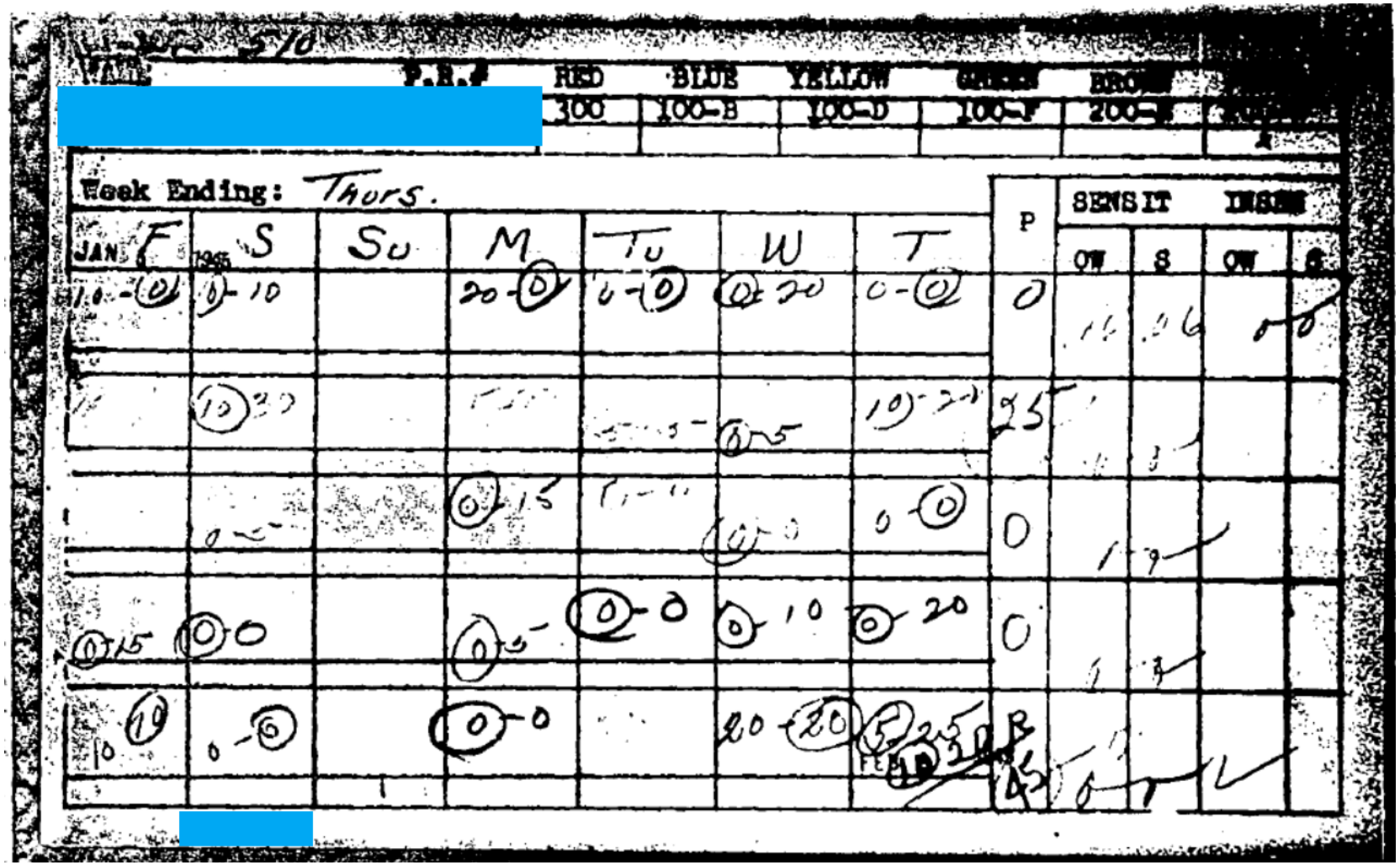
Exposure Records (1942-1947)

NIOSH Exposure Monitoring Records

- Primarily obtain radiation exposure monitoring records from the Department of Energy (DOE) for each energy employee
- NIOSH, through our contractor ORAUT, has produced Technical Basis Documents on the radiation monitoring practices at most of the MED Sites (Hanford, Oak Ridge, Los Alamos, Mallinckrodt, etc.)
  - *www.cdc.gov/niosh/ocas*
- Several of the Committee's questions deal with exposure records. I plan to provide some examples here and several later in this presentation.
  - Hanford examples of an Energy Employee
  - Oak Ridge example for mixture of Energy Employees and Military
  - Mallinckrodt example of both Energy Employees and Military

Hanford External Monitoring Records

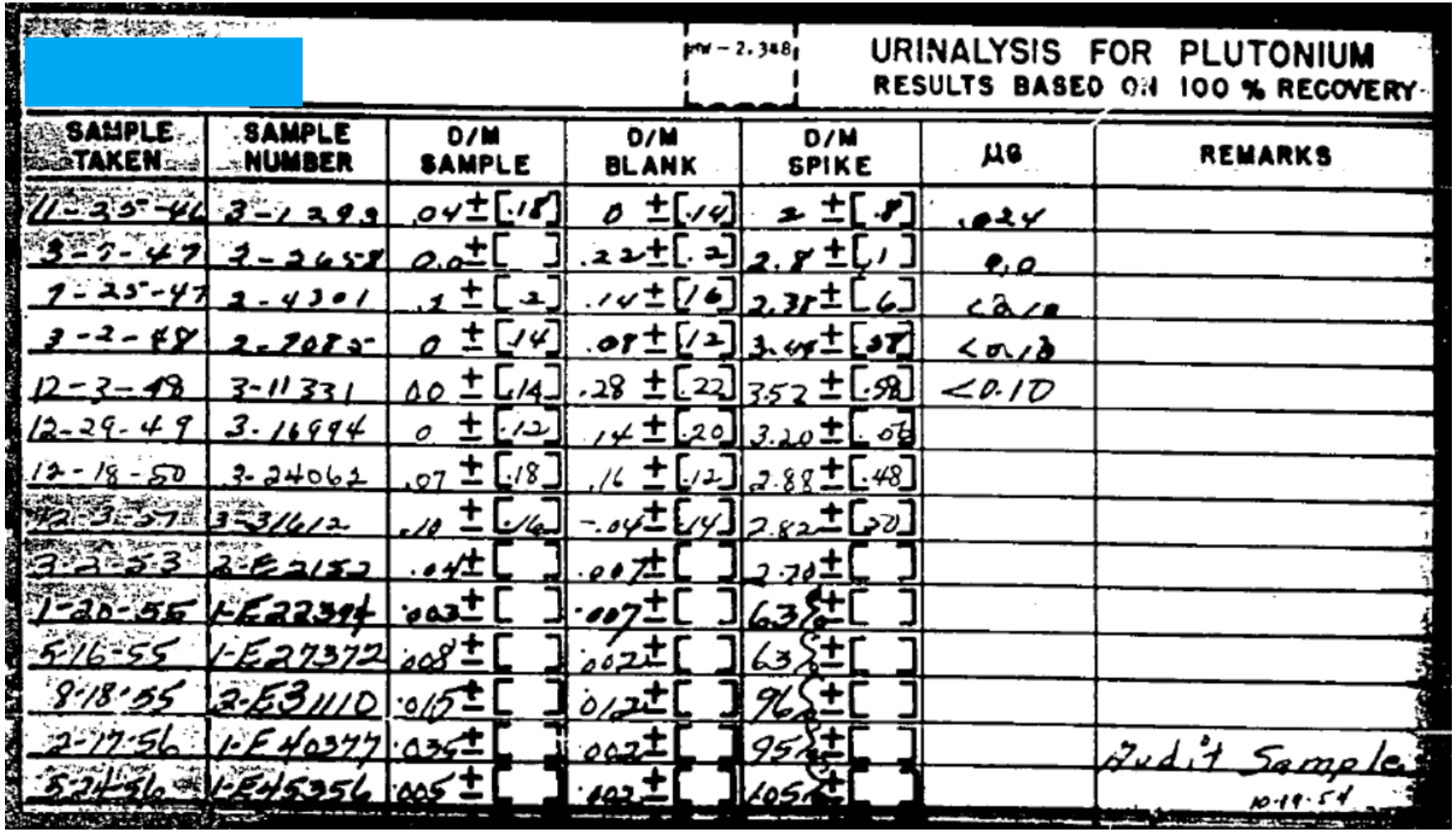
- Pencil Dosimeters and Film Badge Records
- (Jan 5, 1945 – Feb 8, 1945)
- Data provided by the Department of Energy



Example Dosimetry Card from Energy Employee's File

Hanford Internal Monitoring Records

- 1946 Plutonium Urinalysis
- Data provided by Department of Energy



[redacted]

pw - 2.348

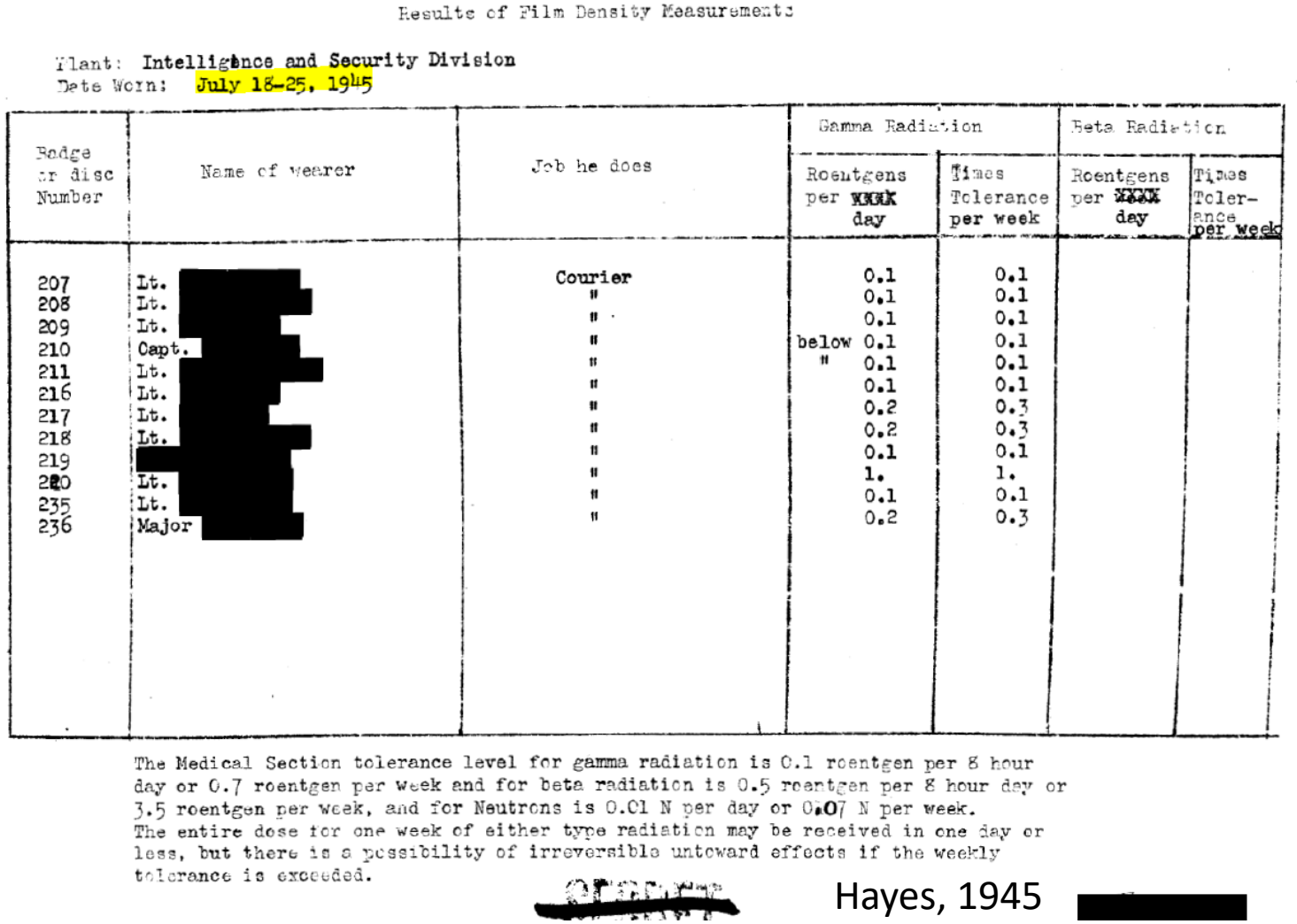
URINALYSIS FOR PLUTONIUM
RESULTS BASED ON 100 % RECOVERY

SAMPLE TAKEN	SAMPLE NUMBER	D/M SAMPLE	D/M BLANK	D/M SPIKE	µG	REMARKS
11-30-46	3-1299	.04 ± [.18]	0 ± [.14]	2 ± [.8]	.024	
3-7-47	3-2658	0.0 ± [ ]	.22 ± [.2]	2.8 ± [.1]	0.0	
7-25-47	2-4301	.2 ± [.2]	.14 ± [.16]	2.38 ± [.6]	<0.10	
3-2-48	2-7082	0 ± [.14]	.08 ± [.12]	3.48 ± [.08]	<0.10	
12-3-48	3-11331	.00 ± [.14]	.28 ± [.22]	3.52 ± [.98]	<0.10	
12-29-49	3-16994	0 ± [.12]	.14 ± [.20]	3.20 ± [.08]		
12-18-50	3-24062	.07 ± [.18]	.16 ± [.12]	2.88 ± [.48]		
12-3-51	3-31612	.10 ± [.16]	-.04 ± [.14]	2.82 ± [.20]		
3-2-53	2-E2152	.04 ± [ ]	.00 ± [ ]	2.70 ± [ ]		
1-20-55	1-E22394	.003 ± [ ]	.007 ± [ ]	63 ± [ ]		
5-16-55	1-E27372	.008 ± [ ]	.002 ± [ ]	63 ± [ ]		
8-18-55	2-E31110	.015 ± [ ]	.012 ± [ ]	96 ± [ ]		
2-17-56	1-E40377	.036 ± [ ]	.002 ± [ ]	95 ± [ ]		
5-24-56	1-E45356	.005 ± [ ]	.003 ± [ ]	105 ± [ ]		Audit Sample 10-19-54

Example Bioassay Card from Energy Employee's File

Oak Ridge Area External Monitoring Records

- 1945 Mixture of Civilian and Military external monitoring records
- Data captured from the Atlanta National Archives and Records Administration (NARA) *(October 3, 2003)*



Results of Film Density Measurements

Plant: Intelligence and Security Division
Date Worn: July 18–25, 1945

Badge or disc Number	Name of wearer	Job he does	Gamma Radiation		Beta Radiation	
			Roentgens per ~~XXXX~~ day	Times Tolerance per week	Roentgens per ~~XXXX~~ day	Times Tolerance per week
207	Lt. [redacted]	Courier	0.1	0.1		
208	Lt.	"	0.1	0.1		
209	Lt.	"	0.1	0.1		
210	Capt.	"	below 0.1	0.1		
211	Lt.	"	" 0.1	0.1		
216	Lt.	"	0.1	0.1		
217	Lt.	"	0.2	0.3		
218	Lt.	"	0.2	0.3		
219	[redacted]	"	0.1	0.1		
220	Lt.	"	1.	1.		
235	Lt.	"	0.1	0.1		
236	Major	"	0.2	0.3		

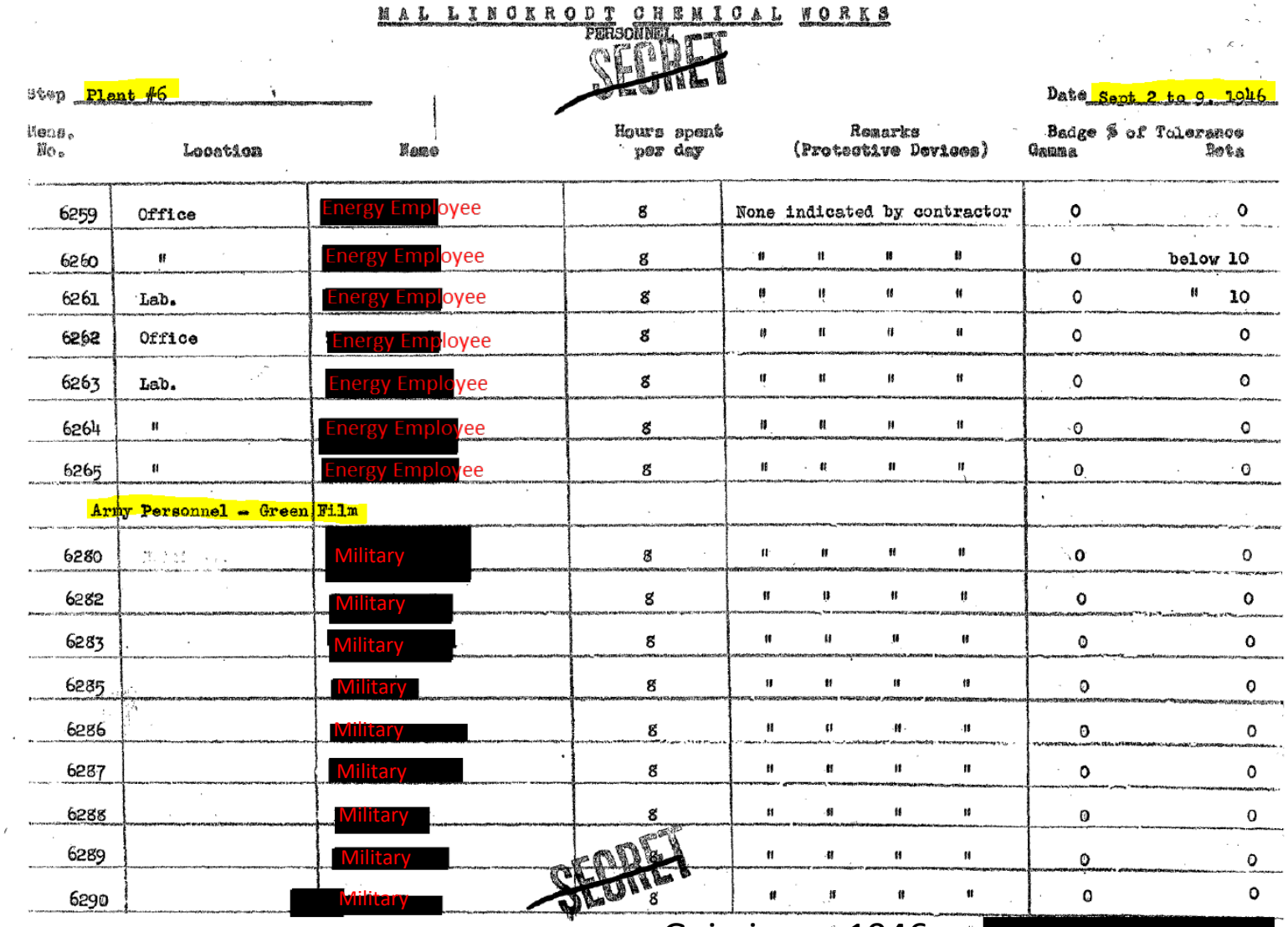
The Medical Section tolerance level for gamma radiation is 0.1 roentgen per 8 hour day or 0.7 roentgen per week and for beta radiation is 0.5 roentgen per 8 hour day or 3.5 roentgen per week, and for Neutrons is 0.01 N per day or 0.07 N per week. The entire dose for one week of either type radiation may be received in one day or less, but there is a possibility of irreversible untoward effects if the weekly tolerance is exceeded.

[redacted]

Hayes, 1945 [redacted]

Mallinckrodt External Monitoring Records

- 1945 Mixture of Energy Employees and Military External Monitoring Records
- Data captured from Oak Ridge Operation Vault *(November 15, 2004)*
- *Page 11 of 14*



MAL LINCKRODT CHEMICAL WORKS

PERSONNEL

SECRET

Shop Plant #6 Date Sept. 2 to 9, 1946

Mens. No.	Location	Name	Hours spent per day	Remarks (Protective Devices)	Badge % of Tolerance Gamma	Beta
6259	Office	Energy Employee	8	None indicated by contractor	0	0
6260	"	Energy Employee	8	" " " "	0	below 10
6261	Lab.	Energy Employee	8	" " " "	0	" 10
6262	Office	Energy Employee	8	" " " "	0	0
6263	Lab.	Energy Employee	8	" " " "	0	0
6264	"	Energy Employee	8	" " " "	0	0
6265	"	Energy Employee	8	" " " "	0	0
	Army Personnel - Green Film					
6280		Military	8	" " " "	0	0
6282		Military	8	" " " "	0	0
6283		Military	8	" " " "	0	0
6285		Military	8	" " " "	0	0
6286		Military	8	" " " "	0	0
6287		Military	8	" " " "	0	0
6288		Military	8	" " " "	0	0
6289		Military	8	" " " "	0	0
6290		Military	8	" " " "	0	0

SECRET

Geissinger, 1946

NIOSH Dose Reconstruction Methodology

Exposure Models vs. Personal Monitoring

- Army Corp of Engineers managed the operations
  - Most of the early exposure, dosimetry and bioassay data is located on memos and letters between members of the *Corp of Engineers, Medical Section*
- General Observation
  - 1942-1944 – External exposure rate information
    - Very few individual monitoring records
  - 1944-1947 – Individual monitoring data more prevalent
    - Use of individual film badge dosimetry greatly expands starting 1944
    - Difficult units (Avg. R/day) and % Tolerance

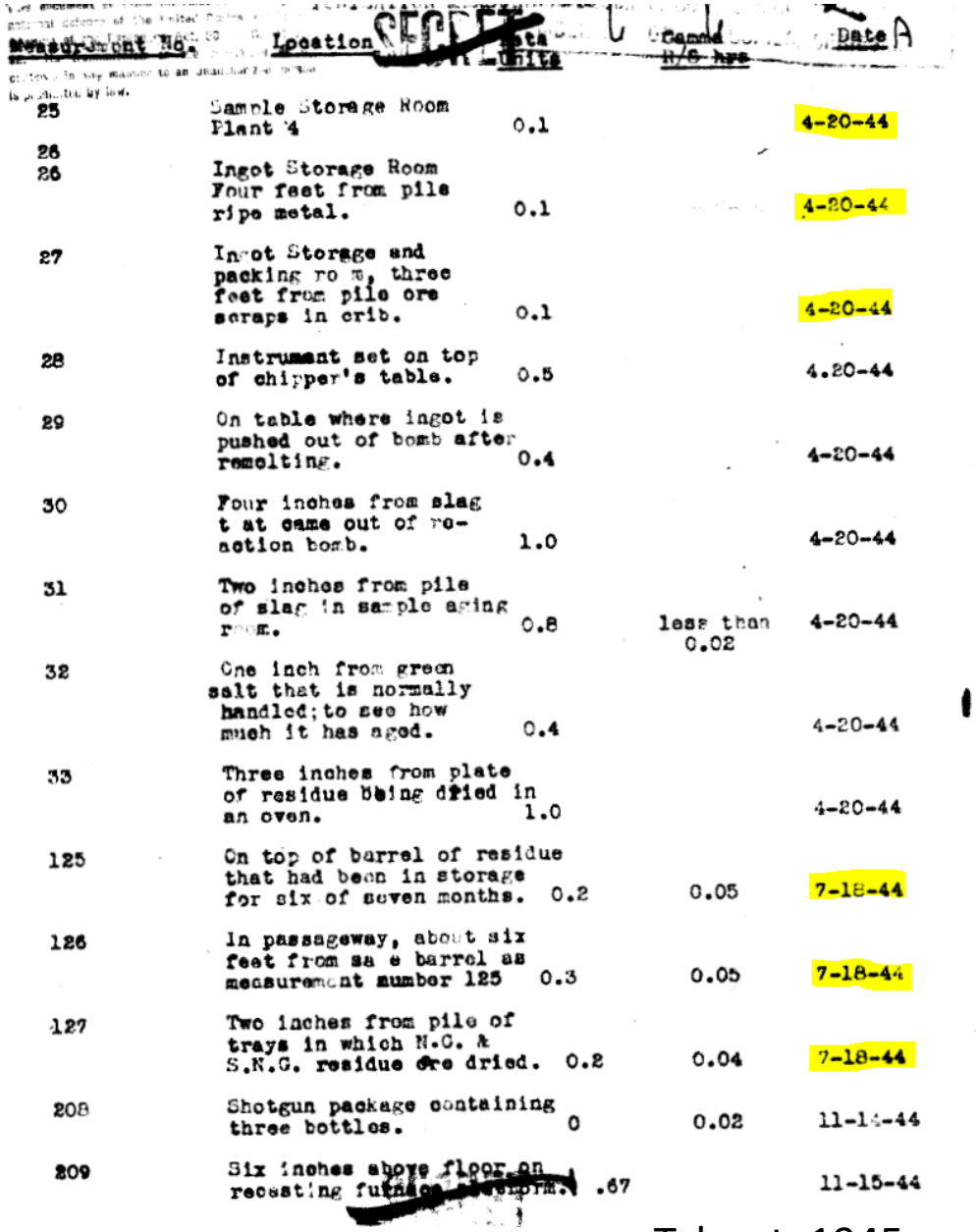
Dose Reconstruction Methodology

- For Dose Reconstruction NIOSH uses a hierarchy of data
  1. Personal monitoring data (film badges, bioassay)
  2. Co-exposure data (aka co-worker data)
  3. Exposure modeling based on measurement or survey data
     - Workplace exposure rates and air sampling data
  4. Source term exposure models

- Primarily use exposure models in the 1942-1944 due to lack of individual dosimetry prior to CH-1553 *(Pardue, 1944)*

External Exposure Models

- Mallinckrodt survey example in April and July 1944 captured at Atlanta NARA
- Frequently NIOSH has sufficient individual dosimetry for dose reconstruction or for the development of Co-exposure models in the post 1944 era

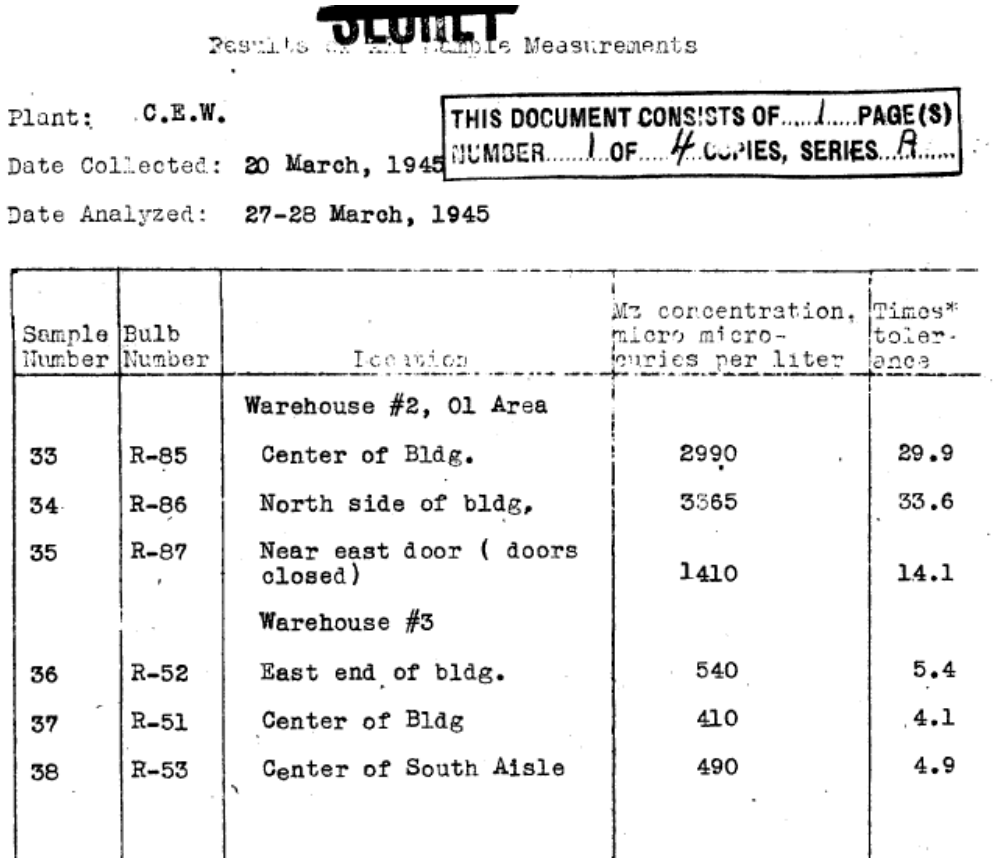


Measurement No.	Location	Beta Units	Gamma R/C hrs	Date
25	Sample Storage Room Plant 4	0.1		4-20-44
26				
26	Ingot Storage Room Four feet from pile ripe metal.	0.1		4-20-44
27	Ingot Storage and packing room, three feet from pile ore scraps in crib.	0.1		4-20-44
28	Instrument set on top of chipper's table.	0.5		4.20-44
29	On table where ingot is pushed out of bomb after remelting.	0.4		4-20-44
30	Four inches from slag t at came out of reaction bomb.	1.0		4-20-44
31	Two inches from pile of slag in sample aging room.	0.8	less than 0.02	4-20-44
32	One inch from green salt that is normally handled; to see how much it has aged.	0.4		4-20-44
33	Three inches from plate of residue being dried in an oven.	1.0		4-20-44
125	On top of barrel of residue that had been in storage for six of seven months.	0.2	0.05	7-18-44
126	In passageway, about six feet from same barrel as measurement number 125	0.3	0.05	7-18-44
127	Two inches from pile of trays in which N.C. & S.N.C. residue are dried.	0.2	0.04	7-18-44
208	Shotgun package containing three bottles.	0	0.02	11-14-44
209	Six inches above floor on recasting furnace [illegible]	.67		11-15-44

Tybout, 1945a

Internal Exposure Models

- Heavy reliance on exposure models using air sample data 1943-1947
- Some individual bioassay at major Department of Energy sites starting around 1945-1946
  - plutonium was a much greater concern compared to uranium
- Very little bioassay at Atomic Weapons Employers, therefore, air dust studies (exposure models) are used throughout the 1940s and 1950s



DECLASSIFIED

Results of Air Sample Measurements

Plant: C.E.W.

THIS DOCUMENT CONSISTS OF 1 PAGE(S)
NUMBER 1 OF 4 COPIES, SERIES A

Date Collected: 20 March, 1945

Date Analyzed: 27-28 March, 1945

Sample Number	Bulb Number	Location	Mz concentration, micro micro-curies per liter	Times* tolerance
		Warehouse #2, 01 Area		
33	R-85	Center of Bldg.	2990	29.9
34	R-86	North side of bldg,	3365	33.6
35	R-87	Near east door (doors closed)	1410	14.1
		Warehouse #3		
36	R-52	East end of bldg.	540	5.4
37	R-51	Center of Bldg	410	4.1
38	R-53	Center of South Aisle	490	4.9

Tybout, 1945b

Claimant Favorable Exposure Models

- Co-exposure models have higher uncertainty in the dose compared to individual dosimetry and bioassay
- Exposure models generally have higher uncertainty than Co-exposure models
- For exposure models, NIOSH tends to use three or four general categories (Production Worker, Labor, Supervisor, and Clerical) for dose estimation instead of a job specific exposure matrix
- As a compensation program we also tend to be claimant favorable and overestimate the dose by using the upper 95^{th} percentile of the measurement data distribution

NASEM Committee Questions

Question #1 - What data does NIOSH have access to

1. *Given NIOSH's important role in supporting EEOICPA, what data, records, or other information does NIOSH have access to and/or custodianship of from 1942–1947 related to individual exposures, number of people exposed, activities conducted, or similar?*

Personnel Roster
Radiological Safety Section
25 May, 1946

Service or Contractor		Name	Test A	Test B	Both Tests	Going A1	Going A2	Going S	Return A1	Return A2	Return S
A	Pvt.	Military	x	x	x			x			x
AAF	Pfc.	Military	x	x	x			x			x
N	Lt.Cdr	Military	x	x	x			x			x
A	Cpl.	Military	x	x	x			x			x
USPHS	Lt.Cdr.	Military	x	x	x			x			x
A	Capt.	Military	x	x	x	x				x	
AAF	Pvt.	Military	x	x	x			x			x
A	Maj.	Military	x	x	x			x			x
N	Lt.jg	Military	x	x	x			x			x
A	T/5	Military	x	x	x			x			x
A	Sgt.	Military	x	x	x			x			x
C.L.	Dr.	Energy Employee		x			x			x	
Chic.	Mr.	Energy Employee	x	x	x	x				x	
A	Maj.	Military	x					x	x		
S.F.	Mr.	Energy Employee	x					x	x		

Roster captured from Atlanta NARA

Pacific Proving Ground – Operation Crossroads

1946 Crossroads-Pacific

PAGE 0001

[redacted]

	Film#	mr	mrad	dy/mo/yr dy/mo/yr
NEW YORK	001667	00000	00000	160846-160846‡
PRINZ EUGEN	000510	00000	00000	140846-140846‡
ARS-22	002460	00000	00000	010746-010746‡
BRULE	001105	00000	00000	160846-160846‡
BRULE	010434	00050	00000	190846-190846‡
PGM 32	006709	00000	00000	290746-300746‡
PGM 32	006559	00000	00000	290746-300746‡
PGM-32	006339	00000	00000	270746-270746‡
APAGON	012226	00000	00000	300846-300846‡
APAGON	012762	00000	00000	280846-280846‡

Film badge printout scanned at DOE Nevada Test Site

Question #2 - Exposure Information Captured

2. *What exposure information is captured or recorded? Do you have the associated dosimetry for any radiation exposure information?*

- *Before 1945, mostly exposure rate information for external dose and air dust studies for internal dose*
- *Personal dosimetry and bioassay begins to become more prevalent after 1945*

Question #3 - NIOSH's Experience

3. *What experience does NIOSH have with performing dose reconstruction for individuals from 1942–1947? What process do you use to identify surrogate populations for these types of historic exposures? What exposure information is captured or recorded? Do you have the associated dosimetry for any radiation exposure information?*

- Quite a bit of experience
- The Use of Data from Other Facilities in the Completion of Dose Reconstructions Under the Energy Employees Occupational Illness Compensation Program Act – OCAS-IG-004

Question #4 - Ability Identify Service Members

4. *Within the data or information you have available, is there a mechanism to identify service members or veterans?*

- Sometimes there is sufficient data, other times there is not a mechanism or indication
- Greatly depends on the facility and the data obtained

Question #5 - Work History Availability

5. *Do you or any partnering organizations keep work history and/or military history, such as information on employees who entered and/or left the military? For energy workers who may not have been active military, are there indicators of veteran status in existing records?*

- Yes, we obtain work history from the Department of Labor (DOL) who define the covered employment period for us to reconstruct the dose
- No military history is provided, but we occasionally see breaks in employment for military service especially during the Korean and Vietnam wars
- Outside of our scope so we haven't really looked for this information

Question #6 - Health Effects Information

6. *What health effect information is captured? Only the compensable conditions? Other comorbidities?*

- Under Part B of EEOICPA, we only obtain cancer diagnosis information from the Department of Labor
- Use the cancer diagnosis to estimate the dose to the target organ

Question #7 - Where does NIOSH Exposure data come from

7. *From where does NIOSH typically receive data or records related to compensation requests?*

- Request and receive individual radiation monitoring records primarily from the Department of Energy (DOE)
- Conduct data captures at DOE sites to retrieve pertinent records mostly for Technical Basis Documents and Co-exposure model development
- Conduct data captures at National Archives Records Administration (NARA) facilities primarily for Atomic Weapons Employers – AWE records
- Also obtained exposure records from large vendors (Landauer, etc…)
- Routinely search the internet (OSTI, Universities, other online records holdings)

Question #8 - Other Contacts

8. *Is there an organization or person that you would recommend the committee reach out to who might have access to data types mentioned (the committee has reached out to DOE, VA, DoD, and NARA)?*

- Paul Blake from Defense Threat Reduction Agency (DTRA)
- Martha DeMarre – retired from NTS (Dosimetry Historian)
- Department of Labor (Part E)
  - Energy Workers Program | U.S. Department of Labor (dol.gov)

Question #9 - NIOSH Site Profiles

9. *How are Site Profiles created and what information is retained after completing the profile?*

- Six (to eight) sections to a full Site Profiles
- Sections follow the dose reconstruction components discussed previously
  - ORAUT-TKBS-XXXX-1 (Introduction)
  - ORAUT-TKBS-XXXX-2 (Site Description)
  - ORAUT-TKBS-XXXX-3 (Medical Dose)
  - ORAUT-TKBS-XXXX-4 (Environmental Dose)
  - ORAUT-TKBS-XXXX-5 (Internal Dose)
  - ORAUT-TKBS-XXXX-6 (External Dose)
    - ORAUT-TKBS-XXXX-7 (Internal Co-exposure Dose) - *New*
    - ORAUT-TKBS-XXXX-8 (External Co-exposure Dose) – Under-development

Question #9 - NIOSH Site Profiles cont.

9. How are Site Profiles created and what information is retained after completing the profile?

- A large portion of the information in our site profiles is applicable to an epidemiologic study (monitoring practices, MDAs, etc.)
- Our Contractor (ORAUT) prepared the vast majority of our site profiles
  - Conduct data captures on DOE sites or at NARA facilities
  - Analyzed and compiled the data and information to create the site profiles
- Site profiles are working documents and are continuously updated
- Internally reviewed by multiple Health Physicist and eventually approved by the DCAS Associate Director for Science (ADS)
- All of the information (data, analysis, etc.) is retained in our Site Research Database (SRDB)

References

- Ferry, J.L. [1944]. Inspection of Warehouse at Oak Ridge. Memorandum to Major P. Merritt. Madison Square Area, New York, N.Y: Area Engineer, Manhattan District, Oak Ridge, Tennessee. August 12. [SRDB Ref ID: 78413]
- Geissinger, G. [1946]. Tabulation of results obtained from measurements of film badges worn by workers at St. Louis from September 2 to 9, 1946. University of Rochester, Manhattan Department. [SRDB Ref ID: 15564]
- Hayes, J.R. [1945]. Tabulation of results obtained from measurements of film badges worn by workers at Clinton from July 18-25, 1945. University of Rochester, Manhattan Department. [SRDB Ref ID: 5939]
- Pardue, L. A., N. Goldstein, and E. O. Wollan, [1944]. Photographic Film As a Pocket Radiation Dosimeter, CH-1553-A-2223, University of Chicago, Metallurgical Laboratory, Chicago, Illinois, April. [SRDB Ref ID: 8599]
- Silverman, L.B. [1944]. Redacted Excretion Analysis. Memorandum to Dr. J.H. Lum. Dayton, Ohio October 31. [SRDB Ref ID: 24550]
- Tybout, R.A. [1945a]. Ionization Measurements made at Mallinckrodt Chemical Company. Letter to M. E. Thayer, St. Louis, Missouri. January 12. [SRDB Ref ID: 197712]
- Tybout, R.A. [1945b]. Industrial Health Control Tests: Air Samples collected at the C.E.W. Plant 20 March 1945. Memorandum to Lt. Col. H.L. Friedell. District Engineer, Oak Ridge Tennessee. March 31. [SRDB Ref ID: 5920]

Questions?

Timothy D. Taulbee, PhD, CHP

Associate Director for Science

Centers for Disease Control and Prevention (CDC)
National Institute for Occupational Safety and Health (NIOSH)
Division of Compensation Analysis and Support (DCAS)
1090 Tusculum Avenue
Mailstop: C-45
Cincinnati, Ohio 45226

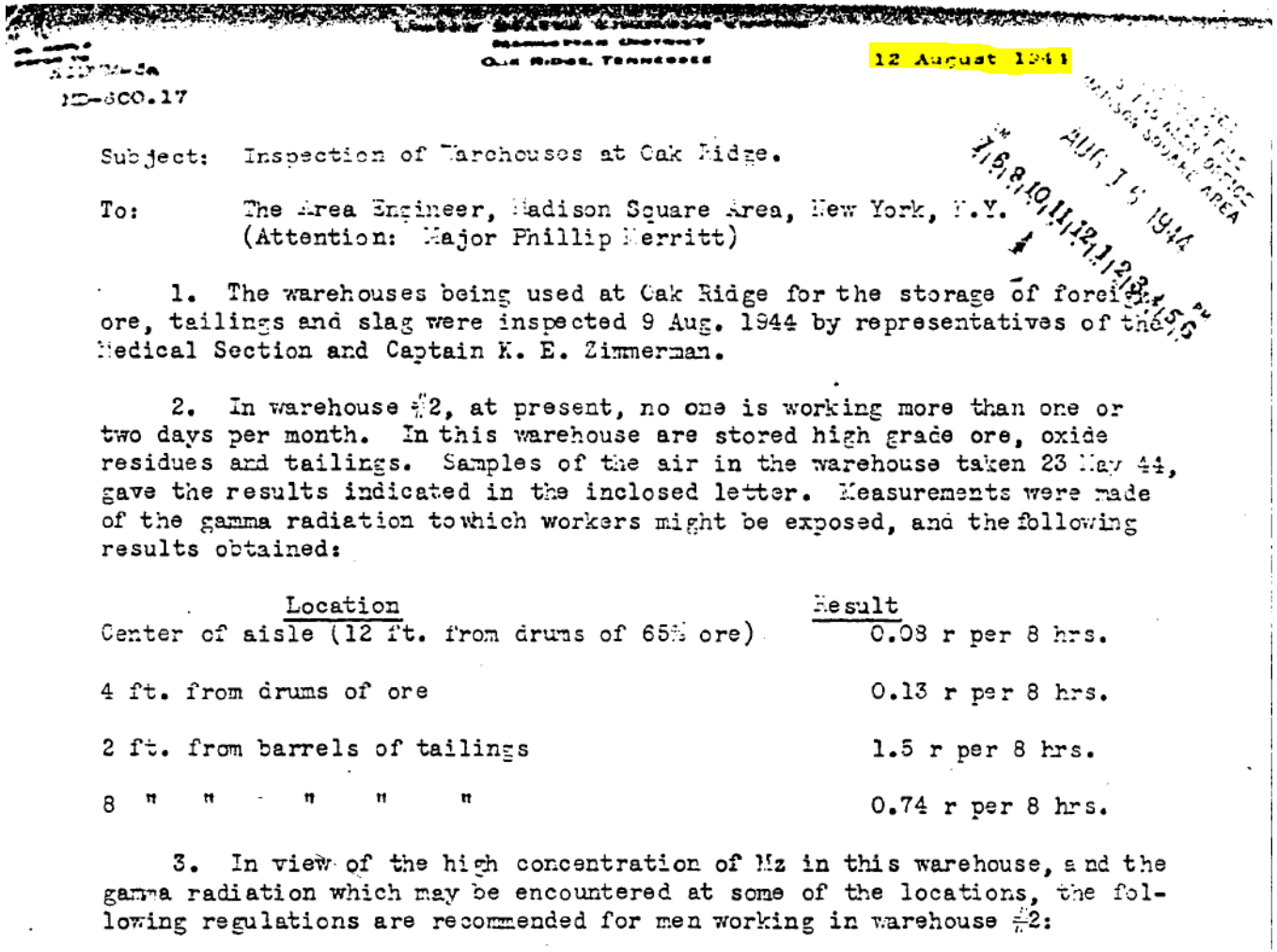
Office: (513) 533-6870
Mobile: (513) 206-3069
Email: ttaulbee@cdc.gov

For more information, contact CDC
1-800-CDC-INFO (232-4636)
TTY: 1-888-232-6348 www.cdc.gov

Additional Examples

External Exposure Model Example

- Inspection of Drums in a Warehouse at Oak Ridge - August 1944



12 August 1944

MD-SCO.17

Subject: Inspection of Warehouses at Oak Ridge.

To: The Area Engineer, Madison Square Area, New York, N.Y.
(Attention: Major Phillip Merritt)

1. The warehouses being used at Oak Ridge for the storage of foreign ore, tailings and slag were inspected 9 Aug. 1944 by representatives of the Medical Section and Captain K. E. Zimmerman.

2. In warehouse #2, at present, no one is working more than one or two days per month. In this warehouse are stored high grade ore, oxide residues and tailings. Samples of the air in the warehouse taken 23 May 44, gave the results indicated in the inclosed letter. Measurements were made of the gamma radiation to which workers might be exposed, and the following results obtained:

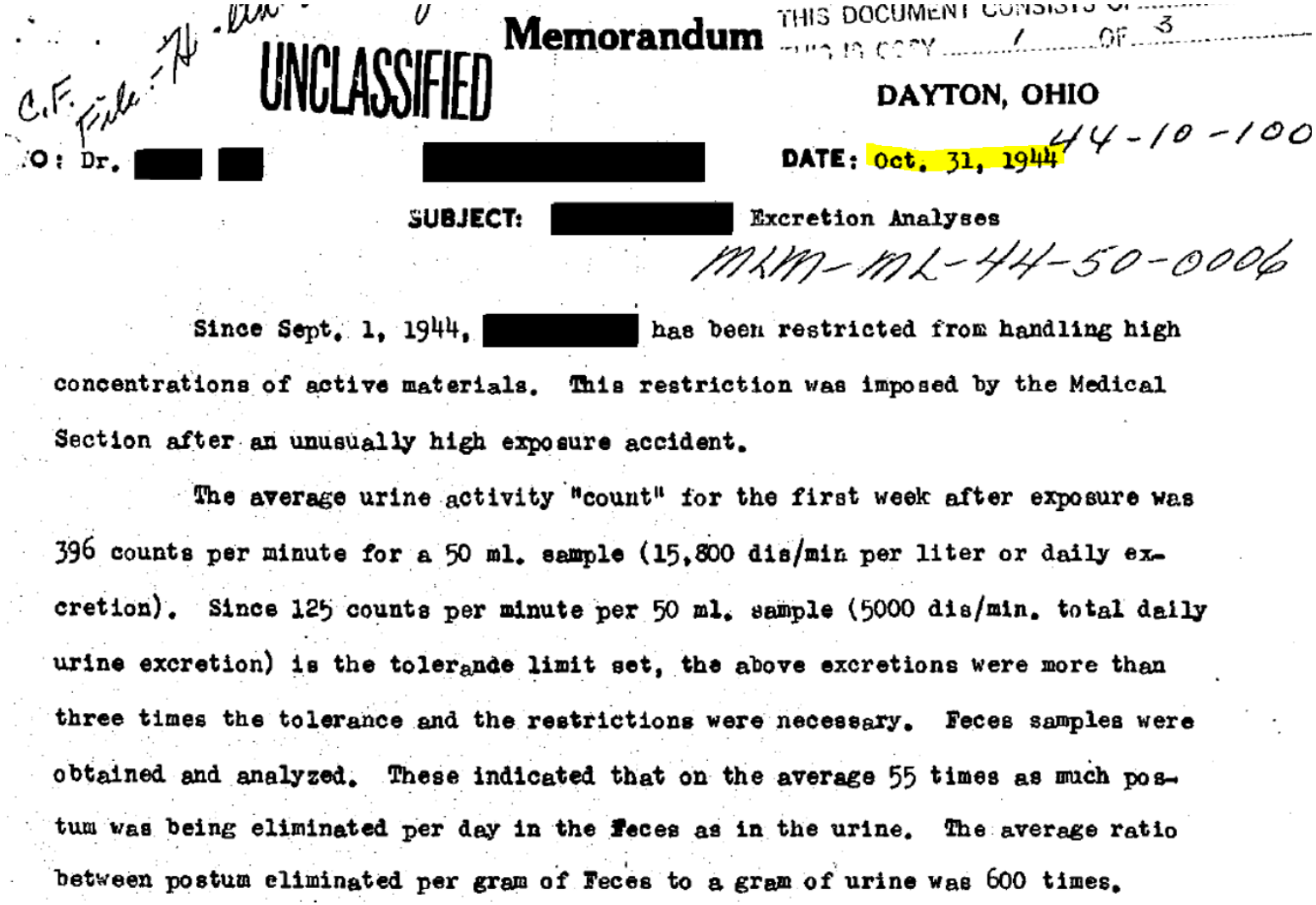
Location	Result
Center of aisle (12 ft. from drums of 65% ore)	0.08 r per 8 hrs.
4 ft. from drums of ore	0.13 r per 8 hrs.
2 ft. from barrels of tailings	1.5 r per 8 hrs.
8 " " " " "	0.74 r per 8 hrs.

3. In view of the high concentration of Rn in this warehouse, and the gamma radiation which may be encountered at some of the locations, the following regulations are recommended for men working in warehouse #2:

Ferry, 1944

Dayton Project Internal Monitoring Records

- 1944 Polonium Urinalysis
- Memo captured from microfiche at Mound *(July 6, 2006)*



C.F. File -H-

UNCLASSIFIED

Memorandum

THIS DOCUMENT CONSISTS OF 3
THIS IS COPY 1 OF 3

DAYTON, OHIO

TO: Dr. [redacted]

DATE: Oct. 31, 1944

44-10-100

SUBJECT: [redacted] Excretion Analyses

MLM-ML-44-50-0006

Since Sept. 1, 1944, [redacted] has been restricted from handling high concentrations of active materials. This restriction was imposed by the Medical Section after an unusually high exposure accident.

The average urine activity "count" for the first week after exposure was 396 counts per minute for a 50 ml. sample (15,800 dis/min per liter or daily excretion). Since 125 counts per minute per 50 ml. sample (5000 dis/min. total daily urine excretion) is the tolerance limit set, the above excretions were more than three times the tolerance and the restrictions were necessary. Feces samples were obtained and analyzed. These indicated that on the average 55 times as much postum was being eliminated per day in the feces as in the urine. The average ratio between postum eliminated per gram of Feces to a gram of urine was 600 times.

Silverman, 1944