



ORAU TEAM Dose Reconstruction Project for NIOSH

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**Evaluation of Health Physics Area and Health
Physics Department Codes To Identify
Neptunium Workers at the Savannah River
Site**

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ACRONYMS AND ABBREVIATIONS

AEC	U.S. Atomic Energy Commission
AFR	away from reactor
AOP	advanced operation planning
cm	centimeter
CS	Central Shops
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DWPF	defense waste pilot facility
EAS	engineering assistance section
E&I	Electrical and Instrumentation
ft	foot
hr	hour
HP	health physics
HPA	Health Physics Area
HPD	Health Physics Department
LOSD	Laboratory Operations and Services Division
m	meter
mR	milliroentgen
nCi	nanocurie
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH-Division of Compensation Analysis and Support Claims Tracking System
ORAU	Oak Ridge Associated Universities
P&A	Performance and Accountability
PTL	Pittsburgh Testing Lab
PuFF	²³⁸ PuO ₂ Fuel Form Facility
RMT	Reactor Materials Technology
SRDB Ref ID	Site Research Database Reference Identification (number)
SRS	Savannah River Site
WMO	Waste Management Operations
μCi	microcurie

1.0 INTRODUCTION

This report by the Oak Ridge Associated Universities (ORAU) Team for the National Institute for Occupational Safety and Health (NIOSH) Dose Reconstruction Project evaluates the usefulness of Health Physics Area (HPA) and Health Physics Department (HPD) codes to identify workers associated with the ²³⁷Np processes at Savannah River Site (SRS) from 1973 through 1989.

Neptunium-237 processes included operations, construction, and maintenance work in Building 235-F, the HB Line, and 321-M. Separations processes associated with ²³⁷Np are closely related to similar processes involving ²³⁸Pu; therefore, monitoring for exposure to ²³⁸Pu is assumed to be an indicator of a potential for ²³⁷Np intake.

This report also examines:

- The intake monitoring of workers in HP Department 205, which is the organization in the Separations Department responsible for work in Building 235-F,
- The NIOSH-Division of Compensation Analysis and Support Claims Tracking System (NOCTS) records of three workers who worked in Building 235-F during the period of interest, and
- The records on workers associated with radiological events involving ²³⁷Np.

2.0 HEALTH PHYSICS AREA CODES

The SRS radiological protection program established and used HPA codes to assist in dose tracking as a performance indicator (Boiter 1973), the collection of bioassay samples, and in the control, accountability, and periodic exchange of personnel dosimeters. During the period covered by this analysis, 1973 through 1989, personnel dosimeters were stored on “badge boards” at each HPA location while they were not being worn.

The HPA code was also an indicator of where workers were most likely to use their dosimeters. An HPA code was included on each worker’s personnel dose report.

Codes given in Table 2-1 reference codes in place at SRS during the time period covered by this report. Some, not all, codes were in service for the entire period. The systems of HPA codes used over the history of the plant are provided in (ORAUT 2014). Old codes were replaced with new codes over time. Table 2-1 contains the majority of codes, associated locations and trade labor designations that were in place by 1990.

Table 2-1. HPA codes and associated locations based on the reference in ORAUT (2014).

HPA Code	Location	Comment
1C	100-C MAIN GATE	1973 listing showed location as “100-C”
1K	100-K	—
1P	100-P	—
2F	200-F MAIN GATE	1973 listing showed location as “200-F”
2G	722-G	—
2H	200-H MAIN GATE	1973 listing showed location as “200-H”
3A	703-A (B Wing)	1973 listing showed location as “703-A”
3M	300-M	—
4D	400-D	—
4H	234-H TRITIUM	1973 listing showed location as “232-234-H”
5A	773-A MAIN BUILDING	1973 listing showed location as “773-A”
5B	777-10A	1973 listing showed location as “777-M”

HPA Code	Location	Comment
5C	TNX	1973 listing showed location as "CMX"
5D	735-A	—
5F	235-F CONST.	1973 listing showed location as "235-F (Separations/Const.)"
5G	705-G T&T	1973 listing showed location as "705-G"
7A	CS SOUTH GATE	1973 listing showed location as "Central Shops (CS)"
7B	PTL (30)	1973 listing showed location as "Pittsburgh Testing Lab (PTL)"
7C	CD-CAB	1973 listing showed location as "TC"
7D	709-A Fire House	1973 listing showed location as "709-A"
7E	713- Receive-Ship	1973 listing showed location as "713-A"
7F	716-A Auto Shop	1973 listing showed location as "716-A"
7G	717-A MAINT	1973 listing showed location as "717-A"
7H	719-A MEDICAL	1973 listing showed location as "719-A"
7I	720-A WSI	1973 listing showed location as "720-A"
7J	IRON WORKER (12)	Central Shops, HPD 040
7K	722-A E&I	1973 listing showed location as "722-A"
7L	723-A EED	1973 listing showed location as "723-A"
7M	724-A TRAINING	1973 listing showed location as "724-A"
7N	725-A MAINT	1973 listing showed location as "725-A"
7P	784-A POWER	1973 listing showed location as "784-A"
7Q	722-4A E&I	—
7R	CS NORTH GATE	—
7S	722-5A CSWE (COMPUTER)	—
7T	707-A DIVERSCO	—
7W	WSI 703-B	—
7Z	UGA ECOLOGY LAB	1973 listing showed location as "735-A (University of Georgia)"
8A	MACHINIST (24)	Central Shops, HPD 040
8B	BOILERMAKERS (30)	Central Shops, HPD 040
8C	CARPENTER (6)	Central Shops, HPD 040
8F	235-F (Separations/ non-const.)	1973 listing shows location as "235-F (Separations/non-const.)"
8G	618-G Class. Yard	1982 listing showed location as "618-G"
8H	HEAVY EQUIPMENT (14)	Central Shops, HPD 040
8I	INSULATOR (31)	Central Shops, HPD 040
8K	CONCRETE (8)	Central Shops, HPD 040
8L	LABORER (5)	Central Shops, HPD 040
8M	MILLWRIGHT (18)	Central Shops, HPD 040
8P	PAINTERS (17)	Central Shops, HPD 040
8S	SHEET METAL (21)	Central Shops, HPD 040
8T	TRANSPORTATION (10)	Central Shops, HPD 040
8Z	U. S. AEC Atlanta	Code Designation in 1973
8Z	SOU BELL (TRAILER)	Code designation in 1990

a. HPA codes for general site workers from CS (HPD 040) were not included in the original 1973 code listing as shown above.

3.0 HEALTH PHYSICS DEPARTMENT CODES

HPD codes were used to define the functional organization or group to which a worker was assigned and for radiation protection tracking. A list of HPD codes for departments involved in separations and research dated 1977 is given in Table 3-1 (DuPont 1977a).

An HPD code was included for each monitored worker on external dose reports (DuPont 1977b).

Table 3-1. HPD codes in 1977 (DuPont 1977a).

Department or group	HPD code
Reactor	100
Separations: F Canyons	200
Separations: F B-Line	201
Separations: F Outside	202
Separations: H Canyons	203
Separations: H Outside	204
235-F: ²³⁸ PuO ₂ Fuel Form Facility (PuFF)	205
Separations: 232-H	206
Separations: 234-H	207
244-H	208
H B-Line	209
F Waste Management	210
H Waste Management Technology	211
F Waste Management Operations (WMO)	212
H WMO	214
Defense Waste Pilot Facility (DWPF)	215
Raw Materials-M	300
GS Process Area	400
Accountability	405
Works Technical: HP	500
Works Technical Laboratories	501
Works Technical: Technical Procedures Office	502
Works Technical: Reactor Materials Technology (RMT)	503
Works Technical: Separations Technology	504
Works Technical: Engineering Assistance Section (EAS)	505
Works Technical: Integrated Safety Program (Quality Assurance) Away from reactor (AFR)	506
Works Engineering: Electrical & Instrumentation (E&I)	601
Works Engineering: Maintenance	602
Works Engineering: Power	603
Works Engineering: Project	604
Works Engineering: RMT	605
Service: Traffic and Transportation	703
Technical: Miscellaneous	906
Technical: Experimental Physics	907
Technical: Reactor Engineering	908
Technical: Nuclear Materials	909
Technical: Source Technology	910
Technical: Separations Chemistry	911
Technical: Analytical Chemistry	912
Technical: Separations Engineering	913
Technical: Radiological Science	914
Technical: Radiation Control (Radiation Safety Department)	915
Technical: Building Operations [LOSD]	916
Technical: Engineering Services (LOSD)	917
Technical: Mechanical Services (LOSD)	918
Technical: High-Level Caves	919
Construction	040

4.0 WORKERS AT RISK FOR INTAKES

Four groups of workers with ^{237}Np intake potential have been identified:

- Workers assigned to HPD code 205,
- Workers who are named in the bioassay logbooks as having a ^{238}Pu or ^{237}Np bioassay,
- Claimants listed in NOCTS with ^{238}Pu or ^{237}Np bioassay results, and
- Workers involved in ^{237}Np contamination events.

Workers assigned to HPD code 205, which is a functional group within the Separations Department, were likely to work routinely in Building 235-F where ^{238}Pu and ^{237}Np operations were conducted. All of these workers are assumed to have exposure potential based on the mission of that group. A total of 196 different employees worked in HPD code 205 during the period of interest and were identified in bioassay logbooks, DOE records in NOCTS, and the SRS intake database (ORAUT 2004). Each of these workers' last names, initials, employee numbers, areas worked, and bioassay sample data are included in the logbooks (DuPont 1969–1973, 1969–1982, 1970–1973, 1973–1978, 1973–1979, 1978–1983, 1979–1980, 1980–1981a, 1980–1981b, 1981–1986, 1986–1989). The bioassay logbook data, combined with various external dosimetry quarterly reports (DuPont 1980a is an example), provide the HPA and HPD codes that identify worker exposure locations. If a worker submitted a bioassay sample that was analyzed for ^{238}Pu or ^{237}Np , that person was probably exposed. The data from the source documents, including sample date, employee number, HPA code, and HPD code, were transcribed and analyzed. A total of 188 individuals who are not members of HPD 205 were identified as part of this group. Claimants whose case information includes ^{238}Pu or ^{237}Np bioassay data or some other indication of intake potential are also included in the evaluations described above.

Monitoring for potential intakes of radionuclides at SRS was controlled by DPSOL 193-302 (DuPont 1971b) from 1971 through 1988 and by DPSOL 193-211 beginning in 1989 (DuPont 1989). The ORAU Team has obtained data to demonstrate that neptunium workers were monitored for internal intakes of ^{237}Np since 1961 (DuPont 1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969–1982, 1970, 1971a, 1974, 1975, 1980b, 1980c, 1980d, 1980e, 1984a, 1984b, 1985a, 1985b, 1985c, 1985d; Reinig 1984). The Team obtained information on the number of neptunium analyses associated with Building 235-F, as reported in the Works Technical Department reports from 1972 through 1989 (as listed in the References list). These data are listed in Table 4-1. The number of ^{237}Np bioassay samples from the HB Line from 1973 to 1989 is provided in Table 4-2. This data is useful in evaluating the use of HPA and HPD codes to identify neptunium workers. A former worker was interviewed by the ORAU Team on August 26, 2013. That interview provided insight on the movement of workers between Building 235-F and the HB Line. Movements and access between these areas was strictly controlled and monitored (ORAUT 2013b).

Table 4-3 identifies some of the incident descriptions of radiological events in the operations at SRS involving work with $^{237}\text{Np}/^{238}\text{Pu}$ from 1972 through 1989 by area, department, and HPA code. There were other events that could have resulted in the intakes documented in Attachment A, Health Physics Monitoring of Specific Events, contained in ORAUT-RPRT-0065, *An Evaluation of Neptunium Operations at Savannah River Site*, for the period from 1973 to 1989 (ORAUT 2016). The correlation of the area, HPD codes, and HPA codes indicates that the work in the 235-F and the HB Line was responsible for the incidents.

Table 4-1. Number of ²³⁷Np bioassay sample results from Building 235-F and associated HPA codes (ORAUT 2016).

Year	Building 235-F	HPA code(s)	Location-area
1973	16	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1974	17	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1975	No results found	No code designated	Not applicable
1976	No results found	No code designated	Not applicable
1977	No results found	No code designated	Not applicable
1978	No results found	No code designated	Not applicable
1979	No results found	No code designated	Not applicable
1980	36	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1981	3	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1982	36	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1983	12	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1984	23	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1985	7	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1986	No results found	No code designated	Not applicable
1987	No results found	No code designated	Not applicable
1988	5	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
1989	3	2F, 5F, 8F	200-F, 235-F Construction, 235-F Nonconstruction
Total	158	Not applicable	Not applicable

Table 4-2. Number of ²³⁷Np bioassay sample results from the HB Line and associated HPA codes (ORAUT 2016).

Year	HB Line	HPA code(s)	Location-area/buildings
1973	No results found	No code designated	Not applicable
1974	No results found	No code designated	Not applicable
1975	No results found	No code designated	Not applicable
1976	No results found	No code designated	Not applicable
1977	No results found	No code designated	Not applicable
1978	No results found	No code designated	Not applicable
1979	No results found	No code designated	Not applicable
1980	No results found	No code designated	Not applicable
1981	2	2H	200-H
1982	32	6H	200-H North Gate (Construction)
1983	4	6H	200-H North Gate (Construction)
1984	5	6H	200-H North Gate (Construction)
1985	2	6H	200-H North Gate (Construction)
1986	No results found	No code designated	Not applicable
1987	No results found	No code designated	Not applicable
1988	5	6H	200-H North Gate (Construction)
1989	No results found	No code designated	Not applicable
Total	50	Not applicable	Not applicable

Table 4-3. Personal neptunium contamination events at SRS, 1973 to 1989.

Date	Type of contamination	Area	HPA code	HPD code	Job title	Comments	Source
12/1972	Wound	235-F	2F	205	Operator	Exposed to Np-237	ORAUT 2004, NOCTS
07/1973	Inhalation	235-F	2F	205	Operator	Exposed to Pu-238	DuPont 1973, NOCTS
07/1973	Inhalation	HB Line	2H	500	HP Inspector	Exposed to Pu-238	ORAUT 2004, NOCTS
09/1973	Airborne	HB Line	2H	209	Operator	Exposed to Pu-238	NOCTS
10/1973	Contamination	HB Line	2H	209	Operator	Exposed to Np-237	NOCTS
10/1974	Inhalation	235-F	2F	200	Operator	Exposed to Pu-238	DuPont 1974
10/1974	Inhalation	HB Line	2H	202	Operator	Exposed to Pu-238	NOCTS
11/1974	Inhalation	235-F	2F	602	Maintenance Mechanic	Exposed to Pu-238/Np-237	NOCTS
01/1975	Airborne	HB Line	2F	500	HP Inspector	Exposed to Pu-238	NOCTS
02/1975	Inhalation	HB Line	2H	201	Operator	Exposed to Pu-238	NOCTS
10/1975	Airborne	HB Line	2H	500	HP Inspector	Exposed to Pu-238	NOCTS
07/1976	Wound	235-F	2F	205	Operator	Exposed to Pu-238/Np-237	NOCTS
11/1976	Inhalation	HB Line	2H	209	Operator	Exposed to Pu-238	NOCTS
01/1978	Airborne	235-F	2F	505	Engineering Assistant	Exposed to Pu-238/Np-237	NOCTS
08/1978	Inhalation	235-F	2F	603	Maintenance Mechanic	Exposed to Pu-238	NOCTS
09/1978	Airborne	235-F	2F	205	Operator	Exposed to Pu-238/Np-237	NOCTS
11/1978	Airborne	235-F	2F	205	HP Inspector	Exposed to Pu-238/Np-237	NOCTS
01/1979	Inhalation	HB Line	2H	209	Operator	Exposed to Pu-238	ORAUT 2004, NOCTS
09/1979	Inhalation	235-F	2H	209	Operator	Exposed to Pu-238	NOCTS
03/1980	Inhalation	235-F	2F	205	Operator	Exposed to Pu-238/Np-237	ORAUT 2004, NOCTS
04/1980	Airborne	HB Line	2H	500	HP Inspector	Exposed to Pu-238	ORAUT 2004, NOCTS
01/1981	Skin	HB Line	2H	500	Operator	Exposed to Pu-238/Np-237	NOCTS
03/1981	Inhalation	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
07/1981	Airborne	772-F (lab for 235-F)	2F	501	Laboratory Technician	Exposed to Pu-238/Pu-239	NOCTS
08/1981	Skin	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
03/1982	Skin	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
03/1983	Airborne	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
09/1983	Inhalation	HB Line	2H	209	No Information	Exposed to Pu-238	ORAUT 2004
11/1983	Airborne	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
12/1983	Skin	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
04/1984	Airborne	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
06/1985	Airborne	HB Line	2H	209	Operator	Exposed to Pu-238	NOCTS
02/1988	Inhalation	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
09/1988	Inhalation	235-F	2F	205	Operator	Exposed to Pu-238	NOCTS
11/1988	Wound	CS	8B	40	Boilermaker	Exposed to Pu-238	ORAUT 2004
04/1989	Inhalation	CS, Old HB Line	8C, 2F	40, 205	Carpenter	Exposed to Pu-238	ORAUT 2004, NOCTS

5.0 CORRELATION OF HEALTH PHYSICS AREA AND HEALTH PHYSICS DEPARTMENT CODES FOR WORKERS MONITORED FOR PLUTONIUM OR NEPTUNIUM INTAKE

It is known that some neptunium workers retrieved their dosimeters from locations not directly adjacent to the immediate neptunium process work locations. Access to areas where neptunium work was conducted was controlled and required approval before entry. The HP organization developed and used departmental locations and HPA codes to track and maintain accountability where external dosimeters were issued. The analysis in this report shows that HPA and HPD codes for operations and maintenance workers have a correlation in terms of the neptunium facilities.

HPA and HPD codes were instrumental as administrative tools for management and radiological safety organizations for tracking workers who performed neptunium operation, construction, and maintenance work in Building 235-F, the HB Line, and Building 321-M. The departments associated with neptunium workers are categorized as being from Separations (Departments 200 to 201), Works Technical (Departments 500 to 505), or Works Engineering (Departments 600 to 604). The following HPA codes are associated with the area/building shown in parenthesis following the codes: 2F (Area/235-F), 5F (Area/235-F), 8F (Area/235-F), 2H (H-Area/HB Line), 6H (H-Area/HB Line), 3M (300-M), 1A (Technical Works Facilities), 3A (300-M), and 5A (773-A). HPA codes 8A, 8B, and 8C did not appear in the 1973 HPA code listing; they represented craftsmen associated with the CS and were added to the list of codes in the 1980s.

5.1 CORRELATION WITH HEALTH PHYSICS AREA CODE

Data from logbooks and personnel dosimetry reports was sorted to produce Figure 5-1, which shows the number of monitoring events (generally, these are bioassays) sorted by HPA code. A large majority (92%) of the monitoring events were associated with five HPA codes (all other HPA codes were associated with 1.2% or less of the monitoring events):

- HPA 2F = 62%,
- HPA 2H = 12%,
- HPA 3M = 9.2%,
- HPA 5A = 8.1%, and
- HPA 4H1 = 1.9%.

¹HPA 4H is generally associated with tritium facilities workers, but replacement workers were rotated to 235-F from the tritium area when external exposures of neptunium workers approached the administrative limit. This type of rotation is confirmed via documentation in a worker's interview (ORAUT 2013).

5.2 CORRELATION WITH HEALTH PHYSICS DEPARTMENT CODE

A large majority (71%) of the monitoring events were associated with seven HPD codes (all other HPD codes were associated with 2% or less of the monitoring events): HPD 205 (Separations: 235-F PuFF) = 50%,

- HPD 500 (Works Technical: HP) = 5.4%,
- HPD 503 (Works Technical: Reactor Technology) = 4.6%,
- HPD 505 (Separations: 235-F PuFF) = 50%
- HPD 209 (Separations: H B-Line) = 4.0%,
- HPD 300 (Raw Materials) = 2.4%,
- HPD 601 (Works Engineering: E&I) = 2.4%, and
- HPD 602 (Works Engineering: Maintenance) = 2.2%.

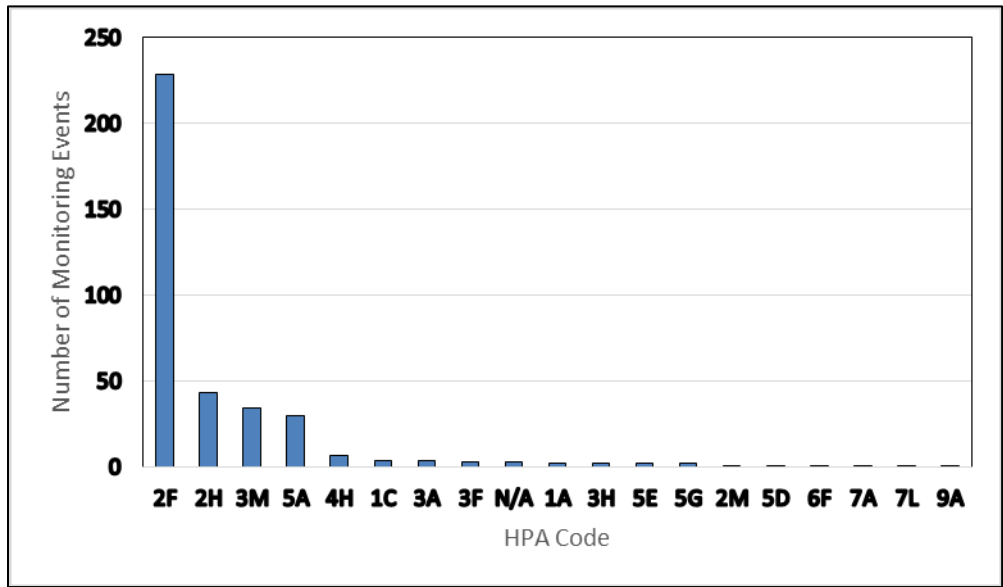


Figure 5-1. Monitoring events sorted by HPA code.

5.3 CORRELATION WITH THE COMBINATIONS OF HEALTH PHYSICS AREA AND HEALTH PHYSICS DEPARTMENT CODES

The data in Table 5-1 shows that most (66%) of the monitoring is associated with seven combinations of HPA codes and HPD codes:

- HPA 2F and HPD 205 (235-F PuFF) = 43%,
- HPA 2H and HPD 205 (235-F PuFF) = 5.6%,
- HPA 3M and HPD 503 (Works Technical: Reactor Technology) = 4.3%,
- HPA 2F and HPD 500 (Works Technical: HP) = 4.0%,
- HPA 2H and HPD 209 (Separations: HB Line) = 3.8%,
- HPA 2F and HPD 601 (Works Engineering: E&I) = 2.4%, and
- HPA 3M and HPD 300 (Raw Materials) = 2.4%.

Table 5-1. Combinations of HPA and HPD codes associated with intake monitoring for exposure to ²³⁸Pu and ²³⁷Np, 1973 through 1989. A description of the HPD code is provided in parentheses where available.

HP Area and HPD Code combination	Number of occurrences	Percentage of total occurrences
2F and 205 (235-F PuFF)	160	43
2H and 205 (235-F PuFF)	21	5.6
3M and 503 (Works Technical: Reactor Technology & RMT)	16	4.3
2F and 500 (Works Technical: HP)	15	4.0
2H and 209 (H B-Line)	14	3.8
2F and 601 (Works Engineering: E&I)	9	2.4
3M and 300 (Raw Materials-M)	9	2.4
2F and 602 (Works Engineering: Maintenance)	7	1.9
2F and 261	6	1.6
2F and 272	6	1.6
2F and 201 (Separations: F B-Line)	5	1.3
3M and 205 (235-F PuFF)	5	1.3
5A and 955	5	1.3
4H and 420	4	1.1
5A and 963	4	1.1

HP Area and HPD Code combination	Number of occurrences	Percentage of total occurrences
2F and 262	3	0.8
2H and 500 (Works Technical: HP)	3	0.8
3F and 40 (Construction)	3	0.8
5A and 909 (Technical: Nuclear Materials)	3	0.8
5A and 912 (Technical: Analytical. Chemistry)	3	0.8
5A and 957	3	0.8
5A and 969	3	0.8
5A and 972	3	0.8
#N/A	3	0.8
2F and 200 (Separations: F Canyons)	2	0.5
2F and 212	2	0.5
2F and 520	2	0.5
2F and 524	2	0.5
2F and 703 (Service: Traffic and Transportation)	2	0.5
3H and 214	2	0.5
3M and 362	2	0.5
5G and 703 (Service: Traffic and Transportation)	2	0.5
1A and 200 (Separations: F Canyons)	1	0.3
1A and 504 (Works Technical: Separations Technology)	1	0.3
1C and 40 (Construction)	1	0.3
1C and 100 (Reactor)	1	0.3
1C and 500 (Works Technical: HP)	1	0.3
1C and 503 (Works Technical: Reactor Technology & RMT)	1	0.3
2F and 204 (Separations: H Outside)	1	0.3
2F and 207 (Separations: 234-H)	1	0.3
2F and 209 (HB-Line)	1	0.3
2F and 220	1	0.3
2F and 266	1	0.3
2F and 501 (Works Technical Laboratories)	1	0.3
2F and 523	1	0.3
2F and 700 (Service: Clerical)	1	0.3
2F and 921	1	0.3
2H and 203 (Separations: H Canyons)	1	0.3
2H and 261	1	0.3
2H and 262	1	0.3
2H and 272	1	0.3
2H and 603 (Works Engineering: Power)	1	0.3
2M and 602 (Works Engineering: Maintenance)	1	0.3
3A and 200 (Separations: F Canyons)	1	0.3
3A and 505 (Works Technical: Engineering Assistance & EAS)	1	0.3
3A and 515	1	0.3
3A and 921	1	0.3
3M and 304	1	0.3
3M and 315	1	0.3
4H and 207 (Separations: 234-H)	1	0.3
4H and 500 (Works Technical: HP)	1	0.3
4H and 520	1	0.3
5A and 40 (Construction)	1	0.3
5A and 583	1	0.3
5A and 906 (Technical: Miscellaneous)	1	0.3
5A and 919 (Technical: High-Level Caves)	1	0.3
5A and 961	1	0.3
5A and 970	1	0.3
5D and 955	1	0.3

HP Area and HPD Code combination	Number of occurrences	Percentage of total occurrences
5E and 205 (235-F PuFF)	1	0.3
5E and 971	1	0.3
6F and 40 (Construction)	1	0.3
7A and 40 (Construction)	1	0.3
7L and 974	1	0.3
9A and 604 (Works Engineering: Project)	1	0.3

The other 68 combinations represented 34% of the monitoring. None of these combinations individually represented more than 2% of the total monitoring effort. Monitoring was not performed in hundreds of other potential code combinations of location and functional department, indicating that little or no intake potential was recognized in them. This shows that the combination of HPA and HPD codes is a powerful predictor of the recognized need for intake monitoring of work involving ²³⁷Np.

6.0 MONITORED WORKERS IN HEALTH PHYSICS DEPARTMENT 205

The HPD 205 worker entries identified from the source documents described in Section 4.0 were examined and analyzed, which resulted in a list of 196 unique employee numbers. These workers had been assigned to seven different HPA codes, but only two HPA codes accounted for 98% of the assignments:

- 168 individuals (86%) were assigned to HPA 2F,
- 24 individuals (12%) were assigned to HPA 2H,
- 1 individual (0.5%) was assigned to HPA 3A,
- 1 individual (0.5%) was assigned to HPA 3M,
- 1 individual (0.5%) was assigned to HPA 4H, and
- 1 individual (0.5%) was assigned to HPA 5E.

The data analysis used data tables with information from the source documents, including a field identifying the source of the data. This field has one of three values: "NOCTS," "logbook," or blank (no entry). All individual claimants listed in NOCTS have bioassay or in vivo counting data during the period of interest. All workers listed in the bioassay logbooks had bioassay monitoring. If the field was blank, the analysis assumed no intake monitoring data was collected. This might not be a correct assumption, but it does result in an accurate estimate, or an underestimate, of the monitoring rate that in either case bounds the estimate. If a worker was monitored for "Pu" or "Np" intake in any year during the period of interest, that person was counted as being monitored. Based on these criteria, 75 workers (38%) were monitored and 121 workers (62%) were not monitored.

In addition, Quarterly Exposure Summaries for February 1, 1979, and February 6, 1979 (DuPont 1979a, 1979b) were reviewed. The names and employee numbers of all of the workers identified in Department 205 were examined. The first document listed 16 workers, and the second listed 23. Combined, 27 unique workers were listed in the two documents. The worker identifications were used to search the bioassay logbooks and intake database (ORAUT 2004) to determine if any of the workers had ever been bioassay sampled. The Quarterly Exposure Summaries show that all the workers were externally monitored for radiation exposure. Of the 27 unique workers, 13 workers had bioassay records in NOCTS, the intake database, or the logbooks. Six had bioassay data in the logbooks, three had bioassay data in the intake database, and seven were in NOCTS with both in vitro and in vivo records. The three workers from the intake database who had bioassay data are part of the seven workers that are in NOCTS. It should be noted that data for these workers who were monitored by whole-body counts or chest counts is only available in NOCTS; the results do not appear in the logbooks or intake database. Therefore, the only way to confirm if workers from Department 205 were in vivo counted would be to retrieve their complete hard-copy individual

personnel dosimetry records, because there is no evidence that an in vivo database for SRS workers exists.

7.0 EXAMINATION OF CLAIMS CASES AND RADIOLOGICAL EVENTS

7.1 EXAMINATION OF WORKS TECHNICAL DEPARTMENT REPORTS AND CLAIMS CASES

A review of Works Technical Department reports and NOCTS intake monitoring records was performed for a small sample of claims and a small sample of radiological events associated with ²³⁷Np. Three of the cases reviewed below are in incident reports, as shown in Table 4-3. The contamination events table is from ORAUT-RPRT-0065 (ORAUT 2016).

- **SEPARATION INCIDENT, SI-76-93: CONTAMINATED PUNCTURE WOUND, BUILDING 235-F, June 30, 1976, (DuPont 1974–1979).**
A Separations operator was packaging waste for removal from the neptunium billet glove box line. A sharp projection from the scrap penetrated the operator's glove and he sustained a contaminated puncture wound to his right thumb. The waste included pre-filters which are made of fiberglass with a metallic reinforcement on each side. The sharp edges of the metallic reinforcement are covered by a frame, but when the filter was rolled out of shape for packaging, the frame provided no protection from the sharp edges. The "wound monitor" in 772-F indicated contamination in the wound at 200 counts/minute. The operator was taken to 719-A Medical for treatment. No other contamination released occurred except to the glove that was punctured. There was no airborne contamination detected. The same type of cf pre-filter is used in the ²³⁸Pu Fuel Form (PuFF) Facility. Maintenance and handling of the pre-filter with gloves will be required. Contamination for similar incidents would be much more severe in the PuFF facility due to the significantly higher activity of ²³⁸Pu.
- **SEPARATIONS INCIDENT, SI-78-10-107: GLOVE FAILURE, BUILDING 235-F NEPTUNIUM TARGET FABRICATION FACILITY, September 25, 1978, (DuPont 1978b)**
Category Code 4, Degradation of a barrier designed to contain radioactive materials. Contamination was discovered on a cabinet glove (#16, about 2,000 d/m). No nasal contamination was detected and no contamination was found either on the cabinet or floor. The glove has been in service since 1978. While loading and pressing a compact a Separations operator detected contamination on his surgeon's glove. The operator, along with all others in the room, evacuated per procedure. All persons in the room received nasal smears which showed less than minimum detectable contamination. During the change-out the glove lip was found to have 5×10^4 d/m alpha. Air activity during the change-out was 7.7×10^{-12} μ Ci/cc air.
- **SEPARATIONS INCIDENT, SI-80-8-109: PREMATURE PENETRATION BORING CONCRETE FLOOR, August 19, 1980, (DuPont 1980h)**
Category 9, Threat to safe operations from natural events or man-made activities. Two concrete finishers from Construction were cutting holes in the concrete floor of second level for ducts to be installed under Project S-2191, Improved Ventilation. Rectangular holes are cut by boring overlapping round holes along the edges of the rectangular hole, using a water cooled boring machine. Operators in the Neptunium Compact Line heard water dripping and traced the source to leakage through the second level slab to the floor of the regulated Compact Line Maintenance Room 107D, 13 feet below. They promptly notified the supervisor who had the work stopped.

Roll 4 construction workers had been told that the floor thickness was 8 inches and instructed to set the boring machine to stop 2 inches before full penetration. Actual thickness of the floor slab in this area is only 6 inches; other areas are thicker. The area in the Compact Line

Maintenance Room under the penetration was not roped off because full penetration and removal of the block was not scheduled until later. A wooden catch box had been made to catch the 22" x 26" block of concrete to be removed, but the box was not at the job site when work began. The boring plug was retained in the boring machine and did not fall to the first floor 13 feet below. There was no personal injury, equipment damage, or contamination spread. This incident had potential for serious consequences.

The NOCTS records of three workers who were involved in incidents from Table 4-3 were reviewed. The incidents occurred in November 1974, March 1981, and December 1983.

- An employee worked as a maintenance mechanic at SRS from July 1953 to October 1993. He worked from the mid-1960s into the 1990s in F-Area. During this time his HPD was 602 and his HPA was 2F. Over his career he was routinely sampled for urine bioassay, whole-body counted, and monitored for external exposures via personnel dosimetry. The worker was involved in a radiological contamination incident in November 1974 when a cabinet glove being used by another worker failed. An air concentration of $\sim 0.00000000001 \mu\text{Ci}/\text{cm}^3$ Pu was measured. Nose swabs were taken and he was bioassay sampled for plutonium, both urine and fecal, over several days after the incident. A special whole-body count was performed on the worker on December 3, 1974, with negative results. All of the incident documentation (initial incident reports, air monitoring data, bioassay cards with results and sample weights, and whole-body count spectra and results) were in the NOCTS records.
- A second employee worked as an operator in the H- and F-Areas at SRS from 1954 to 1986. He began to work in F-Area in 1963 and worked there until end of his career. His HPD code was 205 and HPA was 2F for the latter part of his career. This incident was a radiological inhalation due to his exposure to high plutonium airborne contamination from bags containing plutonium pellets. All documentation of this incident was available in the NOCTS file describing the event, the samples taken, and monitoring requirements with their results. The chest count provided for this incident indicated a lung burden of $<21 \text{ nCi } ^{238}\text{Pu}$. This employee had been involved in other radiological incidents during his employment, and that information was also in his records. The worker was routinely monitored with personnel dosimetry and was internally monitored through urine and fecal sampling and whole-body and chest body counts on the normal schedule established by the HP Department during his entire career.
- A third employee worked as a laboratory technician from 1971 to 1989 and as an operator from 1989 to 2002. Early in his career, about 1973, he transferred from P Reactor to F-Area. His assigned HPD and HPA codes for his duties in F-Area were 205 and 2F, respectively. He was routinely monitored with the standard radiological area requirement. This incident occurred when, without any protective clothing, he entered a laboratory where the floor was highly contaminated to 10,000 dpm of alpha contamination. The alpha contamination was suspected to be ^{239}Pu because the analyst was working with the material. As a result his left little finger became contaminated to 2,000 dpm and his clothing to 8,000 dpm. He was decontaminated to below the minimum detectable activity and required to provide a special urine bioassay sample for plutonium. Results were less than the minimum detectable activity. Sampling and personnel dosimetry result histories were in the records. He worked the rest of his career in the F-Area.

The results of this review indicates that adequate radiological worker records were developed, collected, and evaluated during a worker's employment and were archived after leaving employment.

7.2 EXAMINATION OF CONTAMINATION EVENT REPORTS

Examinations of event and incident reports were undertaken to specifically determine if any HPA and HPD codes were used to identify the administrative work assignment locations or functional work areas in the incident descriptions.

The routinely published Works Technical Reports captured significant events that occurred in the work areas. The reports along with the initial incident reports were used as management tools and information and to develop a tracking and monitoring corrective action system. The following information on incident reports was selected and extracted from ORAUT-RPRT-0065 (ORAUT 2016) because their occurrence was within the timeframe addressed by this report. Because HP monitoring of specific radiological events occurred when necessary, some incidents involving work with radioactive materials were categorized for official review and tracked in the Special Hazard Investigations reports available through 1989 (DuPont 1954–1989), and they are sequentially numbered. Each of the four volumes in the previously cited reference contain descriptions of about 100 incidents per volume that occurred at SRS from 1954 to 1989. Reports of these incidents are retained in SRS Dosimetry Special Hazards Investigations files.

Several examples of these incidents that occurred throughout the time of this report are shown below. They indicate various work locations at the plant where neptunium or plutonium was processed. The workers came from various HPDs and worked in different HPAs. Their personnel dosimetry records contain this location information.

- January 1972, HB Line. One construction worker continued installation of Pu-Np partitioning equipment in the JT-3 process cabinet in Room 311. Transferable contamination was measured up to 108 dpm/ft² and gamma radiation exposure rates to 100 mR/hr were measured in the cabinet. Plastic suits were worn for personnel protection, and containment huts were used for contamination control. Even with these precautions, as one employee undressed after work, he contaminated his hair to 80,000 dpm and his right cheek to 30,000 dpm. A second employee contaminated his coveralls to 40,000 dpm when a seam in his plastic suit failed. Plutonium bioassay analyses indicated that neither employee assimilated radioactive materials (DuPont 1971–1973).
- November 1974, 235-F. While working in the Neptunium Compact Operating Room, two Roll 2 construction trade workers and an operator received nasal contamination to 420 dpm, 25 dpm, and 30 dpm, respectively, due to a process cabinet glove failure. The maintenance mechanic with the highest nasal contamination also had contamination to 10,000 dpm on his wrist. There were five other workers in the room at the time and their nasal smears were negative. Health Physics personnel collected bioassay samples from the three workers with positive nasal smears. A survey of the room revealed one failed glove and 14 contaminated gloves. The failed glove was contaminated to 8×10^6 dpm alpha with levels to 100,000 dpm on the other 14 gloves. The floor was contaminated up to 10⁵ dpm/ft² (DuPont 1974).
- October 1978, 235-F. An operator working in the neptunium line incurred nasal contamination of 190 dpm when a cabinet glove failed. The glove was contaminated to 1×10^4 dpm and the floor to 2×10^3 dpm/0.1 m². Room airborne activity remained less than the radioactivity concentration guide during the incident. Nasal irrigation promptly removed the contamination. A follow-up chest count of the operator indicated less than the minimum detectable amount and urine sample results were negative (DuPont 1978a).
- June 1980, 772-F. Contamination to 2.5×10^5 dpm/100 cm² was detected after clean-up on the floor of a laboratory bench where neptunium samples were processed. Contamination ranging from 4,000 to 20,000 dpm/100 cm² was spread to the utility corridor and three other

laboratory modules. Shoe covers of several lab workers were contaminated to 20,000 dpm. No airborne activity was detected and nasal smears from personnel were negative. Bioassay samples were collected from five workers (DuPont 1980g).

Although the original event descriptions were documented on forms designed for that purpose, and they include general location information, they neither make further use of that information, nor do they capture some of administrative information that would have been depicted by the use of HPA or HPD codes.

8.0 SUMMARY

All workers associated with HPD 205 are assumed to have had a significant exposure potential due to the mission of the group and the location of the work.

- 92% of the intake monitoring was associated with only five HPA codes: 2F, 2H, 3M, 5A, and 4H.
- 71% of the intake monitoring was associated with only seven HPD codes: 205, 500, 503, 209, 300, 601, and 300

Most (66%) of the intake monitoring for ^{238}Pu and ^{237}Np is associated with seven combinations of HPA and HPD codes:

- HPA 2F and HPD 205 (235-F PuFF) = 43%,
- HPA 2H and HPD 205 (235-F PuFF) = 5.6%,
- HPA 3M and HPD 503 (Works Technical: Reactor Technology) = 4.3%,
- HPA 2F and HPD 500 (Works Technical: HP) = 4.0%,
- HPA 2H and HPD 209 (Separations: HB Line) = 3.8%,
- HPA 2F and HPD 601 (Works Engineering: E&I) = 2.4%, and
- HPA 3M and HPD 300 (Raw Materials) = 2.4%.

This indicates that there was little or no known intake potential in other combinations of location and functional department. It suggests that the combination of HPA and HPD code is a powerful predictor of the recognized need for intake monitoring for ^{238}Pu and ^{237}Np . Personnel dosimetry exposure records contain these HPD and HPA codes for the workers. Works Technical Reports and site Special Hazard Investigations reports contain documentation of radiological worker incidents and events that occurred in the various work areas. When necessary, these documents can be references to determine HPD and HPA codes for workers.

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