NIOSH Response to SC&A Comments on ORAUT-RPRT-0092

Response Paper

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ACRONYMS

CC	chest count
CPM	counts per minute
CTW	Construction Trade Worker
DPM	disintegrations per minute
FFTF	Fast Flux Test Facility
FP	fission products
HLC	high-level cave
LAW	low activity waste
MPPF	Multi-Purpose Processing Facility
NOCTS	NIOSH OCAS Claims Tracking System
Pu	plutonium
PUFF	Plutonium Fuel Form Facility
RWP	radiation work permit
subCTW	Construction Trade Worker
SRS	Savannah River Site
SWP	standard work permit
WBC	whole body count
WSRC	Westinghouse Savannah River Corporation

INTRODUCTION

In 2017, the Oak Ridge Associated Universities Team (ORAU Team) issued ORAUT-RPRT-0083, *Evaluation of Monitoring of Construction Trade Workers Identified in High-Level Cave Job Plans at the Savannah River Site* [ORAUT 2017]. In that evaluation, the ORAU Team reported that subcontracted construction trade workers at the SRS were monitored similarly to prime contractor CTWs. In addition, the report found that 99% of DuPont CTWs and 97% of subCTWs in that evaluation were monitored for external dose from 1980 through 1986. However, that evaluation considered only CTWs identified in job plans for high-level caves and cells in Building 773-A for 1981–1986.

The Advisory Board SRS work group requested a similar statistical evaluation of subCTWs working at other operating areas from 1972 through 1998. In 2019, the ORAU Team issued ORAUT-RPRT-0092, *Evaluation of Bioassay*[1] *Data for Subcontracted Construction Trade Workers at the Savannah River Site* [ORAUT 2019a]. That evaluation documented the processes employed to address the work group's request and the results of that effort. Analytical results were presented for the periods from 1972 to 1974, 1975 to 1979, 1980 to 1989, and 1990 to 1998, which match the sets of collected bioassay data.

In response to ORAUT-RPRT-0092, SC&A issued *Review of ORAUT-RPRT-0092, Revision 00, Evaluation of Bioassay Data for Subcontracted Construction Trade Workers at the Savannah River Site* [SC&A 2019], which presented eleven findings and five observations. In this current response document, the ORAU Team addresses the findings and observations specified by SC&A.

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[1] Bioassay refers to whole-body counts, chest counts, urinalyses, and fecal counts unless otherwise stated.

NIOSH RESPONSES TO SC&A COMMENTS

FINDING 1

> *No SWPs or job plans sampled by NIOSH for 1972–1990 contain any requirements or indications for job-specific bioassays, despite respiratory protection being required, bringing into question the approach taken to satisfy RPRT-0092's first evaluation objective. See section 4.1* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH contends that even though the bioassay choice was not checked nor entered on the standard work permits and job plans, there was an ample number of bioassays taken for subCTWs and CTWs that could be associated by bioassay date to the date of the SWPs and job plans, as documented in RPRT-0092 [ORAUT 2019a]. RPRT-0092 used the following era-specific criteria to determine if bioassays should have been taken for the 1972–1989 time period. Based on these era-specific criteria, NIOSH assumes that bioassays would have been obtained.

Mid-DuPont Era (1972-1979)

For the years 1972 through 1974, all job plan files reviewed by the ORAU Team covered work in A Area, Building 773, for which plutonium and fission products were considered to be the primary sources of potential intakes during the period for which bioassay would have been required in work areas. Farrell and Findley [1999], in *Specification of Urine Bioassay Requirements on Radiological Work Permits – (U),* did not specify FPs as a waste concern for the A Area, and specifically, Building 773-A. However, bioassay control procedures in place at the time listed FPs as a requirement for A Area Building 773-A for some workers [DuPont 1971a,b; 1971b, 1976b, 1984, ca. 1977]. This requirement was likely due to handling of waste stream materials from the canyons. For RPRT-0092, all work performed in A Area Building 773-A was assumed to have potential for FP intakes.

For the years 1975 through 1979, the team did not find SWPs or job plans requiring bioassay or respiratory protection for subCTWs.

Late-DuPont Era (1980-1989)

For the years 1980 through 1989, plutonium bioassay requirements for subCTW jobs were determined by considering requirements in the *Bioassay Control* procedures [DuPont ca 1977; 1985a] and job plans [DuPont 1973–1989], supplemented by radionuclide waste stream information in Farrell and Findley [1999].

In RPRT-0092, all 591 subCTWs were required to be sampled for plutonium. The team designated a worker as being monitored for plutonium by the existence of plutonium urinalysis or plutonium analysis by chest counting. Americium bioassay requirements for these subCTW jobs were determined by considering A Area Building 773-A radionuclide waste streams in Farrell and Findley [1999]. While that document reports waste streams with varying percentages of americium in several wings of the building, americium is the primary radionuclide of concern only in the F-Wing waste stream. Therefore, americium was considered as a required bioassay for all job plans identified for the F-Wing.

Farrell and Findley [1999] did not specify FPs as a waste concern for the A Area, and specifically, Building 773-A. However, bioassay control procedures in place at the time listed FPs as a requirement for the building for some workers [DuPont 1976b, ca. 1977, 1985]. This was likely due to handling of waste stream materials from the canyons. For RPRT-0092, all work was assumed to have potential for FP intakes. The subCTWs were not evaluated for uranium or neptunium bioassays during this period because neither radionuclide was identified as a hazard for the location during this time.

FINDING 2

> *"Radionuclides of interest" assumed for sampled permits in RPRT-0092 are of questionable accuracy given cited lack of adequate radiological source term characterization prior to 1990. See section 4.2* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH believes that, prior to 1990, the radiological source terms at SRS were adequately characterized with sufficient accuracy for dose reconstruction purposes.

There is significant evidence that SRS characterized radiation work environments in multiple ways. Isotope production records [NIOSH 2008, PDF p. 41; Reed MB et al. 2002, PDF pp. 453–454] and inventories of transuranic radionuclides and enriched uranium controlled as special nuclear materials confirm that SRS logged quantities and locations and knew where quantities of specific radionuclides would be encountered. Example inventory listings showing quantities and locations are given in [DuPont 1973; DuPont 1983a; DuPont 1984; DuPont 1976–1998].

SRS HP monitored routine and non-routine work during the DuPont era (1972–1989). This resulted in specific characterization of the work and work area. For example, in the May 1972 HP monthly report, air sampling was provided to verify that a Np-237Al tube fabrication in Building 321-M noted a seven-fold decrease in air concentrations following the addition of lathe hoods. The routine air sampling air activity averaged 2.9 x 10^{-11} μCi /cc of uranium in air at three feet from the lathe with the hood, as compared to an average 22.7 x 10^{-11} μCi /cc of uranium in air at three feet without the hood [DuPont 1969–1981, PDF p. 447]. Another example in the April 1983 Works Technical Monthly Report discusses actions taken when construction personnel began installing a new closed-circuit television system for the Hot Canyon crane. Average exposure rates in the hot crane runway were reduced from 50 mR/hr to 15 mR/hr by extensive shielding and decontamination [DuPont 1983b, PDF p. 11].

Detailed information on the production and use of radionuclides are provided in monthly Works Technical Reports generated by SRS from 1953–1989. Example reports are from January 1974 [DuPont 1974], December 1975 [DuPont 1975], July 1977 [DuPont 1977], and June 1979 [DuPont 1979a]. In each report, SRS provided monthly details on the following: isotope production, isotopic separations, and product finishing (including uranium, plutonium, neptunium, and trivalent radionuclides); lists of radionuclide quantities released to the environment; disposal activities; and highlights of HP monitoring. Additional evidence that workplaces where characterized for radiological exposures is provided in monthly reports from the Technical Division of the Savannah River Laboratory. For example, the July 1983 report discusses contamination of a subCTW by Am-241 [DuPont 1983c].

In addition, SRS recorded contamination incidents, verifying the radionuclides involved in the contamination, which further verified the radiological hazard in the areas of contamination. The following are examples:

> *Three persons sustained slight skin and personal clothing contamination (maximum 4000 cpm beta-gamma) while performing tests and repairs on a process heat exchanger in the stack area. A Construction Division employee received nasal contamination to 170 dpm alpha (11% Cm-244, 59% Am-241, and 30% Pu-239) and 180 dpm beta-gamma. A chest count indicated less than MDA and the employee was placed on a follow-up bioassay program* [DuPont 1977, PDF p. 139].
>
> *Construction personnel began renovation of L-171 (772-F). Radiobenches, hoods and glove boxes have been removed, placed in plywood boxes, and stored on the service floor pending determination of plutonium content and transfer to 643-G. Maximum transferable contamination detected was 3 x 10 6 dpm/0.1m2 on an exhaust duct. Maximum air activity was 30 X 10-12 µCi/Pu/cc* [DuPont 1980a, PDF p. 12].

A further demonstration of effective characterization is available through examination of radionuclide bioassay type and frequency determination requirements in the bioassay control procedure DPSOLs, as indicated in the Construction Division Sections. Requirements were specified for operational workers for radionuclides of interest (e.g., plutonium, americium, FPs, and other radionuclides) by specific work areas, as indicated in the Operation Sections [DuPont 1971b, 1976, 1985a, 1989]. Using available inventory data, bioassay control procedures, and ORAUT-OTIB-0081 [ORAUT 2019b, PDF p. 92], NIOSH built a list of radionuclides that were expected by SRS Health Physics. Use of individual radionuclides were restricted to certain areas in each building and not all listed radionuclides were present for the period. For example, Np-237 was processed in the Neptunium Billet line of the PUFF facility, and Am-241 was processed in F Wing at Building 773-A.

FINDING 3

> *The scope of permit sampling for 1972–1990 at SRS is essentially limited to one facility, 773-A, falling short of achieving NIOSH's sampling objective and the representativeness called for in NIOSH's coworker* [co-exposure] *guidelines. See section 4.3* [SC&A 2019, PDF p. 13].

NIOSH Response

NOTE: NIOSH now uses the term "co-exposure" for "coworker" when discussing modeling; "coworker" is employed when referring to actual people in a work area. Verbatim quotes from documents issued by other organizations retain their terminology.

NIOSH believes that subCTWs were adequately monitored in areas outside 773-A between 1972 and 1990. Additional coding efforts support the representativeness called for in the co-exposure implementation guide [NIOSH 2019a, 2020]. CTWs were monitored for radionuclide intakes based on the radionuclides of interest in a similar manner as prime contractor workers. Having located limited numbers of job plans and special work permits, NIOSH reviewed available plutonium logbooks in order to ascertain a more complete picture of subCTW bioassay monitoring. NIOSH recorded the number of subCTWs for whom urinalysis samples were recorded from 1972 through 1990. Table 1 provides the total number of subCTWs sampled for plutonium each year. NIOSH considers these values to be the minimum number of samples reported for subCTWs.

Table 1. SubCTWs sampled for Pu by year.

Year	Total subCTWs
1972	260
1973	198
1974	159
1975	136
1976	129
1977	71
1978	56
1979	217
1980	583
1981	652
1982	637
1983	538
1984	507
1985	517
1986	1042
1987	740
1988	1860
1989	1289
1990	438 (Partial data)

Table 2 shows the distribution of subCTWs sampled for Pu by area using all sample data, not just one sample per worker.

Table 2. SubCTWs sampled for Pu by area.

Area	Total
A	881
D	170
F	2822
G	528
H	1877
M	83
Reactors	2127
S and Z[a]	671
Central Shops	1835

[a] The Defense Waste Processing Center (S Area) and the Saltstone Processing and Vaults Facilities (Z Area) were combined because they were newer waste-handling areas.

In order to assess the degree of FP bioassay, NIOSH tallied counts of a collection of subCTWs used in ORAUT-RPRT-0094 [ORAUT 2019c]. Table 3 shows the number of subCTWs having Pu urinalysis, FP urinalysis, and WBC by year.

Tables 2 and 3 demonstrate that subCTWs were monitored for plutonium either by routine, termination or special bioassay throughout the entire period from 1972 to 1990 and across all areas where plutonium was the major radionuclide of concern. Table 2 is based on data from SRS plutonium logbooks; Table 3 is based on data tabulated from DOE claimant files in NOCTS.

Table 3. Assessment of subCTWs sampled for Pu and FP by year.

Year	Pu	FP	WBC
1972	0	0	no data
1973	1	1	no data
1974	2	2	no data
1975	2	3	no data
1976	3	1	no data
1977	0	0	no data
1978	1	0	1
1979	7	2	2
1980	10	17	no data
1981	19	30	no data
1982	9	22	2

Year	Pu	FP	WBC
1983	16	31	7
1984	14	26	4
1985	20	35	10
1986	31	55	16
1987	17	37	41
1988	28	11	66
1989	17	1	46
1990	29	2	59

FINDING 4

> *SRS incident-based/special bioassays were provided by workers on a more stringent procedural basis and should not be used to supplement the evaluation of permit-related, job-specific bioassays for 1972–1989 as a measure of historic data completeness. See section 4.4* [SC&A 2019].

NIOSH Response

NIOSH contends that incident-based/special bioassay sampling was an integral component of the SRS bioassay program for both prime and subcontractor workers and cannot be disconnected from the routine monitoring program [DuPont 1971a,b; DuPont 1976, PDF p. 273; DuPont ca. 1977]. As such, these data are bounding. Furthermore, the *Criteria for the Evaluation and Use of Coworker Datasets* states:

> *Coworkers are considered to be workers at the same site whose radiation monitoring measurements are considered to be representative or plausibly bounding of those received by one or more workers with no individual monitoring data* [NIOSH 2020, PDF p. 5].

Therefore, to further demonstrate the degree of subCTW bioassay monitoring, NIOSH reviewed available SRS Works Technical reports, Health Physics department reports, and contamination-type incident reports for the period 1972–1990. From those sources, NIOSH further verified that subCTWs were monitored similarly to prime CTWs. As such, HP monitored jobs, monitored workers for contamination and wounds, and also took retrospective special samples when airborne and/or surface contamination were detected.

Summary data for 17 contamination-type incidents involving subCTWs occurring from 1972 through 1980 are listed in Attachment A, Table A-1. This list is comprised of examples only and does not represent all incidents. Although incidents are reported in the cited reports, SRS did not provide the identities of involved workers.

Table A-2 in Attachment A provides examples of 35 from more than 300 subCTWs involved in contamination incidents outside A Area. These examples were obtained from incident logbooks between 1972 and 1989. According to monitoring instructions [DuPont 1969–1986, PDF p. 7] SRS recorded contamination incidents in the same manner for "all nasal and/or skin contamination cases." These data demonstrate that subCTWs were monitored using the same protocols as for all other workers and support the conclusion that dose reconstruction efforts can be done with sufficient accuracy using co-exposure models for all CTWs (e.g., subCTWs and CTWs).

An example of Health Physics actively monitoring subCTW work is shown in Figures A-1 through A-3 regarding a wound contamination event on May 17, 1988. Contamination incidents directly involving subCTWs were identified in 1972–1990.

Routine bioassay was used to verify and validate SRS radiological workplace controls. Special sampling was performed as a direct result of failure of one or more controls, identified by visual observation, HP instrument measurement, or retrospective sampling.

NIOSH previously researched whether there was a problem with incident-based/special bioassays in the F and A Areas which would prove negative for the program if SRS did not have the bioassay results. However, there was a high measure of completeness for the incident-based/special bioassays and for which no systemic program issue was found. This research was not meant to complement completeness of the non-incident-based/non-special bioassay data. This was discussed and agreed upon during the December 6, 2019 ABRWH between NIOSH and SC&A.

The use of incident-based/special bioassay data will likely result in positive results greater than the average routine bioassay result, making the co-exposure model more bounding or claimant favorable. For an incident occurring during the time frame of interest, 1972–1989, the bioassay data from the incident would be relevant to the bioassay dataset. If the routine bioassay data are missing, the co-exposure model would be biased high.

The use of incident-based/special bioassay data is the third basis in the hierarchical order of co-exposure modeling for unmonitored workers. The recently ABRWH-approved procedure, *Criteria for the Evaluation and Use of Coworker Datasets,* states:

> *In general, three types of monitoring programs have been employed at sites covered under EEOICPA. These programs, listed in hierarchical order of preference for use in coworker modeling are: 1) routine, representative sampling of the workers; 2) routine measurement of workers with the highest exposure potential; and 3) the collection of samples after the identification of an incident. Because they are not representative of the overall distribution of exposures, programs that rely on measurement of the highest exposed workers or are incident-based require more careful consideration* [NIOSH 2020, PDF p. 10].

NIOSH has demonstrated that incident-based/special bioassay data should be used to demonstrate data completeness. This is because incident-based/special bioassay data will be bounding. Should routine-based bioassay data be missing, the inclusion of incident-based/special bioassay data would bias the co-exposure modeling high and be claimant favorable.

FINDING 5

> *The incompleteness of SRS dose records for 1972–1990 is substantiated by the acknowledged destruction of subcontractor records and first hand worker accounts, coupled with DOE findings of missing occupational radiation dose data from many SRS personnel files, as well as systemic bioassay delinquencies, and wide gaps in NIOSH's capture of permit documentation. See section 4.5* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH does not agree that dosimetry records for workers were destroyed or lost, but rather, were stored offsite in approved permanent storage facilities [DOE 1990a, PDF p. 439].

The first part of Finding 5, "The incompleteness of SRS dose records for 1972–1990 is substantiated by the acknowledged destruction of subcontractor records and firsthand worker accounts…" is a misleading statement. It implies that subcontractor records, including dosimetry records, were destroyed. The DOE Tiger Team's 1990 assessment of the SRS radiological safety program does not mention destruction of dosimetry records. The report indicated that there was an issue with the availability of dosimetry records, not that they were destroyed. NIOSH does acknowledge in ORAUT-RPRT-0092 that: "…current and former employee interviews indicated that some records were destroyed in the late 1980s or early 1990s,…" and "…the SWPs or job plans for areas might have been destroyed as part of that effort." [ORAUT 2019a, PDF p. 15]. This acknowledgement applies only to SWPs and job plans during that time frame and not to dosimetry records specifically.

The second part of Finding 5, "…DOE findings of missing occupational radiation dose data from many SRS personnel files…" is misleading. As indicated the SC&A review of ORAUT-RPRT-0092:

> *In about the same timeframe (early 1990), DOE headquarters conducted a Tiger Team assessment of SRS and made the following finding. Comprehensive records related to occupational radiation exposure are not retained consistent with ANSI N13.6. There are many personnel files where radiation dose data are missing for many years* [DOE 1990b, PDF p. 530; SC&A 2019, PDF p. 36].

However, the statement above is contradicted in the SC&A review of ORAUT-RPRT-0092 by the following two statements:

> *Radiation exposure history records are maintained in the dosimetry files in Bldg. 735A. All other records are boxed, inventoried, and sent to the Federal Repository in Atlanta, after an interim storage period of up to 2 years onsite…* [SC&A 2019, PDF p. 36].
>
> And:
>
> *While the routine internal and external dosimetry program maintained relatively complete and accessible dose data, the nonroutine job-specific dosimetry data were not being consistently obtained from workers and retained in retrievable form* [SC&A 2019, PDF p. 36].

The statements above clearly indicate that the dosimetry was not retrievable at the time; it does not mean that they were nonexistent or unattainable. This point is emphasized in the SC&A review of ORAUT-RPRT-0092 in the following statement:

> *The cited inability to readily compile radiation exposure data obtained prior to 1990, as well as key radiation control records (e.g., SWPs and job plans), is traceable to a longstanding SRS policy in the DuPont era that limited onsite retention of all but exposure histories. Records were only retained for up to 2 years and then shipped to the Federal Repository, for which retrieval of complete records can be difficult, as noted by the DOE assessment team and illustrated by NIOSH's survey results for the 852 boxes retrieved* [SC&A 2019, PDF p. 37].

Again, the statement above indicates that the dosimetry was not retrievable at the time. It does not mean that they were nonexistent or unattainable. All the dosimetry data was retrieved by SRS in 2001 in order to prepare and respond to EEOIPCA. This resulted in lengthy delays in starting dose reconstruction for SRS as they pulled back their records and indexed them. The end result was the best response to facilitate dose reconstruction, and which subsequently led to completion of the first technical basis document.

Part of Finding 5 indicates that there were "…systemic bioassay delinquencies…" NIOSH does agree that there were some delinquencies; however, this did not impede NIOSH's ability to demonstrate completeness for most of the radionuclides of interest during the DuPont era (1972–1989), and therefore, is not a significant issue. This is illustrated by the completeness demonstrated in the late DuPont era (1980-1989) when, on average, 80% of subCTWs were directly monitored by plutonium bioassay and for whom records were available for analysis for ORAUT-RPRT-0092. See Table 10, "SubCTW plutonium bioassay by year 1980 to 1988" [ORAUT 2019a, PDF p. 51], and Table 5-10, "SubCTW strontium/FP bioassay, 1980 to 1988" [ORAUT 2019a, PDF p. 53].

The "wide gaps in NIOSH's capture of permit documentation" mentioned in part of Finding 5 exists because of some of the issues discussed in the first parts of Finding 5. NIOSH believes that while some permit documentation is unavailable for capture at this time, doses can be reconstructed with sufficient accuracy using the existing data on hand.

FINDING 6

> *For the period 1980–1989, only 20 percent of the identified subcontractor-job plan combinations identified by NIOSH as requiring americium sampling had internal monitoring performed within an acceptable timeframe (i.e., within 2 years for chest counting). See section 5.2.1* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH determined that most SRS workers were unlikely to be exposed to separated americium-241 (Am-241). In the canyons and reactor areas, Am-241 intakes were accompanied by Pu-239 intakes. Intakes of Am-241-only (systemic americium) were only plausible in F-Wing of 773-A and in the MPPF in F Area. Bioassay logbooks indicate that about 70% of americium bioassay samples for the period 1972–1989 were for americium in a plutonium mixture. These records also demonstrate that, in addition to some subCTWs being routinely monitored for americium, other subCTWs were monitored for americium intakes when air monitoring indicated a potential release, or after the observation of a contamination event with the presence of americium. This is a purpose of the routine urinalysis program, although some subCTWs were monitored for americium intakes by chest-counting (MDA: 0.1 nCi) [ORAUT 2005, PDF p. 75]. Americium urinalysis results are representative for bounding intakes because these results represent both incident and routine operations where subCTWs worked.

Americium urine bioassays and chest-counts were evaluated as acceptable sampling for Am-241 intakes. Americium urinary excretion curves show that an Am-241 intake can be detected after several years; however, urine bioassay was capped at 10 years from the date of the job plan. Most of an americium intake clears the lungs in a few months, but 0.4% of the intake remains. At 2 years it is down another order of magnitude. Given the retention values, chest-count results were used up to two years from the date of the job plan, although chest-counting could be valid for longer durations for measuring intakes of americium in mixture with plutonium (with the MDA of the detector being one of the limiting factors) [ORAUT 2019a, PDF p 44; WSRC 1993a; LaBone 1991]. SRS used chest-counting through at least 1992 to track known americium intakes over a period of years [WSRC 1993b, PDF p 9].

ORAUT-OTIB-0060, *Internal Dose Reconstruction* [ORAUT 2018], indicates that for types F and M radionuclides, when there are gaps greater than two years between two consecutive bioassay results, unmonitored dose must be assigned until one year before the second result. Unmonitored dose is assigned using co-exposure data or, if there was no potential for intakes, environmental dose. It does allow you to extend a bioassay result back one year from the second result, but there is still an unmonitored gap that requires an alternate method for assigning intake [ORAUT 2018, PDF pp. 28-29].

NIOSH reviewed the SRS intake database for the period 1972–1989. NIOSH found there were only 15 intakes of separated Am-241 (Am-241 not in a mixture of plutonium).

NIOSH found that 81 subCTWs were monitored for americium intakes by urinalysis for the period 1972–1989; Table 4 provides the list. The types of urinalyses were routine, special, follow-up, and termination.

Table 4. SubCTW Americium urinalysis, 1972–1989.

Area	Bottle Date	Type Intake	SRDB Ref ID	PDF page	PRID
F	1/31/1972	PuAm mixture	53271	243-244	redacted
F	9/5/1972	PuAm mixture	53271	203-204	redacted
F	9/5/1972	PuAm mixture	53271	203-204	redacted
773	10/27/1972	PuAm mixture	53271	223-224	redacted
773	10/27/1972	PuAm mixture	53271	223-224	redacted
773	10/27/1972	PuAm mixture	53271	223-224	redacted
773	10/27/1972	PuAm mixture	53271	223-224	redacted
F	1/19/1973	PuAm mixture	53271	233-234	redacted
F	1/19/1973	PuAm mixture	53271	233-234	redacted
F	1/22/1973	PuAm mixture	53271	233-234	redacted
F	1/22/1973	PuAm mixture	53271	235-236	redacted
F	1/22/1973	PuAm mixture	53271	233-234	redacted
F	1/22/1973	PuAm mixture	53271	233-234	redacted
F	11/15/1973	PuAm mixture	51970	6-7	redacted
F	7/25/1975	PuAm mixture	51970	136-137	redacted
F	7/28/1975	PuAm mixture	51970	136-137	redacted
C	7/22/1977	PuAm mixture	51970	216-217	redacted
C	8/17/1977	PuAm mixture	51970	232-233	redacted
C	8/18/1977	PuAm mixture	51970	232-233	redacted
C	8/25/1977	PuAm mixture	51970	232-233	redacted
G	10/1/1979	Am only	52019	30-31	redacted
G	10/1/1979	Am only	52019	34-35	redacted
G	10/1/1979	Am only	52019	28-29	redacted
G	10/1/1979	Am only	52019	28-29	redacted
G	10/1/1979	Am only	52019	28-29	redacted
G	10/1/1979	Am only	52019	28-29	redacted
G	10/2/1979	Am only	52019	30-31	redacted
G	10/3/1979	Am only	52019	28-29	redacted
G	10/3/1979	Am only	52019	28-29	redacted
G	10/3/1979	Am only	52019	28-29	redacted
G	10/4/1979	Am only	52019	28-29	redacted
G	10/21/1979	Am only	52019	28-29	redacted
G	10/22/1979	Am only	52019	28-29	redacted
G	10/25/1979	Am only	52019	28-29	redacted
C	11/6/1979	PuAm mixture	52018	38-39	redacted
C	11/6/1979	PuAm mixture	52018	40-41	redacted
unknown	11/9/1979	Am only	52019	30-31	redacted
A	2/11/1980	PuAm mixture	52018	48-49	redacted
773	6/1/1983	PuAm mixture	53283	72-73	redacted

Area	Bottle Date	Type Intake	SRDB Ref ID	PDF page	PRID
773	6/1/1983	PuAm mixture	53283	72-73	redacted
773	7/13/1983	PuAm mixture	53283	84-85	redacted
773	7/13/1983	PuAm mixture	53283	84-85	redacted
773	7/13/1983	PuAm mixture	53283	88-89	redacted
773	7/13/1983	PuAm mixture	53283	88-89	redacted
773	7/13/1983	PuAm mixture	53283	88-89	redacted
773	7/13/1983	PuAm mixture	53283	88-89	redacted
773	7/13/1983	PuAm mixture	53283	84-85	redacted
773	7/13/1983	PuAm mixture	53283	84-85	redacted
773	7/13/1983	PuAm mixture	53283	84-85	redacted
773	7/13/1983	PuAm mixture	53283	88-89	redacted
773	7/13/1983	PuAm mixture	53283	90-91	redacted
773	7/20/1983	PuAm mixture	53283	84-85	redacted
773	7/22/1983	PuAm mixture	53283	88-89	redacted
773	8/16/1983	PuAm mixture	52019	52-53	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/12/1983	PuAm mixture	53283	106-107	redacted
773	11/14/1983	PuAm mixture	53283	106-107	redacted
773	11/14/1983	PuAm mixture	53283	106-107	redacted
773	11/15/1983	PuAm mixture	53283	106-107	redacted
773	11/15/1983	PuAm mixture	53283	106-107	redacted
773	11/15/1983	PuAm mixture	53283	106-107	redacted
M	1/15/1984	PuAm mixture	53283	184-185	redacted
unknown	2/28/1984	no result reported	53283	188-189	redacted
F	9/4/1984	PuAm mixture	53283	156-157	redacted
F	9/5/1984	PuAm mixture	53283	156-157	redacted
F	5/1/1985	PuAm mixture	53283	198-199	redacted
F	10/4/1985	PuAm mixture	53283	218-219	redacted
F	5/27/1986	PuAm mixture	52022	4-5	redacted
773	7/29/1986	PuAm mixture	52022	14-15	redacted
F	7/30/1986	PuAm mixture	52022	18-19	redacted
773	11/5/1986	PuAm mixture	52022	46-47	redacted
F	3/13/1987	PuAm mixture	52022	70-71	redacted
S	6/18/1987	PuAm mixture	52022	82-83	redacted
F	10/21/1987	PuAm mixture	52022	96-97	redacted

The high number of americium urinalysis samples recorded for October 1979 were collected to assess potential intakes of americium and curium after air monitoring indicated alpha-contaminated water was being released from Well 42, although the activity was at a low level [DuPont 1979b, PDF p. 18].

Fourteen subCTWs were potentially contaminated after being exposed to an airborne mixture of plutonium and americium when replacing motor-control centers in 773-A in November 1983. Nasal smears and special urinalysis were negative for all 14 workers [DuPont 1983d]. Figure B-3 provides the incident description and result.

NIOSH found additional incident records associated with some of the measurements presented in Table 4 above; these records are provided in Attachment B, Figures B-1 through B-15

Summary

NIOSH has shown that subCTWs had limited exposure to americium contamination and, when they were contaminated, Health Physics provided follow-up monitoring. A majority of americium incidents and intakes, including those involving subCTWs, occurred in areas where Am-241 was present in a mixture with plutonium radionuclides. Because workers with known intakes are included in the co-exposure americium models, NIOSH can bound doses for all workers, including subCTWs.

FINDING 7

> *The total "effectively monitored" population for americium (those monitored directly or have a coworker on the same job plan with a urinalysis result) during the 1980–1989 period is approximately 33 percent. If a urinalysis sample taken during 1991 as a result of an incident in a different SRS location (and is not currently used in the SRS coworker model) is removed, the effective monitored population drops to 26.5 percent. See section 5.2.1* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH disagrees with SC&A's conclusion about the total number of effectively-monitored workers. The total number of effectively-monitored workers is not 33%. It is the total of those directly monitored with urinalysis bioassays or chest count (20%) plus those coworkers indirectly monitored (36%) which leads to an effectively-monitored total of 56%.

The 56% value for effectively-monitored workers employs SC&A's calculations in Table 4 from SC&A's review of ORAUT-RPRT-0092 [SC&A 2019].

> Total subCTWs monitored = 17 (urinalysis) + 13 (chest counts within two years of the date of the job plan) = 30
>
> Effectively monitored = 30 (total subCTWs monitored) + 55 (total coworker matches) = 85
>
> Effectively monitored % = 85 (effectively monitored subCTWs) / 151 (total subCTWs) = 56%.
>
> Note: The 13 coworker chest counts are within the two-year limit; 23 coworker chest counts are outside of the two-year limit.

As indicated in the Finding 6 response, subCTWs were monitored for incidents, including americium or alpha contamination events. As seen previously in Table 4, 15 occurrences of separated americium occurrences are listed. About 30% of incidents in the 1980s involved separated Am, with 14 of the 15 confirmed cases primarily limited to technical and production workers in the A Area, F-wing. During this time period, there was only one confirmed subCTW – one painter of a group of 12 painters – who was exposed to Pu-239 and Am-241 on July 13, 1983 when ventilation ductwork failed.

Further evidence that subCTWs were monitored for Am-241 is documented by HP bioassays on workers following incidents or when Am-241 contamination was suspected. This is illustrated in Table 4 above. Of the 44 subCTWs sampled during the 1980s, there are three subCTWs with potential americium exposures, with one of them confirmed to have received follow-up bioassays. Attachment B provides incident-related documentation for May 1, 1985 (Figures B-7 and B-8) and October 21, 1987 (Figure B-15).

The stipulation that incident-based/special in-vitro and in-vivo data are not to be used in co-exposure models is inaccurate. As indicated in the NIOSH response to Finding 4, it is permissible to use incident monitoring to establish a co-exposure model for unmonitored workers. It is the third basis in the hierarchical order of co-exposure modeling for unmonitored workers. The recently ABRWH-approved procedure, *Criteria for the Evaluation and Use of Coworker Datasets*, states:

> *In general, three types of monitoring programs have been employed at sites covered under EEOICPA. These programs, listed in hierarchical order of preference for use in coworker modeling are: 1) routine, representative sampling of the workers; 2) routine measurement of workers with the highest exposure potential; and 3) the collection of samples after the identification of an incident. Because they are not representative of the overall distribution of exposures, programs that rely on measurement of the highest exposed workers or are incident-based require more careful consideration.* [NIOSH 2020, PDF p. 9]

The use of incident-based/special bioassay data will likely result in positive results greater than the average routine bioassay result, making the co-exposure model more bounding or claimant favorable. For an incident occurring during the time frame of interest, 1980–1989, the bioassay data from the incident would be relevant to the bioassay dataset.

There is no reason why bioassay results from 1991 cannot be used. These results consist of 11 bioassay data points from one individual who experienced an americium exposure during an earlier incident. These data points can be useful.

Dose reconstruction uses all bioassay data for a worker, including WBCs, chest counts, and bioassay results. For SRS, special bioassay samples were collected for workers suspected of having an intake due to elevated air sample results, skin contamination, wounds, or failures in protective equipment.

Sufficient accuracy is achieved in dose reconstructions when the available information allows a bounding estimate of worker exposure, or if possible, a best estimate. Worker exposure records from SRS, including routine bioassay sample, special bioassay sample, chest count, and WBC results, provide that information, regardless of location or craft of the worker [ORAUT 2019d, PDF p 38].

FINDING 8

> *Many of the workers (around 70–73 percent) who should have been monitored for fission products underwent appropriate internal sampling during the two periods evaluated prior to 1990 (1972–1974 and 1980–1989). However, very few of these monitored workers underwent in vivo counting for fission products. Thus, they are not included in the coworker model developed for SRS and are not considered representative of the unmonitored worker. See section 5.3* [SC&A 2019, PDF p. 13].

NIOSH Response

Co-exposure models are stratified to CTW (prime plus subcontractor). Therefore, NIOSH believes there are sufficient data to reconstruct FP doses for unmonitored subCTWs. Table 5 below shows the number of subCTWs used in the SRS fission product co-exposure model by year.

Table 5. SRS fission product co-exposure model SubCTW versus CTW by year

Period	SubCTW	Prime CTW	Total
1972-73	4	50	54
1974	0	70	70
1975	0	88	88
1976	2	60	62
1977	3	92	95
1978	3	88	91
1979	6	60	66
1980	3	78	81
1981	1	90	91
1982	8	77	85
1983	23	69	92
1984	17	52	69
1985	18	37	55
1986	20	42	62
1987	127	53	180
1988	194	46	240
1989	162	78	240
1990	302	86	388

It appears that prime CTWs were routinely monitored during the entire period while subCTWs were monitored by special urinalysis up to 1982. Most of the subCTWs (around 70–73 percent) who should have been monitored for fission products underwent appropriate intake monitoring during the two periods evaluated prior to 1990, (1972–1974 and 1980–1989). This is indicated by applying all directly-monitored WBC results to determining completeness of bioassays, as analyzed for in RPRT-0092 [ORAUT 2019a]. Actual fission product urinalysis results reported for individual subCTWs will be used to reconstruct fission product doses.

For the fission products Cs-37, Ce-144, Ru-106, and Ba-140/La-140, the number of WBCs increased beginning in 1971 and steadily became more common thereafter. By 1976, WBCs had effectively replaced FP urinalysis as the primary means of detecting FP intakes [DuPont 1976]. Fission products such as Cs-137 are retained in the body for periods exceeding three years. Therefore, WBC results were also used up to three years from the date of the job, although WBCs would be valid for longer (with the MDA of the detector being one of the limiting factors).

Although subCTWs are underrepresented in the fission product co-exposure model until 1983, the stratified model is valid for subCTWs because the data included for prime CTWs who performed similar work are sufficient. The co-exposure model can be used to estimate unmonitored subCTW radiation dose. The box-and-whisker plot in Figure 1 below (Figure 4-28 from ORAUT 2019b) shows that there is no discontinuity in the combined CTW data for the period 1972 through 1990 that points to a difference between FP bioassay data available for prime CTWs and sub CTWs.

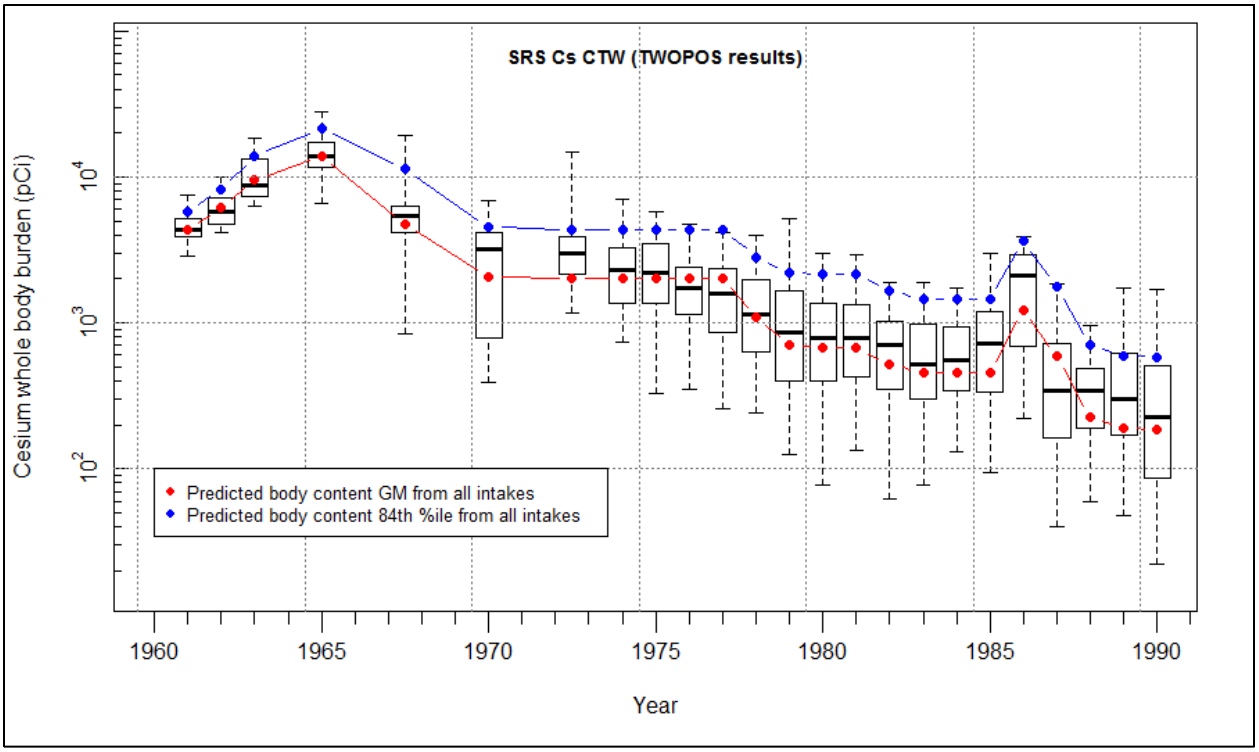


Figure 1. Cesium-137 body burden CTW TWOPOS data box-and-whisker plot.

FINDING 9

> *SC&A does not find that the data collected as part of the RPRT-0092 review support the premise that subcontractors on job plans that should have required internal monitoring for americium were either directly monitored (around 20 percent) or, alternately, appropriately represented in the derived coworker models for SRS (around 13 percent). See section 5.3* [SC&A 2019, PDF p. 13].

NIOSH Response

NIOSH agrees that only around 20 percent of subCTWs were directly monitored for americium in the years 1980-1989 after in-vivo counts done two years beyond potential exposure are removed. The percentage of effectively-monitored subCTWs represents the total of the directly-monitored and indirectly-monitored (i.e., subCTW coworkers), which results in an effectively-monitored subCTW population of 56%. Please refer to the NIOSH response to SC&A Finding 7 for more details. As NIOSH has discussed in this response paper, most SRS work involving americium was with isotopic mixtures of plutonium and americium. Eighty percent of subCTWs evaluated for ORAUT-RPRT-0092 were sampled for plutonium during the same period. Nonetheless, some subCTWs likely performed work in areas such as the MPPF where exposures to separated Am-241 were possible. NIOSH has shown in Table 4 that subCTWs were monitored for Am-241 intakes of both separated americium and americium in a plutonium mixture. Furthermore, examples of incident records provided in Attachment B demonstrate that SRS monitored subCTW work similarly to other construction trade workers.

Regarding the americium CTW co-exposure model, the stratified model is valid because there are sufficient data to reconstruct doses for all CTWs. NIOSH reaffirms its position that subCTWs performed work and were monitored similarly to prime CTWs. Therefore, the developed co-exposure model can be used to estimate unmonitored subCTWs radiation doses.

FINDING 10

> *Data for 1990 are lacking. Therefore, 1990 should be included with the period of limited data, 1972–1989, and not bundled in with the year 1991. See Section 6.1* [SC&A 2019, PDF p. 14].

NIOSH Response

NIOSH believes that 88% direct monitoring for subcontractors is not demonstrably incomplete [ORAUT 2019a, PDF p. 38]. This satisfies criteria set forth in the *Criteria for the Evaluation and Use of Coworker Datasets*, the implementation guide for co-exposure models [NIOSH 2020]. NOCTS data indicate that subcontractors were monitored. Table 6 below (in ORAUT-RPRT-0094 as Table 5-2) presents the results of an evaluation of NOCTS data that indicates that 89% of the subcontractors who are claimants working in 1990 have some form of internal monitoring data (in vitro and/or in vivo) [ORAUT 2019c, PDF p. 18]. This compares favorably with subcontractors who are claimants working in 1991–1997, 71% to 94% of whom have some form of internal monitoring data.

Table 6. Fractions of all SRS workers with claims who are subCTWs and fractions of subCTWs with monitoring records.

Year	subCTW Fraction of All Claims	Fraction of subCTWs with External Records	Fraction of subCTWs with Internal Records	Fraction of subCTWs with Both
1972	4%	82%	66%	59%
1973	4%	81%	77%	67%
1974	5%	76%	42%	36%
1975	7%	73%	45%	42%
1976	6%	79%	44%	40%
1977	8%	64%	25%	24%
1978	11%	65%	20%	19%
1979	11%	68%	26%	23%
1980	11%	75%	61%	54%
1981	12%	82%	67%	59%
1982	12%	69%	66%	53%
1983	13%	71%	61%	54%
1984	15%	62%	49%	42%
1985	17%	63%	49%	40%
1986	18%	73%	54%	47%
1987	17%	73%	68%	57%
1988	17%	75%	77%	59%
1989	16%	85%	73%	63%
1990	17%	94%	89%	85%
1991	15%	96%	91%	89%
1992	13%	94%	94%	90%
1993	12%	83%	93%	81%
1994	12%	67%	83%	63%
1995	12%	64%	82%	59%
1996	11%	73%	79%	65%
1997	9%	78%	71%	64%

SRS continued monitoring all site workers during the change in prime contractors. SRS started the implementation of RWPs in 1989 in reactor areas, but not site-wide until 1991. Nonetheless, SRS continued to sample subCTWs in 1990. SRS issued their first internal dosimetry basis manual in 1990, which documented the foundation and requirements for worker bioassay [WSRC 1990].

FINDING 11

> *For both the 1972–1989 and the 1990–1998 periods, when considering all radionuclides requiring internal monitoring per work permit, as opposed to "at least one radionuclide" requiring monitoring, the percentage of monitored workers drops significantly (particularly in the earlier periods). Directly monitored workers ranged from 47 percent to 77 percent (in comparison to 76–96 percent in RPRT-0092), and effectively monitored workers ranged from 55 percent to 89 percent (in comparison to 85–99 percent in RPRT-0092). See section 7.2* [SC&A 2019, PDF p. 14].

NIOSH Response

The original intent of this work was to determine if subCTWs were monitored working in the same environments as other workers. NIOSH proposed to randomly select radiation work permits to demonstrate this by identifying all subCTWs on an RWP, retrieving all their bioassay results, and matching these required bioassays to bioassays actually performed. The sampling plan, which was used only for the 1990-1998 data, called for calculating a point estimate and a 95% confidence interval for the percentage of subCTWs that had all required bioassay. However, in RPRT-0092, a worker was considered monitored if they had at least one bioassay. NIOSH did evaluate percentages of subCTWs monitored for individual radionuclides but did not provide a point estimate for the sum of all bioassays required per the RWP or Job Plans for the subCTWs. NIOSH believes the data given in the report shows that subCTWs were monitored similarly to other workers and that unmonitored subCTWs worked in the same environments as the monitored workers. Summary statistics provided for individual radionuclides support that conclusion.

NIOSH stands by the results given for effectively monitored workers. Even without consideration of effective monitoring, sufficient numbers of subcontractor trade workers were monitored in the years 1972 through 1998 time frame coupled with internal monitoring data for prime CTWs to develop a co-exposure model for use in reconstructing unmonitored doses. Additional rationale is provided in the NIOSH response to Finding 3.

OBSERVATION 1

> *The back application of assumptions regarding work permits, job-specific bioassays, and target radionuclides to conduct a completeness review for 1972–1998 is not plausible given the significant changes in radiological policies, procedures, and practices that occurred in the early 1990s. See section 4.6* [SC&A 2019, PDF p. 14].

NIOSH Response

NIOSH does not agree with the premise that significant changes in radiological policies, procedures, and practices that occurred in the early 1990s preclude the ability to conduct a completeness analysis during the 1972–1998 evaluation period. Radiological practices were amended based on regulatory changes in DOE orders, which affected work control requirements, such as routine bioassay, special bioassay frequency, radiation analysis, and radionuclide-of-interest location characterization assessments. Despite these changes, routine bioassay requirements remained similar from 1972 through 1998. Special bioassay requirements did not change.

More specifically, despite the changes made from DOE Order 5480.1, Chapter XI (issued 5/5/80, effective as 5480.1A 8/13/1981) to DOE Order 5480.11 (issued Dec. 1988, effective Dec. 1989), SRS policies, procedures, practices, and the required types and locations for routine bioassay analyses remained largely constant between 1972 and 1998. A few areas added and/or dropped radionuclides of interest in procedure revisions. The definitions of workers to be routinely sampled varied in almost each procedure revision; nevertheless, these revisions focused on workers most likely to be in contact with radioactive materials [ORAUT 2019d, PDF p. 32].

Routine bioassays were used at SRS, in part, to monitor other work controls; they were not intended for a comprehensive dose assessment. The routine program, along with routine urine and fecal bioassays, chest counts, routine whole-body counts, workplace air sampling, radiological surveys, and personal worker monitoring were used to evaluate the effectiveness of worker conditions and protections. Even though this monitoring was not meant to perform radiation dose calculations, any indication of internal exposures from this monitoring, or from any positive results obtained in the Routine Bioassay Program, or any elevated air, radiological or contamination levels, or failures in engineering controls led to further sampling under the Special Bioassay Program, which was used to assign dose [ORAUT 2019d, PDF p. 32].

Routine bioassay procedures between 1971 and 1998 listed the requirements for the Routine Bioassay Program. Between 1971 and 1990, CTWs/subCTWs were placed on a minimum routine bioassay for radionuclides of interest with frequencies based on procedures, as previously summarized in Tables 1 and 2. At that time, routine sampling was applied based on work category and location. In the early 1990s, the operational schedule for routine bioassays was applied to job-specific RWPs [ORAUT 2019d, PDF p. 65]. At that time, routine sampling was applied broadly to workers who were expected to have a potential for intakes exceeding 100 mrem.

Routine bioassay requirements remained similar from 1972 through 1998. Despite changes made over time, most radionuclide-of-interest designations and bioassay frequencies did not appreciably change. In 1972, for example, the frequency for a plutonium urine bioassay varied between once every three years (for “minimum potential” personnel assigned to non-process sections and patrolmen) to twice-a-year (for laboratory personnel and personnel in process sections of selected buildings). In 1992, with the introduction of the 5Q1.1 procedures, all personnel were separated into three categories of potential risk. Category I personnel were to provide plutonium urine bioassay samples twice yearly for Building 773-A; Category II personnel were to provide plutonium urine bioassay samples once a year; and Category III personnel were not required to provide in-vitro samples but one annual in-vivo count [ORAUT 2019d, PDF p. 19]. With the March 1999 revisions, routine bioassay samples were required annually for all workers who worked in radiologically-controlled areas (RCAs) [ORAUT 2019d, PDF p. 21].

Special bioassay occurred if there was any indication of an internal exposure. The Special Bioassay Program had additional analytical requirements, including isotopic analysis of the source term for that potential exposure. The Special Bioassay Program was not limited to the radionuclides of interest required by the Routine Bioassay Program, nor did it rely on results from that program [ORAUT 2019d, PDF p. 37]. The vast majority of monitored personnel did not exceed 100 mrem annual internal dose. The Special Bioassay Program requirements did not change appreciably over time [ORAUT 2019d, PDF p. 31].

Due to the regulatory change in 1992 – with new limits based on lifetime committed dose instead of annual dose – the Routine and Special Bioassay Programs had to change. For example, under the new standard, a significantly smaller amount of plutonium had to be measured in a worker, rendering plutonium chest-counts useless for determining compliance. This led to a return to urinalysis (now with alpha spectroscopy). Although chest-counting was no longer feasible for meeting plutonium requirements, it was still used for non-systemic Am-241. The overall result was a reduced number of annual chest counts. However, overall plutonium monitoring frequency requirements were not changed [Taylor et al. 1995, PDF p. 69; ORAUT 2019d, PDF p. 11].

For some potentially missed radionuclides of interest, another analysis can be performed to account for the missing nuclide. For example, if the Am-241 is part of a plutonium mixture, the Pu-239 result can be used in concert with knowledge of the Pu-241 starting content and age of material to determine the Am-241 intake or use an Am-241 chest count to determine the Pu contribution. This has been calculated at other sites. In addition, in areas where americium was present *without* plutonium, such as at the MPPF, routine bioassays were required on RWPs and then collected and analyzed [ORAUT 2019d, PDF pp. 36–37].

In the 1990s, radiological source terms for specific areas, wings, facilities, and rooms were initially identified by reviewing existing waste certification or process stream analysis data. For areas such as 773-A, HEPAs, pre-filters, and job-control waste was analyzed [Farrell and Findley 1999, PDF p. 13]. In 1999, the site-wide characterization effort identified all radioisotopes that contributed 10% or greater to internal exposure for each location or waste stream. Analyses for these radioisotopes were to be included on RWPs. These radioisotopes were also required radionuclides of interest for routine bioassays for those working under RWPs involving actinides and specifying respiratory protection [Farrell and Findley 1999, PDF pp. 9-10].

Dose reconstructors review all bioassay data for a worker, including WBCs, chest counts, and urine or fecal results. For SRS, routine bioassays are conducted for workers not known to have received an intake of radioactive material; special bioassays are conducted for workers suspected of having an intake due to elevated air sample results, skin contamination, wounds, and/or failures in protective equipment. The co-exposure model uses all applicable bioassay data, including results from special and routine bioassay samples.

NIOSH has demonstrated that unmonitored workers worked alongside monitored workers in the same radiological environment (especially during the 1980–1998 time period):

- The bioassay data are present in individual monitoring records and can be used for dose reconstruction.

- These internal monitoring records can also be used to develop valid co-exposure models, and subsequently, during dose reconstruction to supplement gaps in individual monitoring data.

NIOSH does not agree with the premise that significant changes in radiological policies, procedures, and practices that occurred in the early 1990s preclude the ability to conduct a completeness analysis during the 1972–1998 period under evaluation. Despite changes over time due to regulatory, technical, and operational requirements, the requirements for routine and special bioassay remained significantly the same from 1972 through 1998.

OBSERVATION 2

> *During the 1972–1974 period, RPRT-0092 only evaluates one job plan/worker combination (Job Plan 46) for potential americium exposure. However, attachment D, table D-1 indicates at least one other job plan (Job Plan 47) requiring americium monitoring during this period. Neither of the workers were directly monitored nor had an appropriate coworker monitored for americium. See section 5.1.1* [SC&A 2019, PDF p. 14].

NIOSH Response

In ORAUT-RPRT-0092, Table D-1 (partially reproduced in Table 7 below), Job Plan No. 47 indicates "A" or assumed for Am, but should have been marked "No" because the work was performed in the high-level cave [ORAUT 2019a, PDF p. 148]. Job Plan No. 46 indicates "A," which is correct because the work was performed in the F Wing. This will be corrected in the next revision of RPRT-0092.

Table 7. Job plan bioassay requirements, 1972 to 1989.

Job Plan No.	Job Date	Wing/Room	Pu	Am/Cm	SRDB Ref ID	PDF Page
36	4/17/1973–4/18/1973	HLC high bay	A*	No	173830	55
37	4/24/1973	HLC pipe	A	No	173830	58
38	4/24/1973	HLC	A	No	173830	58
39	reserved	N/A	N/A	N/A	N/A	N/A
40	5/8/1973	HLC	A	No	173830	63
41	5/23/1973	HLC	A	No	173830	65
42	5/24/1973 – 5/25/1973	HLC	A	No	173830	66
43	5/29/1973	HLC	A	No	173830	82
44	5/31/1973 – 6/1/1973	HLC	A	No	173830	83
45	6/12/1973 – 6/13/1973	HLC	A	No	173830	95
46	7/10/1973	F wing	A	A	173830	106
47	8/10/1973	HLC	A	A	173830	107

* A = Assumed americium
Source: [ORAUT 2019a, PDF p. 148] (Table D-1, partially reproduced above)

OBSERVATION 3

> *Only 13 percent of the subcontractor-job plan combinations (17 total) had americium urinalysis performed that could be considered relevant to coworker modeling. Eleven of the 17 urinalysis data points represented a single worker who had a single sample taken in 1991 as a result of an incident that occurred in a different area (M Area) during that year (i.e., representative of a different area and different period). See section 5.2.1.* [SC&A 2019, PDF p. 14]

NIOSH Response

NIOSH acknowledges SC&A observation that 11 of the 17 urinalysis data points represent a single worker who had a single sample taken in 1991. It is possible, if not likely, that a worker would work on more than one job plan and have only one bioassay sample at the end of all the job plans. It is also possible for one worker to have multiple samples taken for one job plan. The bioassay samples and the frequency of their analysis serve as the basis for the completeness determination, not the number of bioassay data points per worker. As long as the bioassay sample is taken for similar work and similar work environment in a similar time frame, these are appropriate criteria to apply for determining completeness.

There are three issues associated with this observation that warrant discussion. The first is the original intent of this report, the second is the application of this result for individual dose reconstruction purposes, and the third is the application of this result for co-exposure modelling purposes. The original intent of this report was to assess if unmonitored workers worked in the same environments as monitored workers. If true, then NIOSH can apply co-exposure models. In this example, it has been shown that an unmonitored subCTW worked in the same environment as a monitored subCTW in the 1980-1989 time period because a bioassay sample for americium analysis was collected within the acceptable window from the job plan. Hence a bioassay sample collected in 1991 is a valid sample to conduct an individual dose reconstruction from a potential intake that may have occurred earlier. Regarding co-exposure models, the application of the bioassay result reported in 1991 would generally be applied to the year in which it was collected (assuming there were sufficient data for statistical purposes). In this case, the bioassay result was a 24-hour sample implying that the purpose for the sample was a special bioassay (e.g., associated with a potential exposure). This datum would be incorporated into a co-exposure model to help bound the dose estimates.

OBSERVATION 4

> *SC&A's analysis indicates that identified coworker matches may not be sufficiently representative of the subCTW intakes in all cases unless strict criteria are applied, such as the same craft designation as well as the same date and time of the work performed. See section 6.3* [SC&A 2019, PDF p. 14].

NIOSH Response

Table 8 presents a summary of SC&A concerns, as listed in Section 6.3 [SC&A 2019, PDF p. 61].

Table 8. Summary of use of monitored coworkers for unmonitored subCTWs for plutonium.

Criterion	Percentage of Workers Who Meet Criterion
Coworkers listed on same RWP	96%
Coworkers signed in on same RWP and date	77%
Coworkers signed in on same RWP, date, and time	66%
Coworkers signed in with same craft	60%
Coworkers signed in on same RWP, date, time, and craft	45%

Source: [SC&A 2019, PDF p. 61]

NIOSH considers the following criteria for matching coworkers:

- An RWP as a small work activity
- An RWP on the same day and time
- Similar time periods (i.e., morning or afternoon)
- Not the same craft, but the same exposure environment
- Exposure environment variation depending on the RWP work

The co-exposure worker guidance recently approved by the ABRWH discusses one reason for considering an RWP as a small work activity:

> *The minimum number of samples should, of course, be considered considering the number of workers potentially exposed to the airborne source-term. For example, the number of samples necessary to be representative of the exposures at a uranium foundry, where airborne activity is generally widespread, will be greater than the number required of a small glove box operation where six workers were involved in the manipulation of plutonium parts. In the latter situation, it may be that samples for three out of six workers could be used to bound exposures for the three who were not monitored* [NIOSH 2020, PDF p. 8].

It is implied that a small work group of workers, such as usually occurs on an RWP, describes a small work activity. NIOSH notes that in the discussion of co-exposure in the Implementation Guide [NIOSH 2020, PDF pp. 5–9], there was no mention of crafts. Nonetheless, when NIOSH compared the subCTW plutonium bioassays by craft for 1990–1998, there were no significant differences noted, as indicated in Table 9 [ORAUT 2019a, PDF p. 40].

Table 9. subCTW plutonium bioassay by craft, 1990 through 1998.

Craft	Bioassay Required	No. of RWPs	subCTWs Monitored	Percentage with Bioassay	SubCTWs Matched to Coworkers	Effectively Monitored %
Boilermaker	27	12	24	89%	2	96%
Carpenter	79	33	71	90%	7	99%
Electrician	56	24	49	88%	2	91%
Insulator	17	9	16	94%	0	94%
Iron/Sheet metal	137	33	122	89%	12	98%
Laborer	174	70	147	84%	14	93%
Millwright	15	6	13	87%	2	100%
Painter	22	12	17	77%	4	95%
Pipefitter	102	42	94	92%	4	96%
Other	15	8	14	93%	0	93%
Totals	644[a]	140	567	88%	47	95%

Source: [ORAUT 2019a, PDF p. 40]

a. Three subCTWs waived termination bioassay; two subCTWs deemed a sample not needed.

NIOSH's use of an RWP on the same day and time was illustrated by an example presented to the ABRWH SRS work group on December 5, 2019 [NIOSH 2019b, PDF p. 22]. An RWP that specified four subCTWs for deconning a V2 riser for hut tear-down resulted in a requirement for plutonium and strontium/fission products bioassays. All but one of the subCTWs received the required bioassays (see Table 10) [ORAUT 2019a, PDF p. 40; NIOSH 2019b, PDF p. 21].

Table 10. Coworker matching example #1 from Table 4-7, Location: 241H (Tank Farms) work description: deconning V2 riser for hut tear down.

SID	CTW	Craft	Date	Time In	Time Out	Pu Monitoring	Sr/FP
4	CTW-128	Laborer	3/24/1992	8:16	11:00	Yes	Yes
4	CTW-268	Sheet metal	3/24/1992	8:30	11:00	No	Yes
4	CTW-449	Laborer	3/24/1992	8:30	11:00	Yes	Yes
4	CTW-466	Carpenter	3/24/1992	8:15	11:00	Yes	Yes

Source: [ORAUT 2019a, PDF p. 40; NIOSH 2019b, PDF p. 21]

NIOSH believes this is all similar work that meets the match criteria. As mentioned above, craft matching is not necessary. NIOSH does not believe it is correct to say this worker was *not monitored* because the worker was not monitored for all radionuclides on an RWP. In this case, one subCTW (a sheet metal worker) was not monitored for plutonium. The dose reconstruction can be conducted for strontium using the worker's personal bioassay. The co-exposure model can be used to estimate plutonium because this RWP represents similar work in the same radiological environment [NIOSH 2019b, PDF p. 21].

OBSERVATION 5

> *Bioassay data in the 1990s are not entirely free of the earlier data issues. The implementation of methods used to correct for the bioassay deficiencies seen in the 1970s and 1980s did not take place immediately with the change in the contracting company in 1990. It was not a step function that took place in 1990; instead, it took a number of years to identify, address, and effectively implement the changes. For example, there was only one RWP with one subCTW listed for 1990 in RPRT-0092, and specific radionuclides were not required on the RWPs until the mid-1990s. See section 6.4* [SC&A 2019, PDF p. 14].

NIOSH Response

From 1990 through 1998, several deficiencies were identified by self-assessment and audit. NIOSH believes that none of these were consequential to operation of the Routine Bioassay Program or to dose reconstruction.

SRS phased in the RWP system starting with the 100/Reactor Areas; implementation in A, F, and H Areas followed in 1991, and then in S and Z Areas as operations began there [DOE 1990a]. While SRS was in the process of implementing RWPs in 1990, they consistently monitored subCTWs for intakes, as demonstrated in the NIOSH response to Finding 3.

SRS implemented bioassay programs to cover 35 facilities that processed actinides, fission products, and tritium [Thomas, 1993]. The program was a defense-in-depth approach to radiological control with the intention to prevent non-tritium intakes [WSRC 1998]:

- Policy (zero intake policy)
- Engineered Controls
- Procedural Controls
- Personnel Protective Equipment (PPE)
- Surveillance used to verify Engineering, Procedural, and PPE
- Air Monitoring
- Facility Contamination Surveys
- Personnel Contamination Surveys
- *Routine and Job Specific Bioassay*

During this time period (1990–1998) as well as the entire period starting in 1972, SRS performed urine sampling for radioactive material using both routine and special sampling. Workers with "reasonable potential" for internal exposure were included in the routine bioassay program. The special bioassay program was designed for assessing "inadvertent intakes" of radioactive material that could exceed the 100 mrem threshold [LaBone 2001]. SRS maintained a written policy to not deliberately expose any worker to radioactive materials [LaBone 1992a]. Routine and job-specific bioassays were used to verify effectiveness of procedural and engineered controls and to serve as a trigger for special bioassay programs [WSRC 1992b; WSRC 1999]. Routine samples were requested from workers who had a reasonable potential for intakes but who SRS was confident did not have intakes in excess of 2% of the annual limit [WSRC 1990; LaBone 1992b].

Some issues remained in the 1990s that were similar to those during the 1972–1989 DuPont-era. However, as discussed in RPRT-0092 and this response paper, bioassay data completeness can be verified and is deemed adequate for most radionuclides of interest for both eras. Table 11 reproduces Table 7 from the SC&A review of RPRT-0092 for the period 1972 to 1980 while Table 12 produces that information for 1980 to 1989 [SC&A 2019, PDF p. 53].

Table 11. Summary of SC&A evaluation of pre-1990 subcontractor data for total monitored versus RPRT-0092 values (1972 to 1980)

Radionuclide (time period)	Years with Available Data	SC&A Monitored %	RPRT-0092 Monitored %	Ratio [SC&A/RPRT-0092]	SC&A Effectively Monitored %	RPRT-0092 Effectively Monitored %	Ratio [SC&A/RPRT-0092]
Americium (1972–1974)	1973	0	0	N/A	0	0	N/A
Plutonium (1972–1974)	All	50.0	51	0.986	64.7	69.0	0.936
Fission products (1972–1974)	All	69.9	74	0.941	69.9	94.0	0.742
All radionuclides (1975–1979)	None	N/A	N/A	N/A	N/A	N/A	N/A

Source: [SC&A 2019, PDF p. 53]
N/A = Not applicable

Table 12. Summary of SC&A evaluation of pre-1990 subcontractor data for total monitored versus RPRT-0092 values.

Radionuclide (time period)	Years with Available Data	SC&A Monitored %	RPRT-0092 Monitored %	Ratio [SC&A/RPRT-0092]	SC&A Effectively Monitored %	RPRT-0092 Effectively Monitored %	Ratio [SC&A/RPRT-0092]
Americium (1980–1989)	1981–1987	19.9	34	0.577	33.1	76.0	0.435
Plutonium (1980–1989)	All	79.4	80	0.994	97.0	97.0	0.998
Fission products (1980–1989)	All	72.6	78	0.927	73.9	99.0	0.750

Source: [SC&A 2019, PDF p. 53]
N/A = Not applicable

In response to 1990 Tiger Team concern RP.7-1 (i.e., the site-wide internal dosimetry program does not comply with the requirements of DOE 5480.11), SRS stated:

> *The SRS program like many in the DOE complex is based on years of experience, awareness of what has constituted good practice in the past, common sense, and conservative assumptions for determining employee doses. To conclude that a sound technical basis for the existing program does not exist is somewhat excessive. It is true that a formal technical basis for the SRS bioassay program has yet to be established. However, the SRS is already well into the process of creating a rigorous, systematic technical basis document for the internal dosimetry program consistent with the requirements of the Order and appropriate guidance* [DOE 1990a, PDF p. 432].

SRS published the first technical basis document for internal dosimetry in December 1990 [WSRC 1990]. SRS has published 14 revisions since 1990 including 1992, 1994, 1996, and 1997. SRS published procedure 5QL.1 506 in 1992 to guide bioassay scheduling and administration [WSRC 1992b]. SRS issued the SRS Actinide Bioassay Program Basis Document [WSRC 1993h] and the SRS Tritium Bioassay Program Basis Document in 1993 [WSRC 1993g].

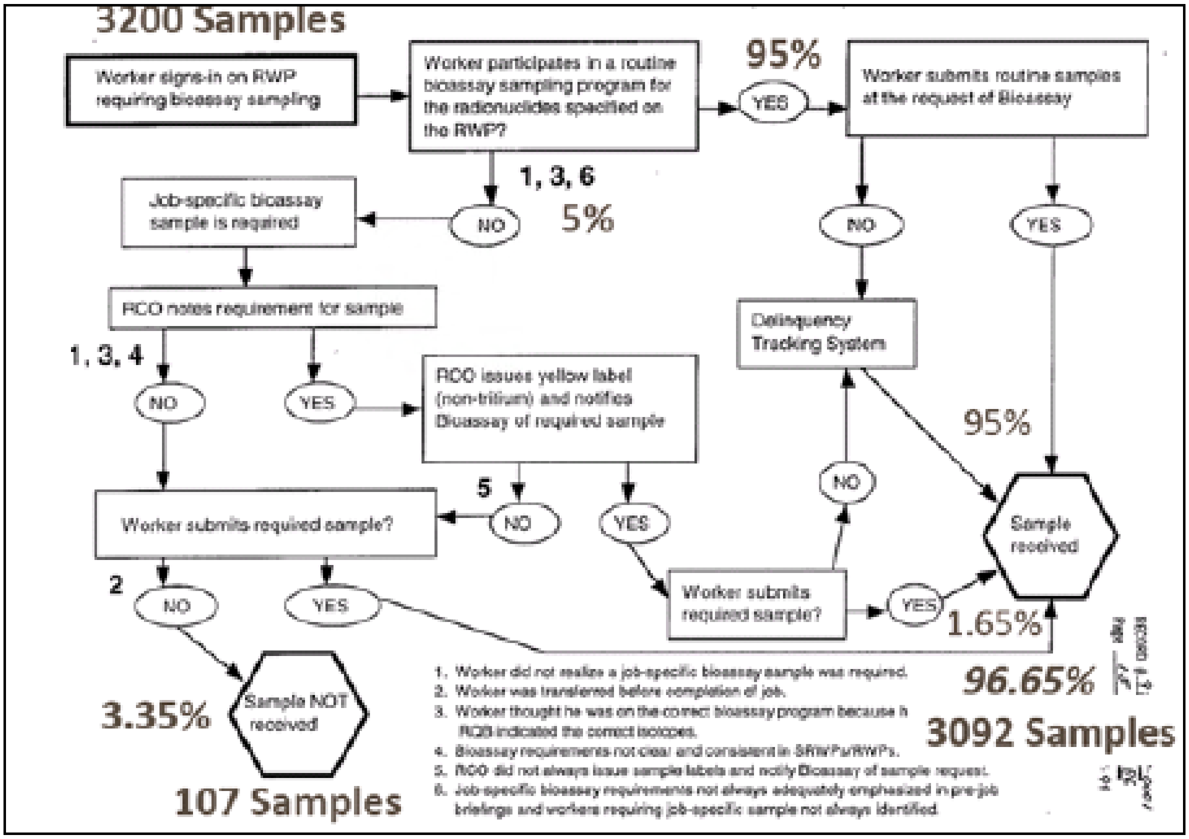
In 1990, SRS conducted a self-assessment of the Tritium Facility bioassay program to determine the rate of delinquencies and how they were handled. The assessment did not reveal any delinquencies; however, it did provide opportunities for improvement in informing workers about sample collection and to more readily identify delinquent workers [Mackie 1990]. In 1991, SRS noted further bioassay delinquency at actinide facilities. This issue was addressed by modifying bioassay reporting to management, which allowed for identification of scheduled workers and delinquent workers twice per month. The report had been sent weekly, but that frequency did not allow for samples to be left, collected, analyzed, and reported before the next report was distributed. As a result, workers were reported to be delinquent when they were not [Stephenson 1992].

In 1996, the SRTC (A Area) Radiation Control Officer was cited for giving special bioassay sample labels to a construction supervisor without determining who should be sampled or recording names of persons requested to leave a sample. This issue was resolved by giving the SRTC Radiation Control Officer full control of bioassay labels with the duty of maintaining positive control of all labels [Matheny 1996].

In a May 1997 self-assessment, SRS found that while all workers were complying with the routine bioassay program, some were not following through by providing job-specific bioassay samples. SRS determined that the issue of worker non-participation in the job-specific bioassay program was a potential noncompliance with the Price-Anderson Amendments Act. This was reported into the Noncompliance Tracking System on December 10, 1997, with a Corrective Action Report issued on December 8th, followed by a formal root cause determination completed in January 1998. An off-normal occurrence was entered into DOE’s Occurrence Reporting and Processing System (ORPS) on December 18, 1997 [DOE ORPS, 1998]. On September 21, 1998, the Department of Energy (DOE) issued a preliminary Notice of Violation (NOV) (NTS-SR-SRS-ESH-1997-0001) to Westinghouse Savannah River Company. The NOV was for a violation of 10 C.F.R. 830 and was titled “Inadequate Bioassay Program Participation” [Brush 1998, PDF pp. 8–17]. The NOV text described several issues related to workers following through with required job-specific bioassays, specifically that work was not performed in accordance with Procedure 5Q1.1-504, RWP, in that:

> *…from January 1, 1996, to September 30, 1997, procedural requirements were not adhered to in that: (1) workers signed-in on RWPs without adhering to RWP requirements for bioassay (i.e., workers failed to submit bioassay samples as required); (2) site management did not hold workers and the work group supervisors accountable for worker submission of RWP required bioassay samples; (3) the names and social security numbers of workers required to submit RWP, job-specific bioassay samples were not documented and the Bioassay Customer representative was not notified for purposes of sample tracking; and (4) bioassay requirements were not always identified on RWPs as required* [Brush 1998, PDF pp. 8–17].

The results of the May 1997 self-assessment are illustrated by the flowchart in Figure 2 below Kornacki and Gatlin [1998, PDF p. 23]. The flow begins with the requested 3,200 samples; 95% of these flow to the right for routine samples, and 5% flow down and to the left for job-specific samples. All of the requested routine samples were received by the analytical laboratory. For the job-specific bioassays, 3.35% or 107 of the requested samples terminated in the hexagonal node labeled “Sample NOT received.” This resulted in 96.65% or 3,092 samples received at the laboratory for the first four months of 1997.



Source: Kornacki and Gatlin [1998, PDF p. 23]

Figure 2. Attachment 2 to root cause analysis corrective action report, expected process, actual with added text to illustrate May 1997 results.

This limited assessment of 3,200 requested bioassay samples found a 33% compliance rate for the job-specific samples. The follow-up assessment in September 1997 found a compliance rate of 21% for job-specific bioassay samples. The number of workers who did not provide samples in 1997 was only 256. Each of these 256 subCTWs left follow-up bioassay samples in 1998 and no intakes were observed.

SRS procedures held the individual worker responsible for submitting bioassay samples. For job-specific samples, they were to be told to provide them at the end of the assignment. SRS did not find any willful noncompliance with the program but identified several reasons, including:

1. Worker did not realize a job-specific sample was required.
2. Worker was transferred before completion of job.
3. Worker thought he was on the correct bioassay program because his RQB indicated the correct isotopes.
4. Bioassay requirements not clear and consistent in SWRPs/RWPs.

5. Radiological Control Operations did not always issue sample labels and notify Bioassay of sample request.
6. Job-specific bioassay requirements not always adequately emphasized in pre-job briefings and workers requiring job-specific samples not always identified.

With respect to using routine pre-scheduled and job-specific bioassay to generate co-exposure distributions, the degree and direction of potential bias generated in a co-exposure model by missing samples is more important than the number of samples that were requested but not provided. Missing routine job-specific samples do not automatically invalidate the radiation protection program at SRS and do not automatically render the vast amounts of available monitoring data worthless in the context of generating a co-exposure model.

The 1997 self-assessment leading to the NOV was performed to address bioassay scheduling concerns raised by the WSRC Facility Evaluation Board in 1994, 1995, and 1996. The Manager of Health Physics Technology at the time addressed those concerns in a letter that showed how these issues did not affect the overall bioassay program [Matheny 1998]. Although deficiencies were noted with the SRS bioassay program from 1990 through 1998, none of them adversely affected the control of worker exposures to radioactive materials or would have kept SRS from assessing dose to workers receiving doses from intakes exceeding 100 mrem.

It is true that radionuclides were not specified in early RWPs until about 1994. However, NIOSH used Farrell and Findley [1999] and other information given on the RWP to identify target radionuclides (e.g., task specifications). For example, the work context of subCTW coworkers, based on RWP information, was used to support the use of developed co-exposure models for reconstructing doses for non-monitored subCTWs. This is demonstrated in the following RPRT-0092 example:

> *Sample (SID) #234 (Table 2-10) had an unmonitored subCTW on a work crew of four CTWs in which two prime CTWs were monitored, providing a monitoring rate of 75% for the job crew. Both of the subCTWs were laborers working on the same task at the same time and for the same duration. For that reason the monitored subCTW could serve as a surrogate for the unmonitored laborer….Fortunately, by capturing the complete information, the context of the work can be considered in the evaluation. For example, if all the DuPont CTWs were pipefitters and the subCTW was simply brought in as an additional worker, then the criteria noted in NIOSH (2015) would be appropriate and 64% would be considered a success. If the DuPont CTWs were electricians that did electrical work in the morning and the subCTW was a pipefitter who worked in the afternoon doing a separate task, then the DuPont CTWs would not be appropriate coworkers. The context matters, which is why the team looked carefully at each unmonitored subCTW to determine if there was a reasonable monitored coworker. Note that some determinations involved professional judgment* [ORAUT 2019a, PDF p. 30].

The relevant issues and deficiencies that extend into the 1990s that SC&A raises have been previously discussed in detail in this report in the course of responding to the findings and observations. In part, this was done through the use of 1972–1989 data. The use of the criteria listed below also aided in the determination of bioassay requirements, and therefore, the assessment of completeness. For the RWPs that did not designate the specific bioassay, as required, the RWP was reviewed to identify other qualifiers, such as [ORAUT 2019a, PDF p. 31]:

- Respiratory requirements
- Air monitoring and contamination survey results listed on the RWP
- Bioassay requirements for similar RWPs for the same areas and location
- Guidelines given in the 1990, 1992, and 1996 versions of the SRS *Internal Dosimetry Technical Basis Manual* [WSRC 1990]
- *Specification of Urine Bioassay Requirements on Radiological Work Permits* [Farrell and Findley 1999]

The number of required plutonium bioassays on RWPs increased from 4% in 1993 to 78% in 1994, and to 100% in 1995, as summarized in SC&A's review of RPRT-0092 (Table 15) [SC&A 2019, PDF p. 63]. Using the requirements for bioassay and the coworkers concept, including but not limited to considering work context, the subCTW plutonium completeness determination resulted in an effectively-monitored average of 99% for 1990-91 [ORAUT 2019a, PDF p. 45]. Even without inclusion of coworkers, the percentage of subCTWs with a required bioassay for plutonium was 95% for 1990-91. See Table 13 from this response below, which was Table 4-6 in RPRT-0092 [ORAUT 2019a, PDF p. 45]. Even though the radionuclide of interest was not documented on the RWP, this did not mean that the subCTW did not have a bioassay taken.

Table 13. subCTW plutonium bioassay, 1990 to 1998.

Year	Bioassay Required	No. of RWPs	subCTWs Monitored by Bioassay	Percent with Bioassay	subCTWs Matched to Coworkers with Bioassay	Effective Percent Monitored
1990–1991	82	17	78	95%	3	99%
1992	88	23	85	97%	3	100%
1993	173	27	154	89%	11	95%
1994	140	32	104	74%	20	89%
1995	57	15	52	91%	5	100%
1996	24	7	20	83%	0	83%
1997	55	9	54	98%	1	100%
1998	25	10	20	80%	4	96%
Totals	**644**[a]	**140**	**567**	**88%**	**47**	**95%**

Source: [ORAUT 2019a, PDF p. 45]

a. Three subCTWs waived termination bioassays; two subCTWs deemed samples not needed.

Dose reconstruction reviews all bioassay data for the worker, including WBCs, chest counts, and bioassay results. For SRS, the routine bioassay sample results were collected for workers not known to have received an intake of radioactive material. Special bioassay samples were collected for workers suspected to have had an intake due to events such as elevated air sample results, skin contamination, wounds, and failures in protective equipment. The co-exposure model uses all applicable bioassay data, including results from special and routine bioassay samples.

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ATTACHMENT A (Re: Finding 4)

Table A-1 lists summary data for 17 contamination-type incidents involving subCTWs occurring from 1972 through 1980. This list is comprised of examples only and does not represent all incidents. Although incidents are reported in the cited reports, SRS did not provide the identities of involved workers. Table A-2 provides a summary of data for 35 contamination-type incidents involving subCTWs occurring in areas other than A Area. Both tables support the NIOSH response to Finding 4. Figures A-1 through A-3 are examples of SRS incident reporting; these particular examples apply to subCTW #32 from Table A-2, incident date May 17, 1988, listed in Table A-2.

Table A-1. Contamination-type incidents involving subCTWs

Year	Facility	Description	SRDB Ref ID
1972	105	Charleston Roofing Company personnel began preparing the roof for resurfacing. Personnel dose rates were less than 1 mrem/hour.	68268, PDF p. 13
1972	294-H	Construction personnel continued installation of a new air supply tunnel for the sand filter. Exposure rates to 100 mr/hour were encountered while chipping concrete, instilling a process drain line, and welding on a previously-installed steel duct work.	68268, PDF p. 15
1972	HB Line	Construction personnel completed installation of an additional stage of HEPA filtration for the exhaust air. Personnel encountered transferable contamination to 80,000 dpm/ft^2 alpha in the exhaust header during the filter tie-in. Containment huts effectively prevented the spread of alpha activity.	68266, PDF p. 13
1972	690-G	Construction continued rebuilding failed canyon vessels, two condenser columns, and a centrifuge from Building 221-F. Exposure rates averaged 20 mrads/hour (beta + gamma) and 5 mr/hour (gamma). No migration of airborne or transferable contamination detected outside the control huts. Respiratory protection was worn for all work inside the huts.	68267, PDF p. 13
1973	JB Line	A Construction Division employee received nasal contamination of about 100 dpm/alpha while working in the dissolver maintenance room. Air activity in the maintenance room increased to 3 x 19^{-10} µCi/cc of air. The employee was decontaminated successfully and a chest count did not indicate any significant assimilation. A bioassay (urinalysis) program was performed.	68034, PDF p. 12

Year	Facility	Description	SRDB Ref ID
1973	772-F	Construction personnel removed eight glove boxes and associated equipment from the abandoned PuO_2 facility in L-158 and L-162. The boxes, containing an estimated 455 curies of Pu-238, were packaged in reinforced-plywood shipping containers and transferred to 643-G for concrete encapsulation. Body exposure rates to 500 mrads/hour were measured at one foot from a glove box. Transferable alpha contamination to 2 x 10^6 dpm/ft^2 was found on the inner hut floor during line breaks; however, no contamination was spread beyond the plastic enclosure. Air-supplied plastic suits were worn for all hut work.	68168, PDF p. 12
1974	776-A	Construction Division personnel began removal of obsolete one-inch solvent drain line between the high-level cases and the waste-loading station in Building 776-A. Transferable contamination 1.5 x 10^6 alpha was detected on one section of the line. Body exposure rates to 1500 mrads/hour were encountered as a result of the radiation intensities to 5 rads/hour at three inches from parts of the line.	113972, PDF p. 13
1975	773-A	The replacement of leaking dampers in the B and C section hood-exhaust diversion systems with positive-closure dampers was completed without incident by the Construction Division.	113981, PDF p. 32
1975	776-4A	The building was being increased in size by the Construction Division to accommodate additional exhaust equipment, including double-HEPA filtration for both the high-level and low-level waste-tank vent systems. Body exposure rates averaged 3 mr/hour in the work area. Transferable contamination to 2 x 10^5 dpm/ft^2 was detected on the top of the high-level waste trailer during a survey for connecting the loading lines to the trailer. It is believed the trailer was contaminated during maintenance work on a vent line from an adjacent platform. Assault masks were worn by personnel during the work.	113981, PDF p. 47
1976	241-F	Construction Division personnel continued tie-in of Tanks 7 and 18 waste-transfer lines (Building 241-F Concentrated) to the evaporator. During this work, radiation exposure dose rates were measured up a maximum of 10 rads/hr, with measurements of 300 mR/hr at 30 cm.	72910, PDF p. 124
1977	C Area	Three persons sustained slight skin and personal clothing contamination (maximum 4000 cpm beta-gamma) while performing tests and repairs on a process-heat exchanger in the stack area. A Construction Division employee received nasal contamination to 170 dpm alpha (11% Cm-244, 59% Am-241, and 30% Pu-239) and 180 dpm beta-gamma. A chest count indicated less than MDA and the employee was placed on a follow-up bioassay program.	72917, PDF p. 139

Year	Facility	Description	SRDB Ref ID
1978	772-F	Construction personnel began removing equipment from laboratory module L-142 for conversion to a laboratory training facility. The entire lab module was lined with plastic to control alpha contamination, which ranged to 10^7 dpm/100 cm^2 (fixed) and 10^6 dpm/100 cm^2 (transferable) in service strips. Hoods and radiobenches were disassembled and placed in lined plywood boxes for transfer to Building 643-G. Exposure rates ranged to 5 mr/hour.	28279, PDF p. 15
1978	JB Line	A Construction Division painter received low-level (40 dpm alpha) nasal contamination, as well as hand and forearm contamination to 1 x 10^5 dpm during removal of plastic from duct work in the decontamination room. The plastic contacted the interior of an exhaust duct that was contaminated to 3.5 x 10^7 dpm alpha. The painter's rubber gloves were contaminated to 1.5 x 10^7 dpm, a ladder to 2 x 10^6 dpm, and the floor to 1 x 10^6 dpm. Airborne activity ranged to 980 x 10^{-12} µCi/cc. The painter wore a full-face respirator. Initial chest counts showed less than the minimum detectable amount. A special bioassay program was performed.	108843, PDF pp. 93-94
1979	241-F	Contamination ranging from 2,000 to 60,000 cpm beta-gamma was spread outside a plastic control hut while Construction Division personnel were grinding process-waste piping in preparation for making a tie-in of DB-5 to the existing CTS line. The migration of contamination occurred when a section of the hut wall and entry air lock was not replaced following removal of piping through the hut. Nasal sears taken from personnel who were working outside the hut without respiratory protection were negative. All special bioassay samples were negative.	68334, PDF p. 16
1979	772-H	Construction personnel removed old equipment from lab modules L-162 and L-166 in preparation for installing a new mass spectrometer. Alpha contamination to 2.5 x 10^7 dpm fixed and 1 x 10^6 dpm/0.1 m^2 transferable was detected in the service strips. Two air reversals from the rooms to the adjoining labs and utility corridor occurred during the work, causing short-duration airborne alpha contamination to 600 x 10^{-12} µCi/cc in the corridor.	68336, PDF p. 12
1979	304-H	A construction electrician incurred alpha nasal contamination of 90 dpm while installing a security system in Compressor Room 304-H. Transferable alpha contamination to 4 x 10^4 dpm was found on a 2-foot section of pipe and on 1-square-foot of the floor in the room. A chest count on the employee was less than the MDA. A special bioassay sample program was performed.	68339, PDF p. 16

Year	Facility	Description	SRDB Ref ID
1980	772-F	Construction personnel began renovation of L-171. Radiobenches, hoods, and glove boxes were removed, placed in plywood boxes, and stored on the service floor pending determination of plutonium content and transfer to 643-G. Maximum transferable contamination detected was 3 x 10^{6} dpm/0.1m2 on an exhaust duct. Maximum air activity was 30 X 10^{-12} µCi/Pu/cc.	68324, PDF p. 12

Table A-2 below provides the summary data for 35 contamination-type incidents involving subCTWs that occurred in areas other than A Area. (Legend: Y=Yes, N=No, NA=Insufficient information to determine if performed)

Table A-2. Contamination-type incidents involving subCTWs, areas other than A Area

subCTW Incident No	Incident Date	Name	PRID	Incident Type[a]	Location[b]	Wound	Nasal / Saliva	Urine	WBC	Chest	SRDB Ref ID	PDF Page[c]
1	8/2/1972	redacted	redacted	nasal contamination	294-H	NA[d]	Y	NA	NA	NA	53411	20
2	8/2/1972	redacted	redacted	nasal contamination	294-H	NA	Y	NA	NA	NA	53411	20
3	11/9/1973	redacted	redacted	possible air contamination	221-F	NA	Y	NA	NA	NA	166047	28
4	11/15/1973	redacted	redacted	possible air contamination	221-F Diss Maint Room	NA	Y	Y	NA	NA	166047	28
5	4/29/1974	redacted	redacted	possible air contamination	221-F Diss Maint Room	NA	Y	Y	NA	NA	166047	30
6	9/10/1974	redacted	redacted	possible air contamination	221-F	NA	Y	N	NA	NA	166047	31
7	7/25/1975	redacted	redacted	air contamination	221-F	NA	Y	Y	NA	NA	166047	34
8	9/24/1975	redacted	redacted	hand contamination	221-F	NA	Y	Y	NA	NA	166047	35
9	2/2/1976	redacted	redacted	unknown	221 MLO #4	NA	Y	N	NA	NA	166047	36
10	10/27/1976	redacted	redacted	possible air contamination	221-F MLO #3	NA	Y	N	NA	NA	166047	39
11	4/7/1977	redacted	redacted	possible air contamination	221-F Room 410	NA	Y	N	NA	NA	166047	40

subCTW Incident No	Incident Date	Name	PRID	Incident Type[a]	Location[b]	Wound	Nasal / Saliva	Urine	WBC	Chest	SRDB Ref ID	PDF Page[c]
12	12/14/1978	redacted	redacted	contamination	221-F Decon Room	NA	Y	NA	NA	NA	166047	52
13	12/20/1978	redacted	redacted	possible air contamination	221-F Decon Room	NA	Y	Y	NA	NA	166047	52
14	1/12/1979	redacted	redacted	shoe contamination	221-F MLO #3	NA	Y	NA	NA	NA	166047	52
15	1/12/1979	redacted	redacted	shoe contamination	221-F MLO #3	NA	Y	NA	NA	NA	166047	52
16	6/4/1980	redacted	redacted	contamination	235-F	NA	N	NA	NA	NA	175443	20
17	8/12/1980	redacted	redacted	possible air contamination	235-F	NA	N	N	NA	NA	175443	20
18	10/9/1980	redacted	redacted	possible air contamination	235-F W Maint Room	NA	N	NA	NA	NA	175443	22
19	1/9/1981	redacted	redacted	possible air contamination	221-F	NA	Y	N	NA	NA	175433	7
20	6/2/1981	redacted	redacted	chipping concrete	JB Line	NA	Y	N	NA	NA	166046	6
21	4/13/1982	redacted	redacted	wound	221-F	Y	N	Y	NA	NA	175433	14
22	5/11/1983	redacted	redacted	skin contamination	221-F Warm Shop	NA	Y	N	NA	NA	175433	18
23	8/25/1983	redacted	redacted	wound	105-L	Y	NA	Y	NA	NA	167191	13
24	3/20/1984	redacted	redacted	contaminated clothing	221-F WCMA	NA	Y	Y	NA	NA	175433	20
25	9/25/1984	redacted	redacted	possible air contamination	772-F	NA	NA	Y	NA	NA	166045	9

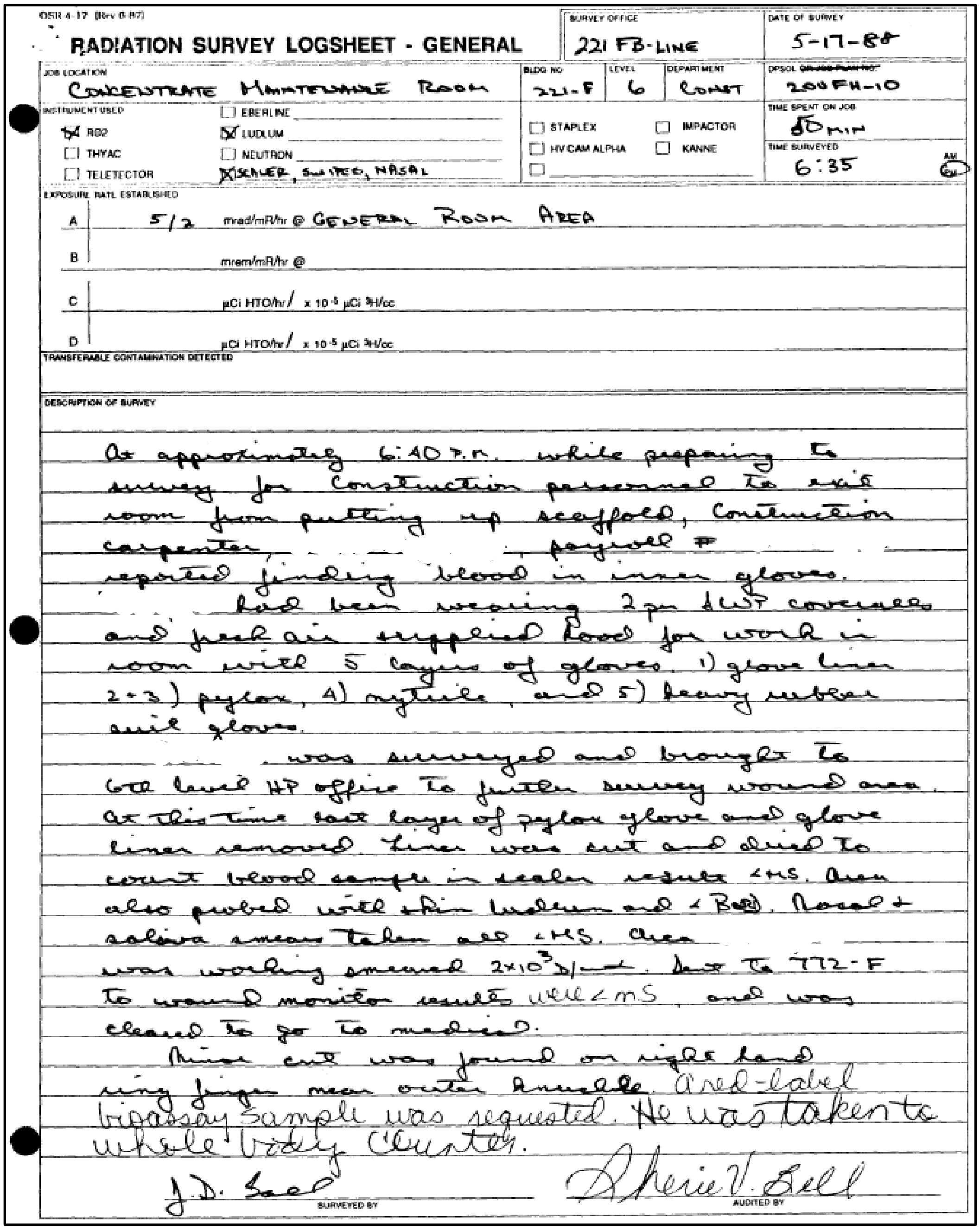
subCTW Incident No	Incident Date	Name	PRID	Incident Type[a]	Location[b]	Wound	Nasal / Saliva	Urine	WBC	Chest	SRDB Ref ID	PDF Page[c]
26	1/19/1985	redacted	redacted	possible air contamination	FB Line	NA	Y	Y	Y	Y	167194	121
27	9/12/1985	redacted	redacted	possible air contamination	221-F HGVC	N	Y	N	NA	NA	175433	28
28	2/11/1986	redacted	redacted	hole in plastic suit	221-F Warm Decon Cell	N	Y	N	NA	NA	175433	34
29	11/14/1986	redacted	redacted	contamination	772-F	NA	NA	Y	NA	NA	166045	18
30	6/18/1987	redacted	redacted	possible air contamination	772-F L-110	NA	NA	Y	NA	NA	166045	21
31	12/17/1987	redacted	redacted	wound	221-F	NA	N	Y	Y	Y	175432	152
32	5/17/1988	redacted	redacted	wound	221-F	Y	Y	Y	Y	Y	166124	23
33	9/7/1988	redacted	redacted	acid burn	707-1F	Y	Y	Y	NA	NA	175443	46
34	10/13/1988	redacted	redacted	possible air contamination	772-F L-170	NA	NA	Y	NA	NA	166045	25
35	10/5/1989	redacted	redacted	puncture	Tank Farm	Y	Y	Y	Y	Y	153905	144

a Selection of incident type made using available documentation and professional judgement.

b Identification of facility made using available documentation and knowledge of the site.

c Data for some incidents span multiple pages; the starting page is listed.

d No information available in the incident source to determine if performed. NA does not mean measurement was not performed.



OSR 4-17 (Rev 6-87)

RADIATION SURVEY LOGSHEET - GENERAL

SURVEY OFFICE: 221 FB-LINE
DATE OF SURVEY: 5-17-88
JOB LOCATION: CONCENTRATE MAINTENANCE ROOM
BLDG NO: 221-F
LEVEL: 6
DEPARTMENT: CONST
DPSOL ~~OR JOB PLAN NO~~: 200FH-10
TIME SPENT ON JOB: 50 MIN
TIME SURVEYED: 6:35 AM [✓ PM]

INSTRUMENT USED
☒ R02
☐ THYAC
☐ TELETECTOR
☐ EBERLINE
☒ LUDLUM
☐ NEUTRON
☒ SCALER, SWIPES, NASAL
☐ STAPLEX
☐ HV CAM ALPHA
☐
☐ IMPACTOR
☐ KANNE

EXPOSURE RATE ESTABLISHED
A 5/2 mrad/mR/hr @ GENERAL ROOM AREA
B mrem/mR/hr @
C µCi HTO/hr / x 10-5 µCi 3H/cc
D µCi HTO/hr / x 10-5 µCi 3H/cc

TRANSFERABLE CONTAMINATION DETECTED

DESCRIPTION OF SURVEY

At approximately 6:40 P.M. while preparing to survey for Construction personnel to exit room from putting up scaffold, Construction carpenter, , payroll # reported finding blood in inner gloves. had been wearing 2 pr DWT coveralls and fresh air supplied hood for work in room with 5 layers of gloves. 1) glove liner 2+3) pylox, 4) nytrile, and 5) heavy rubber acid gloves.

was surveyed and brought to 6th level HP office to further survey wound area. At this time last layer of pylox glove and glove liner removed. Liner was cut and dried to count blood sample in scaler results <MS. Area also probed with thin ludlum and < BKG. Nasal + saliva smears taken all <MS. Area was working smeared 2×10^3 D/min. Sent to 772-F to wound monitor results were <MS, and was cleared to go to medical.

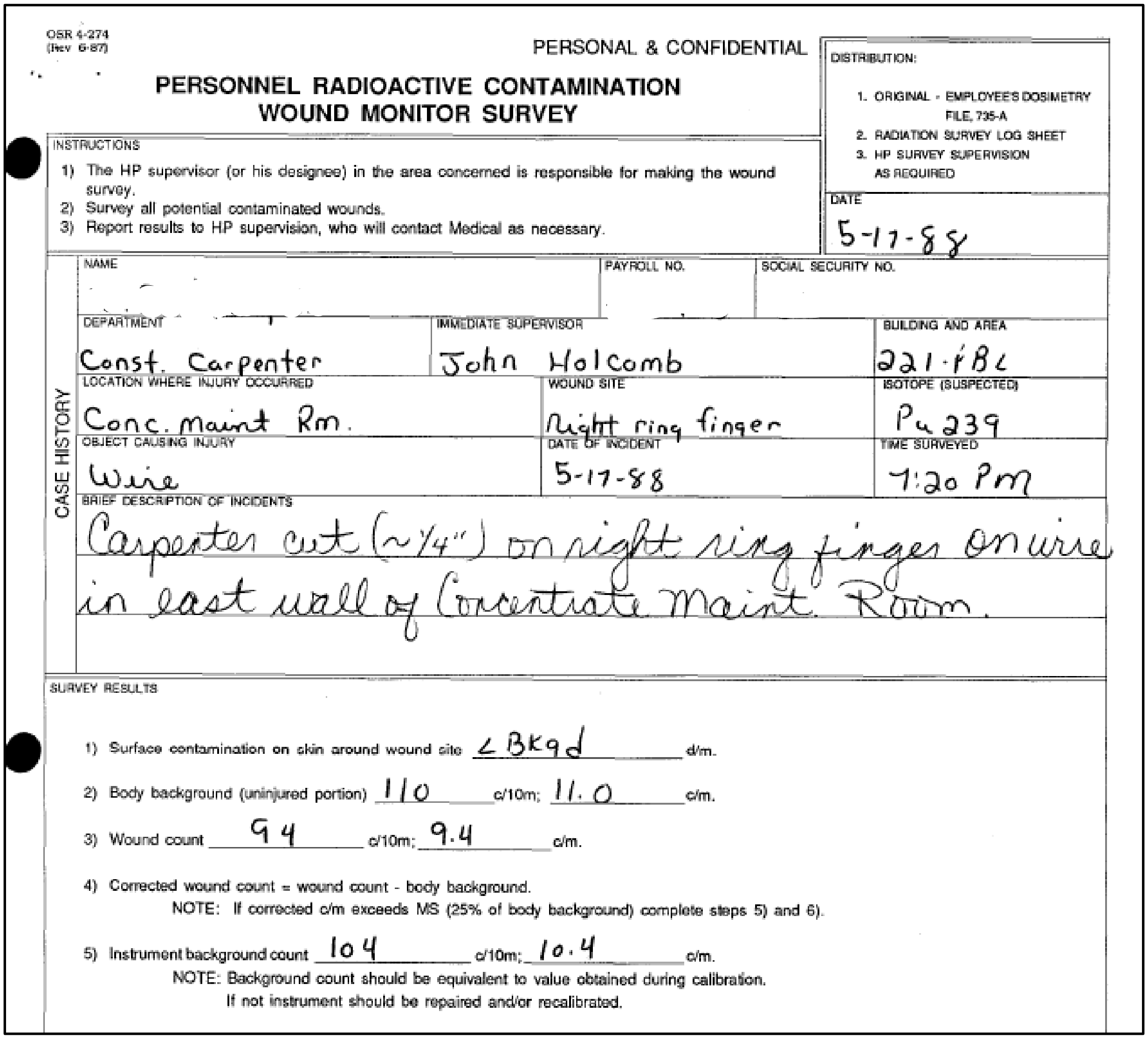
Minor cut was found on right hand ring finger near outer knuckle. A red-label bioassay sample was requested. He was taken to whole body Counter.

J. D. [illegible]
SURVEYED BY

Sherie V. Bell
AUDITED BY

Source: [DuPont 1988]

Figure A-1. Radiation survey logsheet, May 17, 1988, FB Line.



OSR 4-274
(Rev 6-87)

PERSONAL & CONFIDENTIAL

PERSONNEL RADIOACTIVE CONTAMINATION
WOUND MONITOR SURVEY

DISTRIBUTION:
1. ORIGINAL - EMPLOYEE'S DOSIMETRY FILE, 735-A
2. RADIATION SURVEY LOG SHEET
3. HP SURVEY SUPERVISION AS REQUIRED

INSTRUCTIONS
1) The HP supervisor (or his designee) in the area concerned is responsible for making the wound survey.
2) Survey all potential contaminated wounds.
3) Report results to HP supervision, who will contact Medical as necessary.

DATE: 5-17-88

CASE HISTORY

NAME:

PAYROLL NO.:

SOCIAL SECURITY NO.:

DEPARTMENT: Const. Carpenter

IMMEDIATE SUPERVISOR: John Holcomb

BUILDING AND AREA: 221-FBL

LOCATION WHERE INJURY OCCURRED: Conc. Maint Rm.

WOUND SITE: Right ring finger

ISOTOPE (SUSPECTED): Pu 239

OBJECT CAUSING INJURY: Wire

DATE OF INCIDENT: 5-17-88

TIME SURVEYED: 7:20 Pm

BRIEF DESCRIPTION OF INCIDENTS: Carpenter cut (~1/4") on right ring finger on wire in east wall of Concentrate Maint. Room.

SURVEY RESULTS

1) Surface contamination on skin around wound site < Bkgd d/m.

2) Body background (uninjured portion) 110 c/10m; 11.0 c/m.

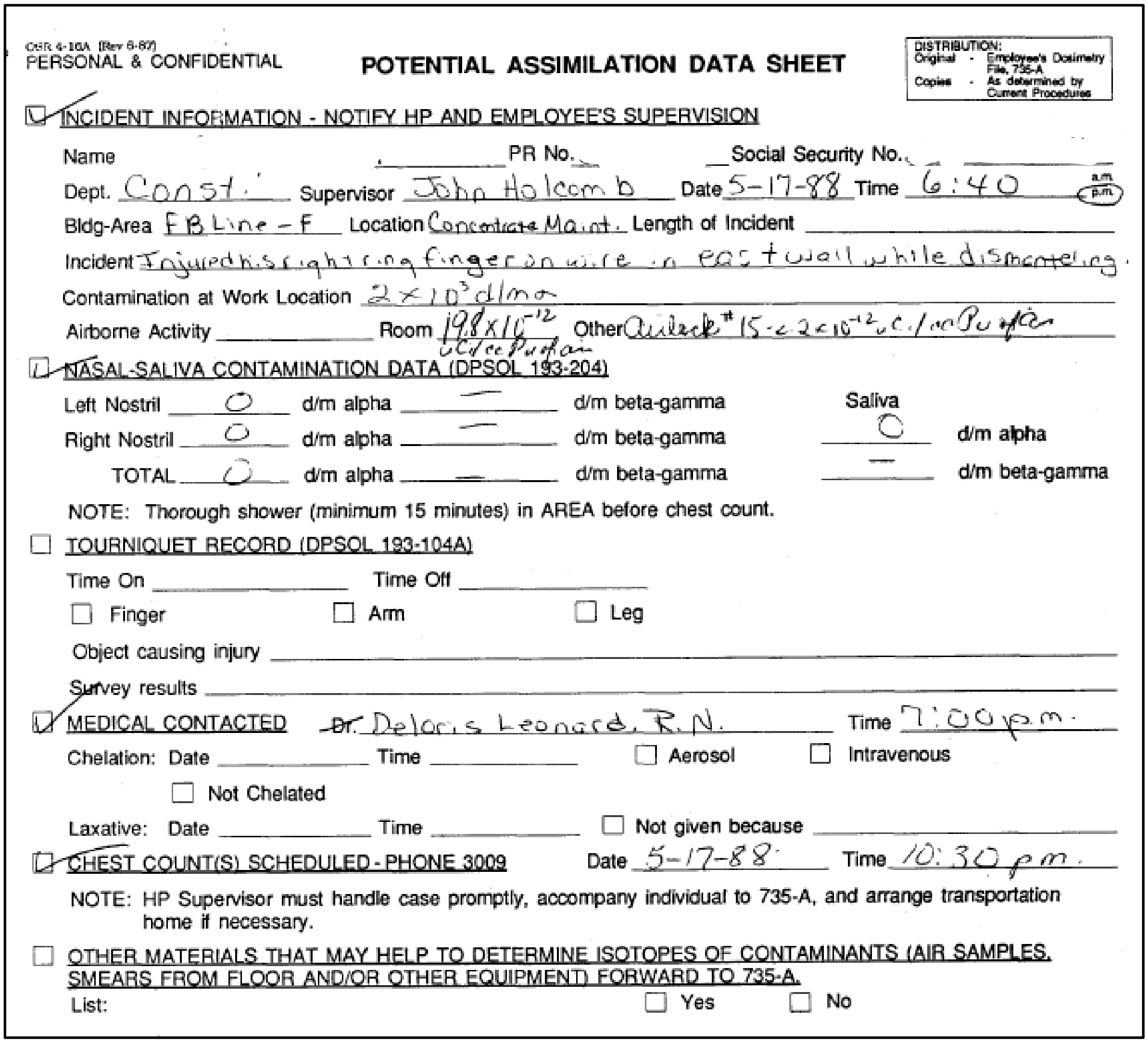
3) Wound count 94 c/10m; 9.4 c/m.

4) Corrected wound count = wound count - body background.
NOTE: If corrected c/m exceeds MS (25% of body background) complete steps 5) and 6).

5) Instrument background count 104 c/10m; 10.4 c/m.
NOTE: Background count should be equivalent to value obtained during calibration.
If not instrument should be repaired and/or recalibrated.

Source: [DuPont 1988]

Figure A-2. Wound monitor survey, May 17, 1988, FB Line.



CSR 4-16A (Rev 6-87)
PERSONAL & CONFIDENTIAL

POTENTIAL ASSIMILATION DATA SHEET

DISTRIBUTION:
Original - Employee's Dosimetry File, 735-A
Copies - As determined by Current Procedures

☑ INCIDENT INFORMATION - NOTIFY HP AND EMPLOYEE'S SUPERVISION

Name ____ PR No. ____ Social Security No. ____

Dept. Const. Supervisor John Holcomb Date 5-17-88 Time 6:40 a.m. [✓ p.m.]

Bldg-Area FB Line - F Location Concentrate Maint. Length of Incident ____

Incident Injured his right ring finger on wire in east wall while dismanteling.

Contamination at Work Location 2×10^3 d/m α

Airborne Activity ____ Room 19.8×10^{-12} uCi/cc Pu alpha Other Airlock # 15 - $<2\times10^{-12}$ uCi/cc Pu alpha

☑ NASAL-SALIVA CONTAMINATION DATA (DPSOL 193-204)

Left Nostril 0 d/m alpha — d/m beta-gamma

Right Nostril 0 d/m alpha — d/m beta-gamma

TOTAL 0 d/m alpha — d/m beta-gamma

Saliva

0 d/m alpha

— d/m beta-gamma

NOTE: Thorough shower (minimum 15 minutes) in AREA before chest count.

☐ TOURNIQUET RECORD (DPSOL 193-104A)

Time On ____ Time Off ____

☐ Finger ☐ Arm ☐ Leg

Object causing injury ____

Survey results ____

☑ MEDICAL CONTACTED ~~Dr.~~ Deloris Leonard, R.N. Time 7:00 p.m.

Chelation: Date ____ Time ____ ☐ Aerosol ☐ Intravenous

☐ Not Chelated

Laxative: Date ____ Time ____ ☐ Not given because ____

☑ CHEST COUNT(S) SCHEDULED - PHONE 3009 Date 5-17-88 Time 10:30 p.m.

NOTE: HP Supervisor must handle case promptly, accompany individual to 735-A, and arrange transportation home if necessary.

☐ OTHER MATERIALS THAT MAY HELP TO DETERMINE ISOTOPES OF CONTAMINANTS (AIR SAMPLES, SMEARS FROM FLOOR AND/OR OTHER EQUIPMENT) FORWARD TO 735-A.

List: ☐ Yes ☐ No

Source: [DuPont 1988]

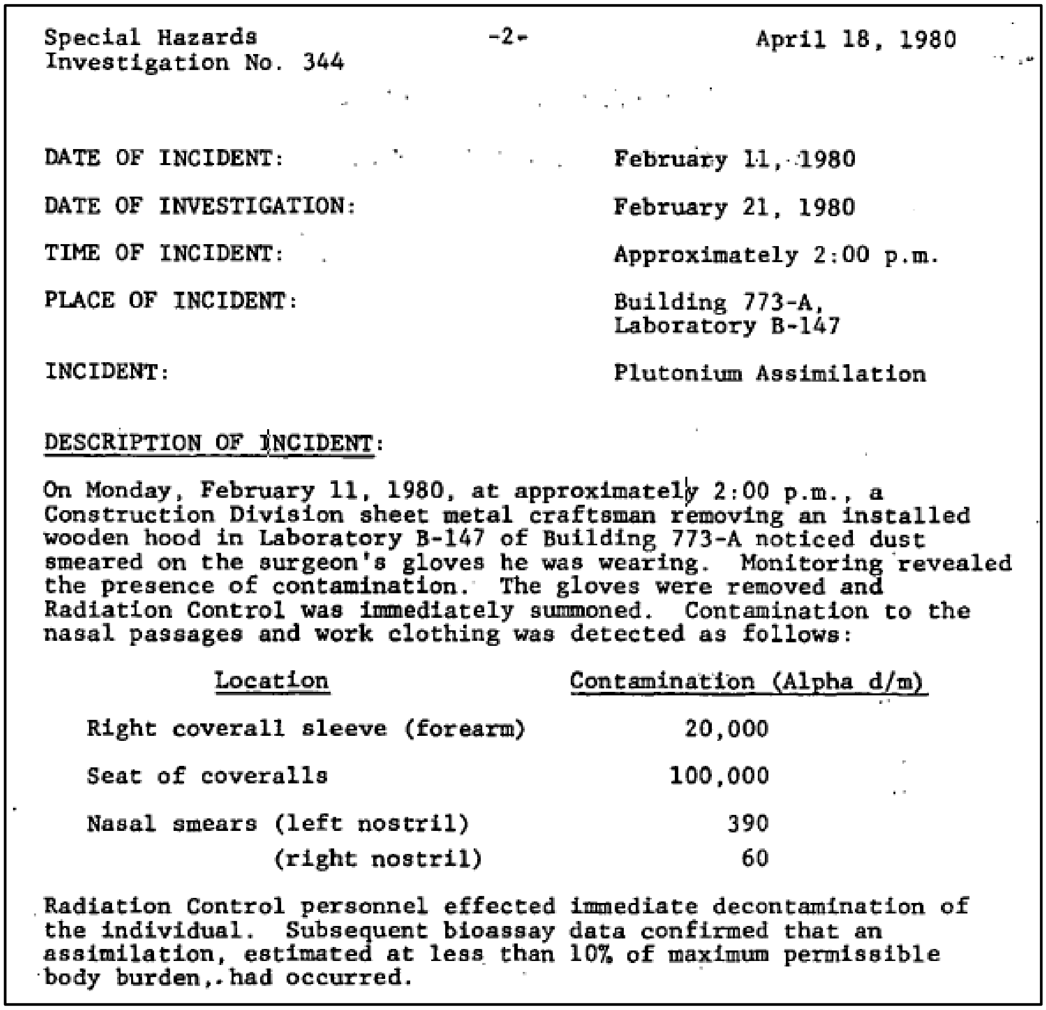
Figure A-3. Potential assimilation data sheet, May 17, 1988, FB Line.

ATTACHMENT B (Re: Finding 6)
Incident Reports Associated with Am-241 Sampling

Attachment B contains fifteen figures that document incidents involving subcontractor construction trade workers from 1980 through 1987.

Incident Result for February 11, 1980

NIOSH found that a subCTW's clothing was contaminated while removing a wooden hood in Laboratory B-147, 773-A [DuPont 1980b, PDF pp. 290–295]. The subCTW was monitored by nasal smear, chest-counting, and urinalysis for plutonium and americium. The urinalysis results show an assimilation of less than 10% of the maximum permissible body burden for plutonium. Figure B-1 below provides the incident report and result.



Special Hazards
Investigation No. 344

-2-

April 18, 1980

DATE OF INCIDENT: February 11, 1980

DATE OF INVESTIGATION: February 21, 1980

TIME OF INCIDENT: Approximately 2:00 p.m.

PLACE OF INCIDENT: Building 773-A, Laboratory B-147

INCIDENT: Plutonium Assimilation

DESCRIPTION OF INCIDENT:

On Monday, February 11, 1980, at approximately 2:00 p.m., a Construction Division sheet metal craftsman removing an installed wooden hood in Laboratory B-147 of Building 773-A noticed dust smeared on the surgeon's gloves he was wearing. Monitoring revealed the presence of contamination. The gloves were removed and Radiation Control was immediately summoned. Contamination to the nasal passages and work clothing was detected as follows:

Location	Contamination (Alpha d/m)
Right coverall sleeve (forearm)	20,000
Seat of coveralls	100,000
Nasal smears (left nostril)	390
(right nostril)	60

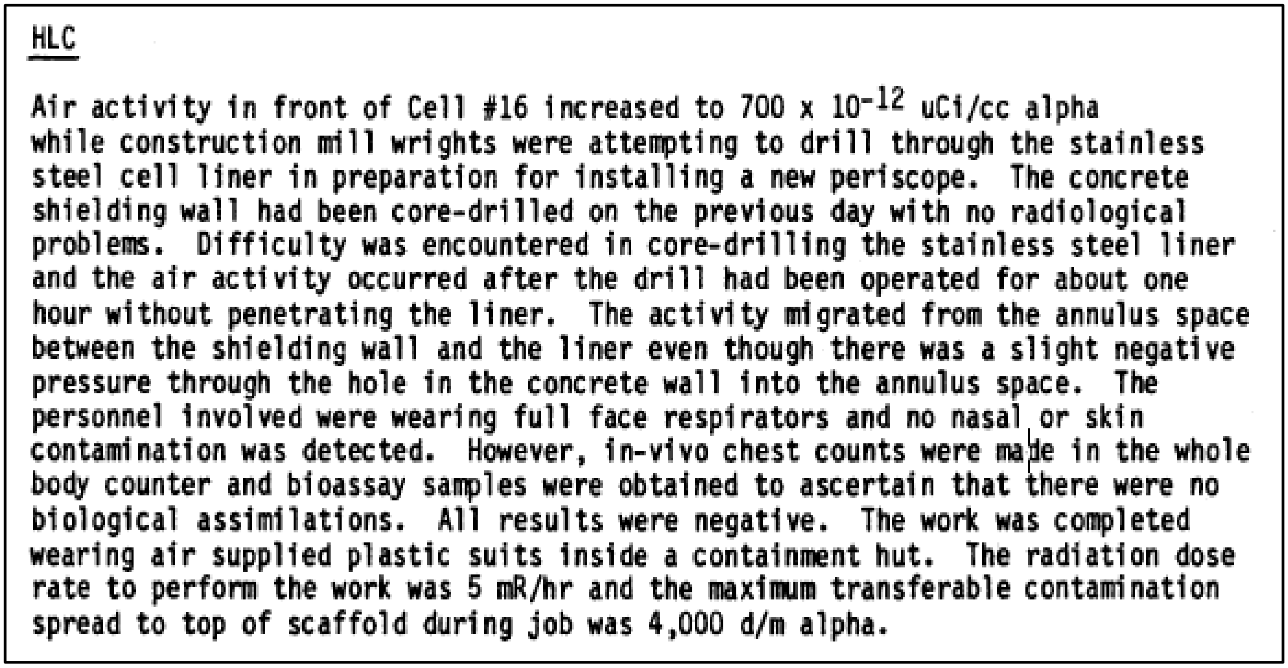
Radiation Control personnel effected immediate decontamination of the individual. Subsequent bioassay data confirmed that an assimilation, estimated at less than 10% of maximum permissible body burden, had occurred.

Source: [DuPont 1980b, PDF pp. 290-295]

Figure B-1. Special hazard incident report, February 11, 1980.

Incident Result for June 1, 1983

Two subCTWs were contaminated while attempting to drill through a stainless-steel cell liner in preparation for installing a new periscope. Air activity was detected at 700 x 10^{-12} µCi/cc alpha. Both workers were monitored by nasal smear, chest counting, and urinalysis for a plutonium-americium mixture. All bioassay results were reported as negative [DuPont 1983d]. Figure B-2 provides the incident description and result.



HLC

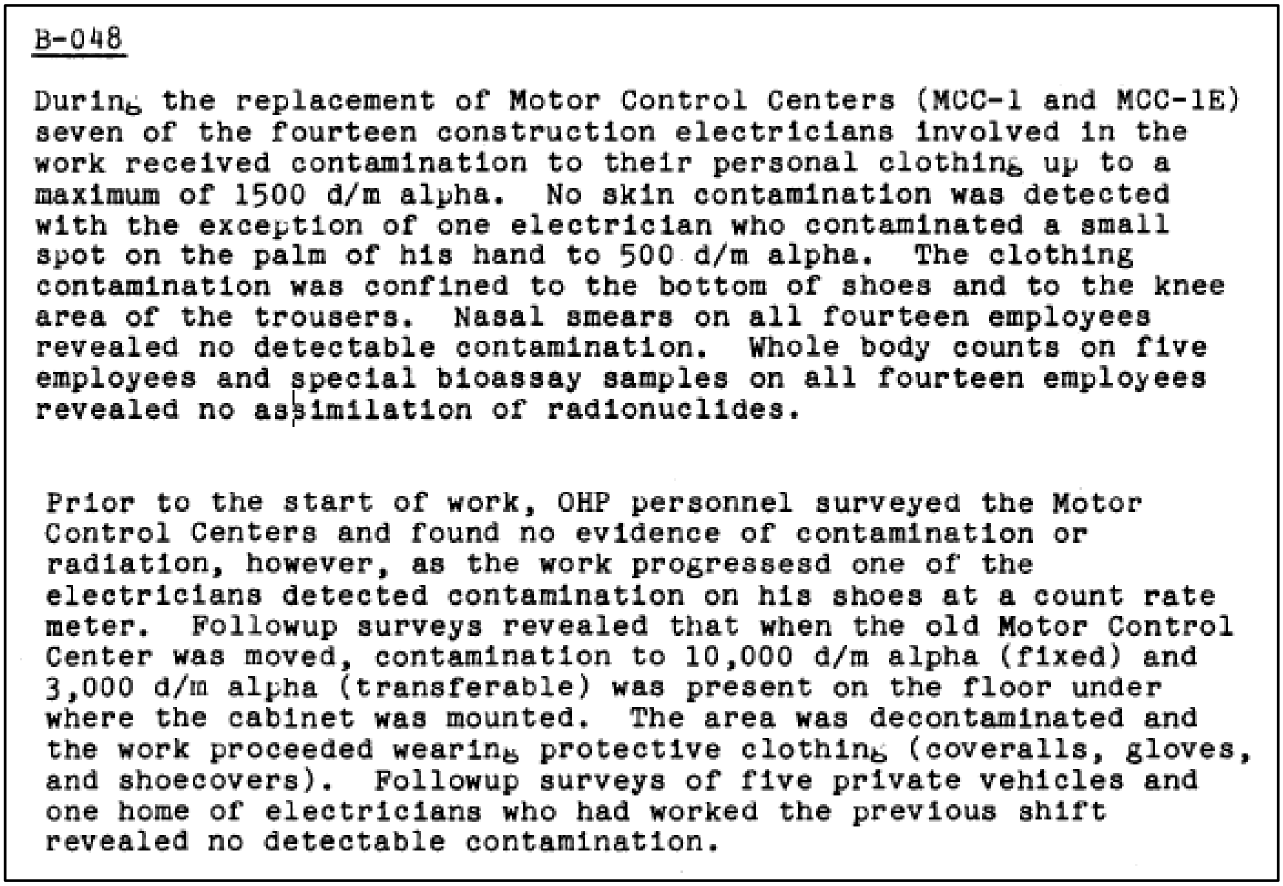
Air activity in front of Cell #16 increased to 700 x 10^{-12} uCi/cc alpha while construction mill wrights were attempting to drill through the stainless steel cell liner in preparation for installing a new periscope. The concrete shielding wall had been core-drilled on the previous day with no radiological problems. Difficulty was encountered in core-drilling the stainless steel liner and the air activity occurred after the drill had been operated for about one hour without penetrating the liner. The activity migrated from the annulus space between the shielding wall and the liner even though there was a slight negative pressure through the hole in the concrete wall into the annulus space. The personnel involved were wearing full face respirators and no nasal or skin contamination was detected. However, in-vivo chest counts were made in the whole body counter and bioassay samples were obtained to ascertain that there were no biological assimilations. All results were negative. The work was completed wearing air supplied plastic suits inside a containment hut. The radiation dose rate to perform the work was 5 mR/hr and the maximum transferable contamination spread to top of scaffold during job was 4,000 d/m alpha.

Source: [DuPont 1983d]

Figure B-2. Incident description, June 1, 1983.

Incident Result for November 12, 1983

Fourteen subCTWs were potentially contaminated after being exposed to an airborne mixture of plutonium and americium when replacing motor-control centers in 773-A. Nasal smears and special urinalysis (see also Table 6) were negative for all 14 workers [DuPont 1983e]. Figure B-3 provides the incident description and result.



B-048

During the replacement of Motor Control Centers (MCC-1 and MCC-1E) seven of the fourteen construction electricians involved in the work received contamination to their personal clothing up to a maximum of 1500 d/m alpha. No skin contamination was detected with the exception of one electrician who contaminated a small spot on the palm of his hand to 500 d/m alpha. The clothing contamination was confined to the bottom of shoes and to the knee area of the trousers. Nasal smears on all fourteen employees revealed no detectable contamination. Whole body counts on five employees and special bioassay samples on all fourteen employees revealed no assimilation of radionuclides.

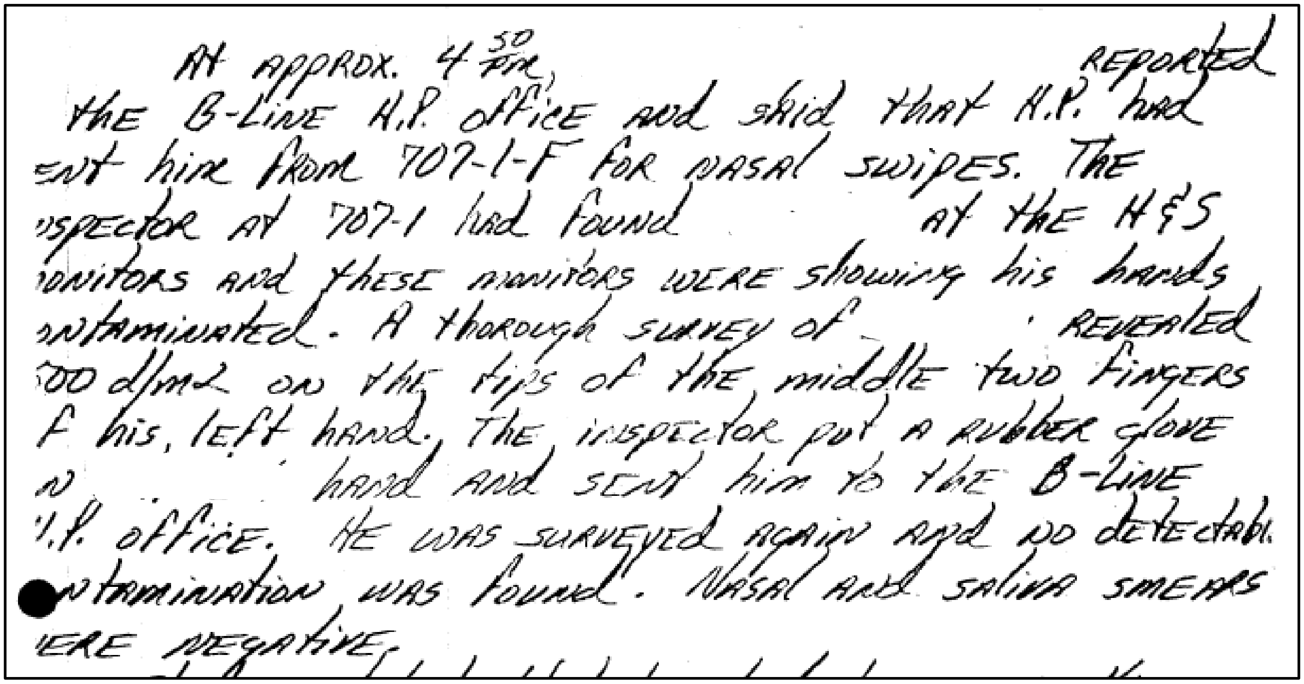
Prior to the start of work, OHP personnel surveyed the Motor Control Centers and found no evidence of contamination or radiation, however, as the work progressesd one of the electricians detected contamination on his shoes at a count rate meter. Followup surveys revealed that when the old Motor Control Center was moved, contamination to 10,000 d/m alpha (fixed) and 3,000 d/m alpha (transferable) was present on the floor under where the cabinet was mounted. The area was decontaminated and the work proceeded wearing protective clothing (coveralls, gloves, and shoecovers). Followup surveys of five private vehicles and one home of electricians who had worked the previous shift revealed no detectable contamination.

Source: [DuPont 1983e]

Figure B-3. Incident description, November 12, 1983.

Incident Result for February 27, 1985

A subCTW's clothing was found to be contaminated after working in FB Line. The worker was monitored by nasal smear, chest-counting, and urinalysis for plutonium and americium. The initial chest count suggested an intake of 0.24 nCi of Am-241; however, a follow-up special urinalysis was negative [DuPont 1985b, PDF pp. 234-236]. Figures B-4 through B-6 provide a description of the incident and the results of some of the worker bioassays.

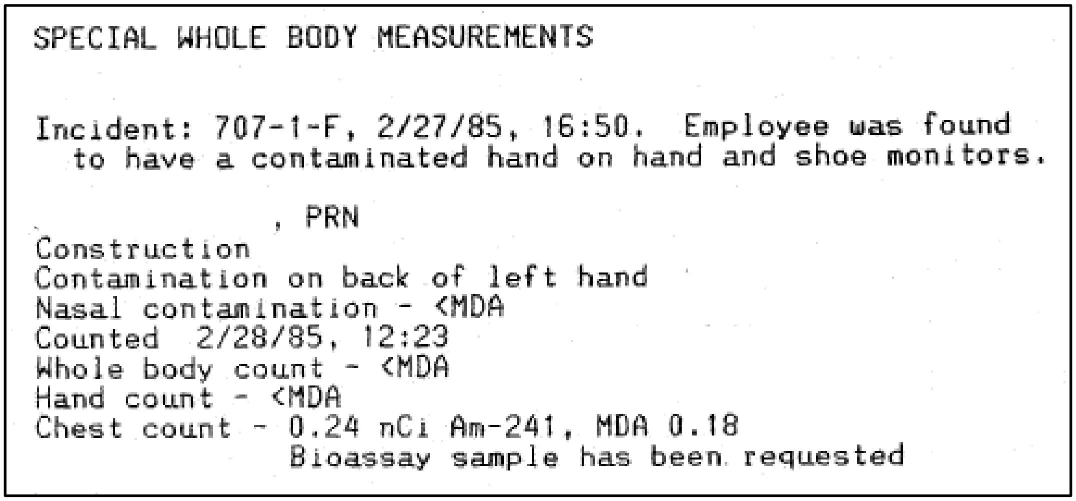


At approx. 4^{50} PM, reported
the B-Line H.P. office and said that H.P. had
ent him from 707-1-F for nasal swipes. The
spector at 707-1 had found at the H&S
onitors and these monitors were showing his hands
ntaminated. A thorough survey of revealed
00 d/mα on the tips of the middle two fingers
f his, left hand, The inspector put a rubber glove
n hand and sent him to the B-Line
.P. office. He was surveyed again and no detectab
ntamination was found. Nasal and saliva smears
ere negative.

Source: [DuPont 1985b, PDF p. 236]

Figure B-4. Incident description, February 27, 1985.

The handwritten note above reads: At approximately 4:50 PM, [redacted] #[redacted] reported [to] the B-Line H.P. office and said that H.P. had sent him from 707-1-F for nasal swipes. The inspector at 707-1 had found [redacted] at the H&S [hand and shoe] monitors and these monitors were showing his hands contaminated. A thorough survey of [redacted] revealed 500 dpm alpha on the tips of the middle two fingers of his left hand. The inspector put a rubber glove in [redacted] hand and sent him to the B-Line H.P. Office. He was surveyed again and no detectable contamination was found. Nasal and saliva smears were negative.



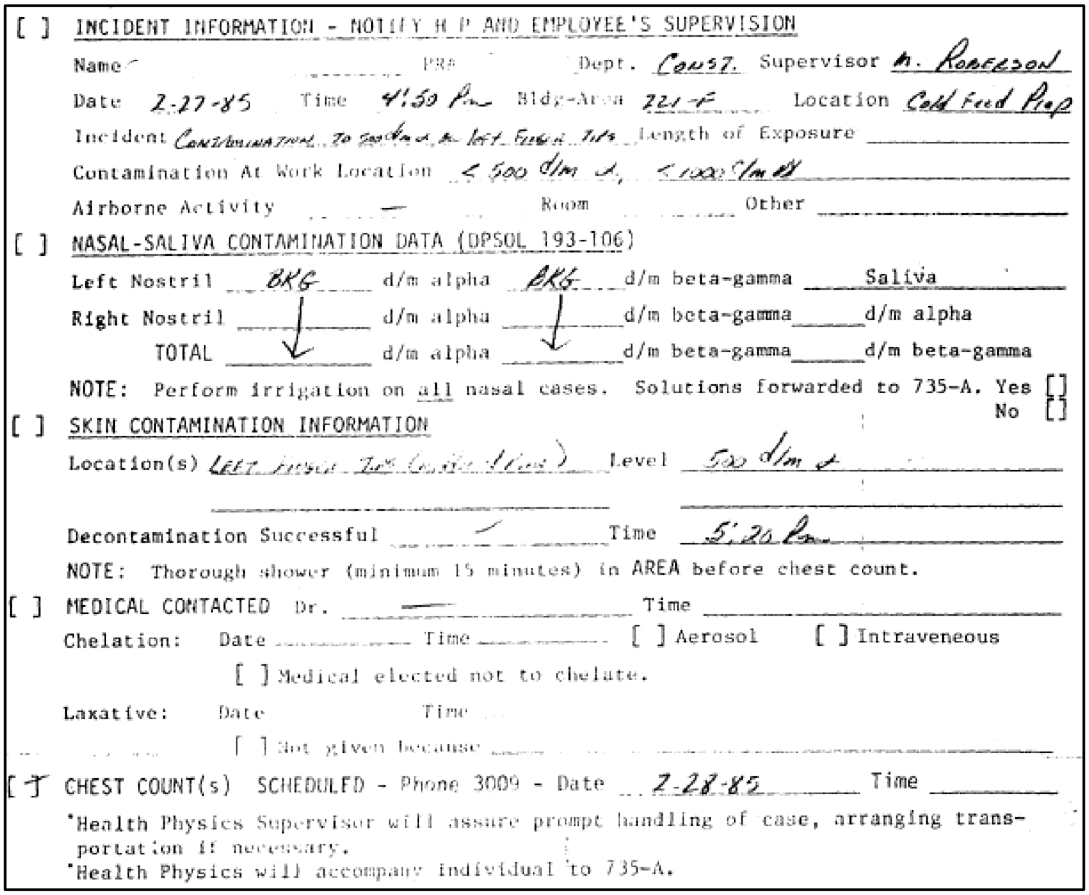
SPECIAL WHOLE BODY MEASUREMENTS

Incident: 707-1-F, 2/27/85, 16:50. Employee was found to have a contaminated hand on hand and shoe monitors.

, PRN
Construction
Contamination on back of left hand
Nasal contamination - <MDA
Counted 2/28/85, 12:23
Whole body count - <MDA
Hand count - <MDA
Chest count - 0.24 nCi Am-241, MDA 0.18
Bioassay sample has been requested

Source: [DuPont 1985b, PDF p. 234]

Figure B-5. Special bioassay results, February 27, 1985.



☐ INCIDENT INFORMATION - NOTIFY H P AND EMPLOYEE'S SUPERVISION

Name PRN Dept. CONST. Supervisor A. ROBERSON
Date 2-27-85 Time 4:50 Pm Bldg-Area 221-F Location Cold Feed Prep
Incident CONTAMINATION TO BACK & LEFT FINGER TIPS Length of Exposure
Contamination At Work Location < 500 d/m α, < 1000 d/m βγ
Airborne Activity — Room Other

☐ NASAL-SALIVA CONTAMINATION DATA (DPSOL 193-106)

Left Nostril BKG d/m alpha BKG d/m beta-gamma Saliva
Right Nostril ↓ d/m alpha ↓ d/m beta-gamma ____ d/m alpha
TOTAL ____ d/m alpha ____ d/m beta-gamma ____ d/m beta-gamma

NOTE: Perform irrigation on all nasal cases. Solutions forwarded to 735-A. Yes ☐ No ☐

☐ SKIN CONTAMINATION INFORMATION

Location(s) LEFT FINGER TIPS ([illegible]) Level 500 d/m α

Decontamination Successful ✓ Time 5:20 Pm

NOTE: Thorough shower (minimum 15 minutes) in AREA before chest count.

☐ MEDICAL CONTACTED Dr. — Time
Chelation: Date Time ☐ Aerosol ☐ Intraveneous
☐ Medical elected not to chelate.
Laxative: Date Time
☐ Not given because

☑ CHEST COUNT(s) SCHEDULED - Phone 3009 - Date 2-28-85 Time

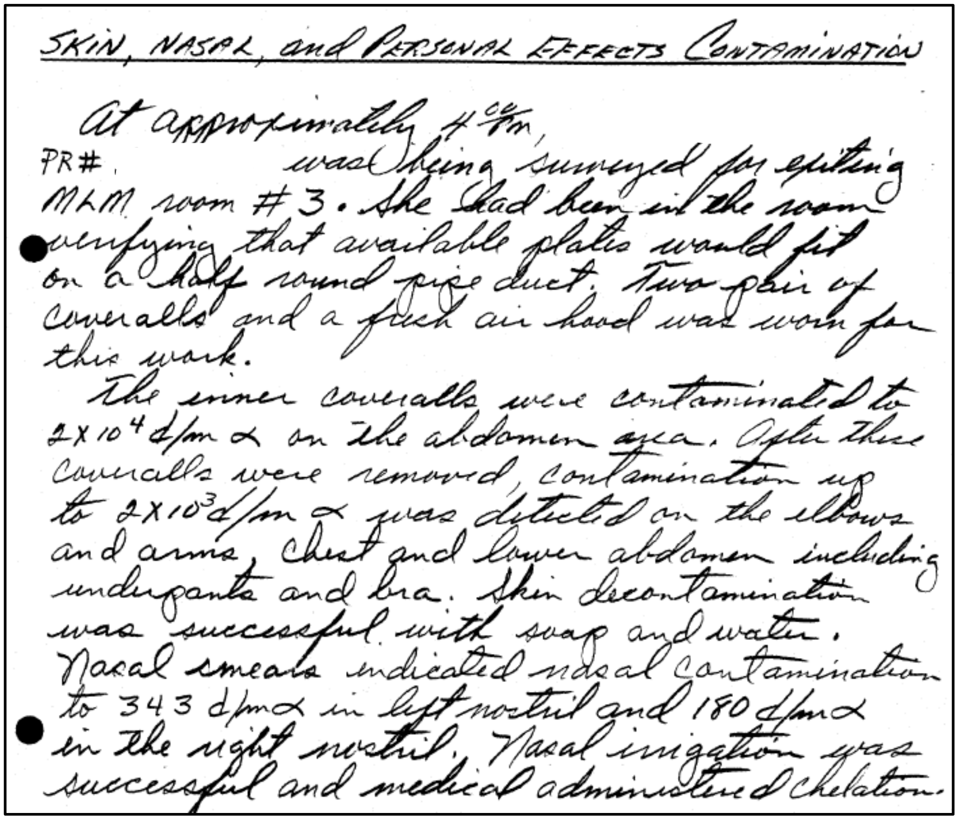
- Health Physics Supervisor will assure prompt handling of case, arranging transportation if necessary.
- Health Physics will accompany individual to 735-A.

Source: [DuPont 1985b, PDF p. 235]

Figure B-6. Additional incident information, February 27, 1985.

Incident Result for May 1, 1985

A subCTW was contaminated by a mixture of plutonium and americium while working in FB Line. The worker was analyzed by nasal smear, chest-count, and urinalysis. Nasal smears were positive and fecal analysis revealed that the subCTW received intakes of Pu-239 and Am-241 [DuPont 1985b, PDF pp. 197, 199]. Chelation was performed. Figures B-7 and B-8 provide the incident description and some bioassay results.



SKIN, NASAL, and PERSONAL EFFECTS CONTAMINATION

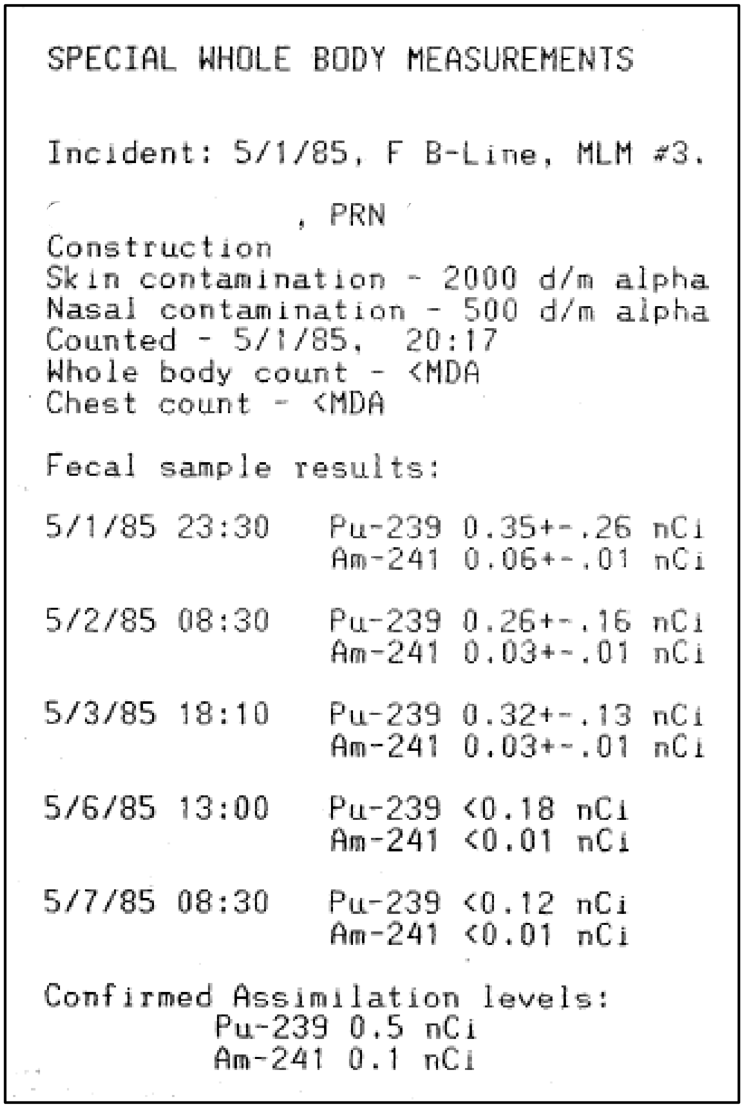
At approximately 4^{00} pm,
PR#. was being surveyed for exiting
MLM room #3. She had been in the room
verifying that available plates would fit
on a half round pipe duct. Two pair of
coveralls and a fresh air hood was worn for
this work.
The inner coveralls were contaminated to
2×10^4 d/m α on the abdomen area. After these
coveralls were removed, contamination up
to 2×10^3 d/m α was detected on the elbows
and arms, chest and lower abdomen including
underpants and bra. Skin decontamination
was successful with soap and water.
Nasal smears indicated nasal contamination
to 343 d/m α in left nostril and 180 d/m α
in the right nostril. Nasal irrigation was
successful and medical administered chelation.

Source: [DuPont 1985b, PDF p. 199]

Figure B-7. Incident description, May 1, 1985.

The handwritten note reads: At approximately 4:00 PM, [redacted] PR# [redacted] was being surveyed for exiting MLM room #3. She had been in the room verifying that available plates would fit on a half round pipe duct. Two pairs of coveralls and a fresh air hood was worn for this work.

The inner coveralls were contaminated to 2 x 10^4 d/m alpha on the abdomen area. After these coveralls were removed, contamination up to 2 x 10^3 d/m alpha was detected on the elbows and arms, chest and lower abdomen including underpants and bra. Skin decontamination was successful with soap and water. Nasal smears indicated nasal contamination to 343 d/m alpha in left nostril and 190 d/m alpha in the right nostril. Nasal irrigation was successful and medical administered chelation.



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SPECIAL WHOLE BODY MEASUREMENTS


Incident: 5/1/85, F B-Line, MLM #3.

               , PRN
Construction
Skin contamination - 2000 d/m alpha
Nasal contamination - 500 d/m alpha
Counted - 5/1/85,  20:17
Whole body count - <MDA
Chest count - <MDA

Fecal sample results:

5/1/85 23:30   Pu-239 0.35+-.26 nCi
               Am-241 0.06+-.01 nCi

5/2/85 08:30   Pu-239 0.26+-.16 nCi
               Am-241 0.03+-.01 nCi

5/3/85 18:10   Pu-239 0.32+-.13 nCi
               Am-241 0.03+-.01 nCi

5/6/85 13:00   Pu-239 <0.18 nCi
               Am-241 <0.01 nCi

5/7/85 08:30   Pu-239 <0.12 nCi
               Am-241 <0.01 nCi

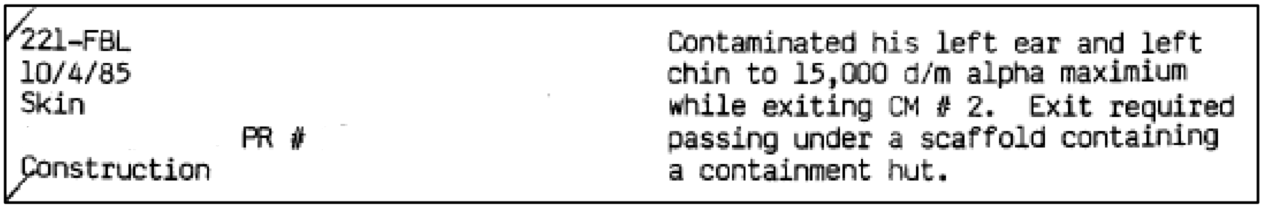
Confirmed Assimilation levels:
         Pu-239 0.5 nCi
         Am-241 0.1 nCi
```

Source: [DuPont 1985b, PDF p. 197]

Figure B-8. Special bioassay results, May 1, 1985.

Incident Result for October 4, 1985

The face of a subCTW was contaminated by a mixture of plutonium and americium while working in FB Line [DuPont 1983-1988, PDF p. 143]. Urinalysis was negative for both radionuclides. Figure B-9 provides a short incident description.



221-FBL
10/4/85
Skin
PR #
Construction

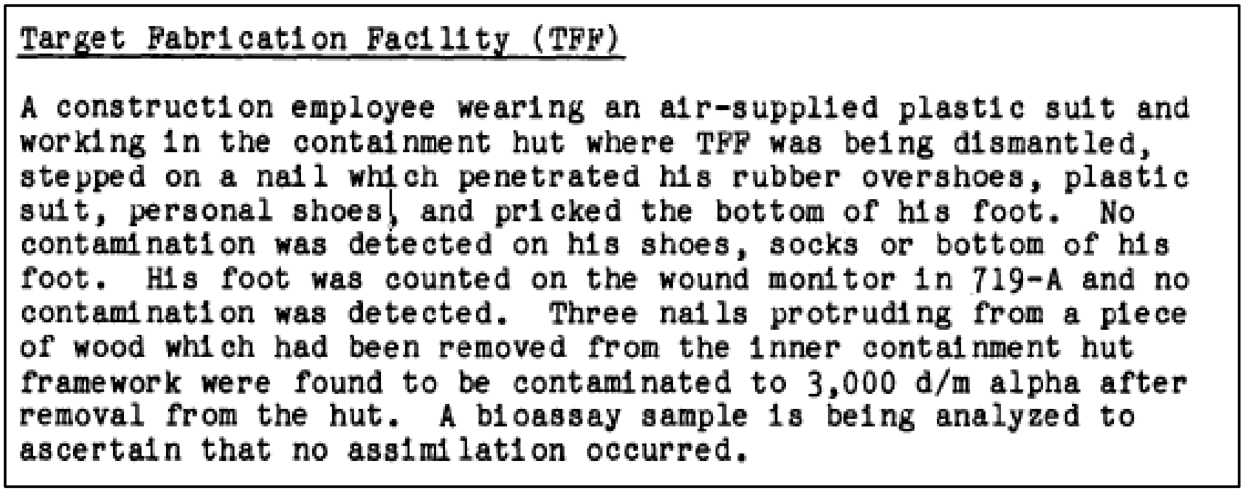
Contaminated his left ear and left chin to 15,000 d/m alpha maximium while exiting CM # 2. Exit required passing under a scaffold containing a containment hut.

Source: [DuPont 1983–1988, PDF p. 143]

Figure B-9. Incident description, October 4, 1985.

Incident Result for July 29th, 1986

A subCTW employee was injured after stepping on a nail in the Target Fabrication Facility (F-Wing) at 773-A. Urine bioassay results revealed no measurable intakes of plutonium or americium [DuPont 1986a]. Figure B-10 provides an incident description.



Target Fabrication Facility (TFF)

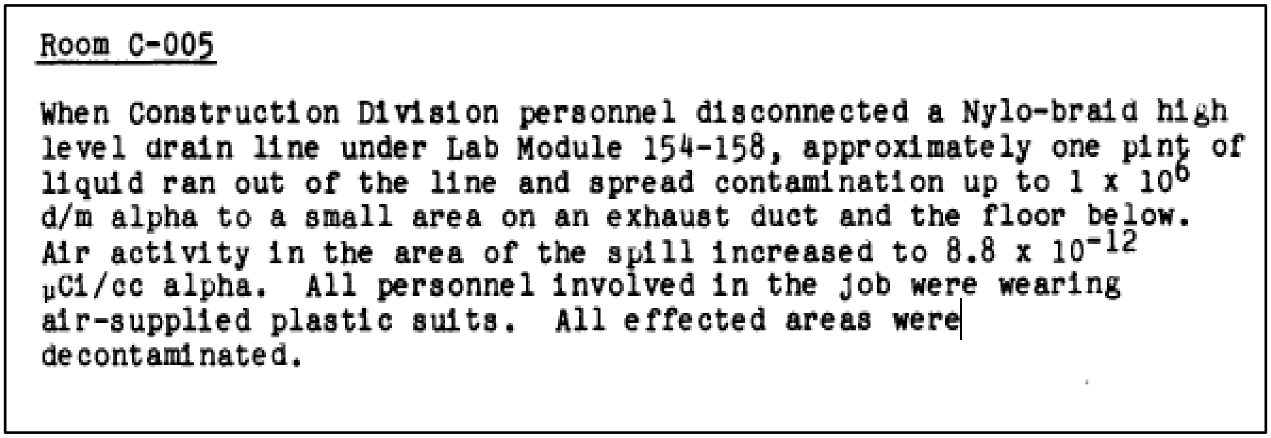
A construction employee wearing an air-supplied plastic suit and working in the containment hut where TFF was being dismantled, stepped on a nail which penetrated his rubber overshoes, plastic suit, personal shoes, and pricked the bottom of his foot. No contamination was detected on his shoes, socks or bottom of his foot. His foot was counted on the wound monitor in 719-A and no contamination was detected. Three nails protruding from a piece of wood which had been removed from the inner containment hut framework were found to be contaminated to 3,000 d/m alpha after removal from the hut. A bioassay sample is being analyzed to ascertain that no assimilation occurred.

Source: [DuPont 1986a, PDF p. 6]

Figure B-10. Incident description, July 29, 1986.

Incident Result for September 11, 1986

A subCTW was contaminated while removing an abandoned high-level drain header in C-005, 773-A [DuPont 1986b]. Urinalysis for Pu-239 and Am-241 was negative for both radionuclides [DuPont 1986–1989, PDF pp. 36–37]. Figure B-11 provides a description of the incident, which also involved DuPont personnel.



Room C-005

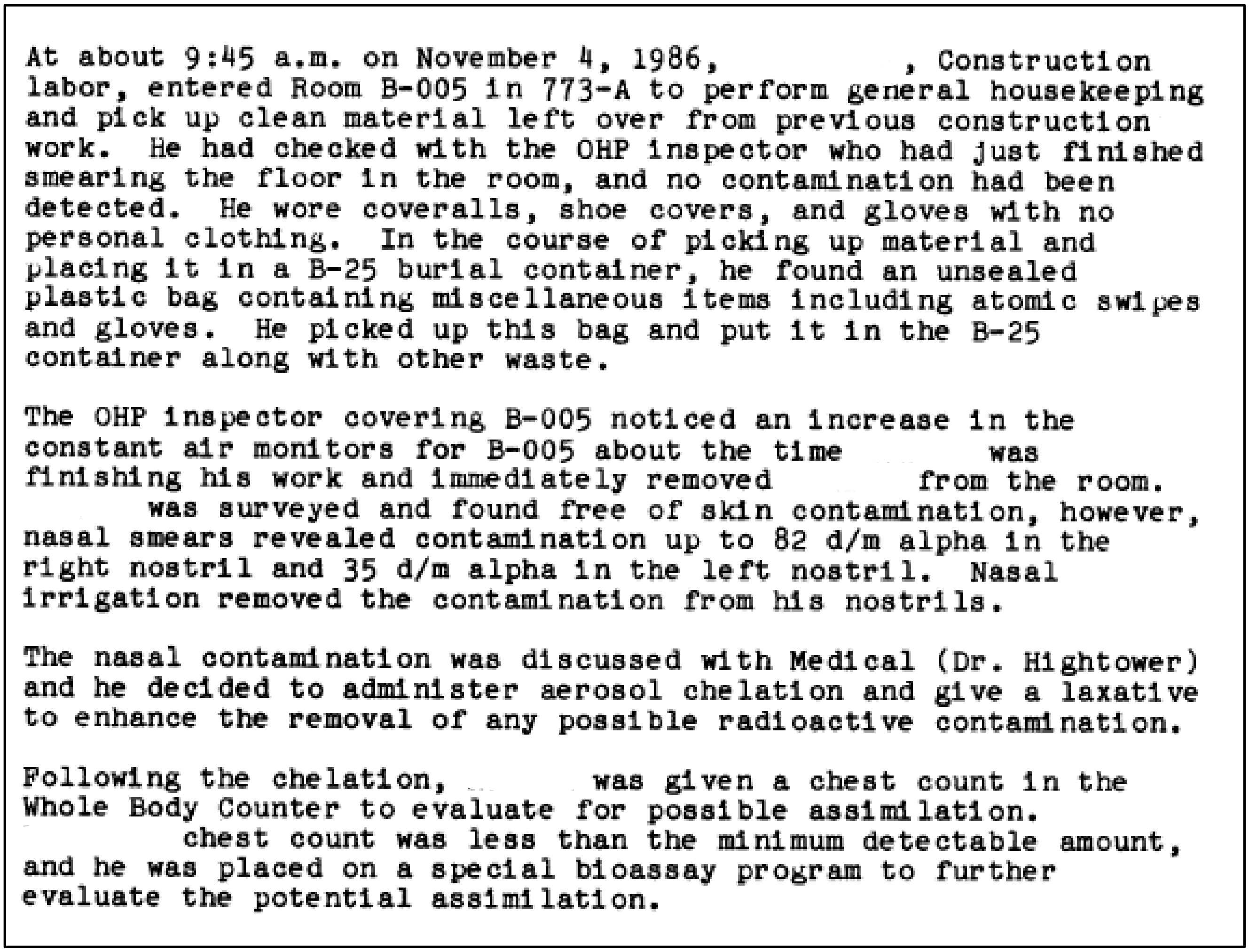
When Construction Division personnel disconnected a Nylo-braid high level drain line under Lab Module 154-158, approximately one pint of liquid ran out of the line and spread contamination up to 1×10^6 d/m alpha to a small area on an exhaust duct and the floor below. Air activity in the area of the spill increased to 8.8×10^{-12} μCi/cc alpha. All personnel involved in the job were wearing air-supplied plastic suits. All effected areas were decontaminated.

Source: [DuPont 1986b; DuPont 1986–1989, PDF pp. 36–37]

Figure B-11. Incident description, September 11, 1986.

Incident Result for November 4, 1986

A subCTW sustained low-level nasal contamination after picking up a bag of unsealed waste [DuPont 1986c; DuPont 1986d, PDF pp 4-10]. Health Physics determined that the bag was contaminated with 100,000 dpm alpha, which was later determined to be a mixture of plutonium and americium. Urinalysis bioassay revealed that the worker received intakes of both Pu-239 and Am-241 [DuPont 1986–1989, PDF pp. 80–81]. Figures B-12 and B-13 provide the incident description and the Health Physics Radiation Survey Logsheet.



At about 9:45 a.m. on November 4, 1986, , Construction labor, entered Room B-005 in 773-A to perform general housekeeping and pick up clean material left over from previous construction work. He had checked with the OHP inspector who had just finished smearing the floor in the room, and no contamination had been detected. He wore coveralls, shoe covers, and gloves with no personal clothing. In the course of picking up material and placing it in a B-25 burial container, he found an unsealed plastic bag containing miscellaneous items including atomic swipes and gloves. He picked up this bag and put it in the B-25 container along with other waste.

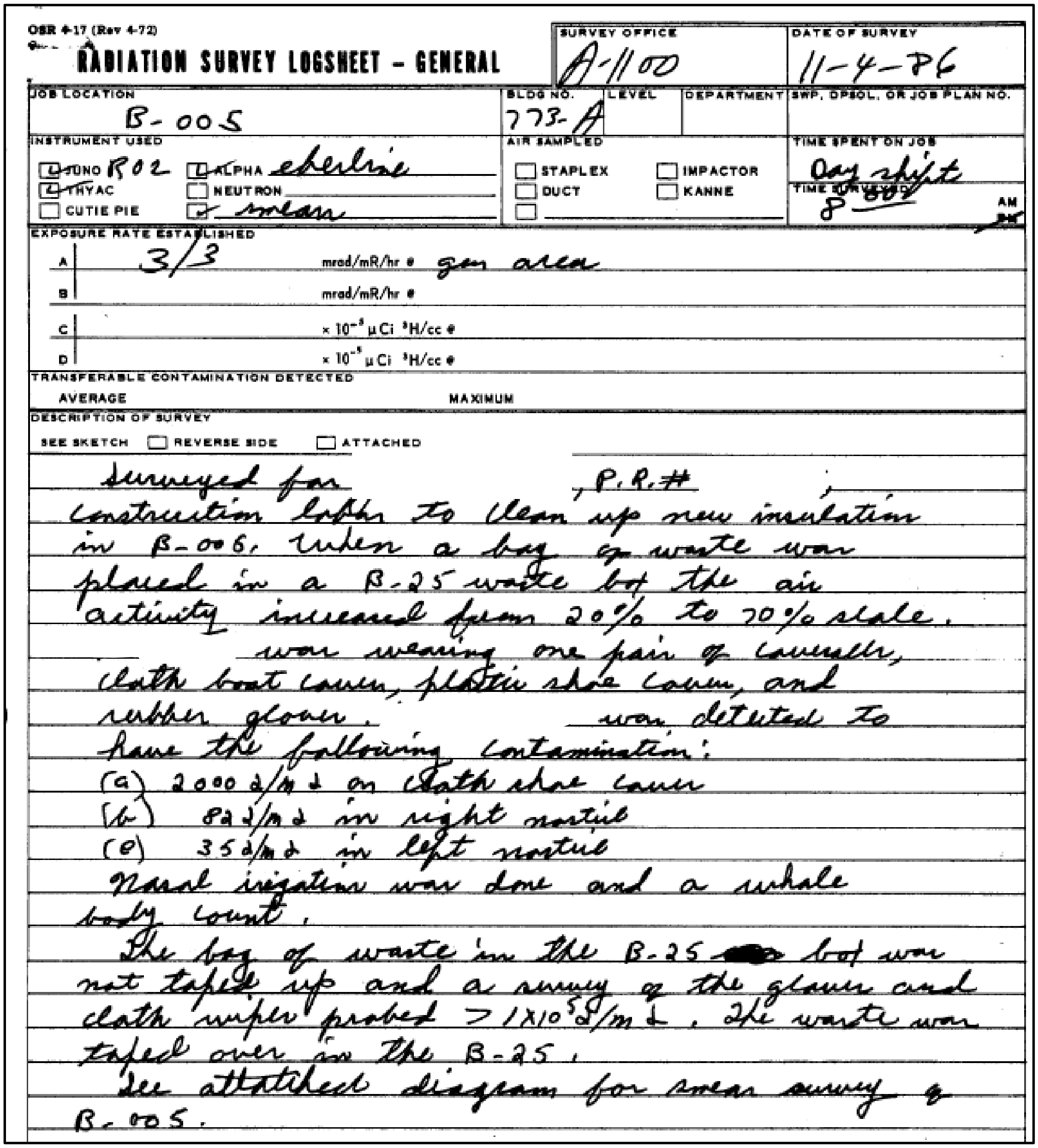
The OHP inspector covering B-005 noticed an increase in the constant air monitors for B-005 about the time was finishing his work and immediately removed from the room. was surveyed and found free of skin contamination, however, nasal smears revealed contamination up to 82 d/m alpha in the right nostril and 35 d/m alpha in the left nostril. Nasal irrigation removed the contamination from his nostrils.

The nasal contamination was discussed with Medical (Dr. Hightower) and he decided to administer aerosol chelation and give a laxative to enhance the removal of any possible radioactive contamination.

Following the chelation, was given a chest count in the Whole Body Counter to evaluate for possible assimilation. chest count was less than the minimum detectable amount, and he was placed on a special bioassay program to further evaluate the potential assimilation.

Source: [DuPont 1986c; DuPont 1986d, PDF p. 7]

Figure B-12. Incident description, November 4, 1986.



OSR 4-17 (Rev 4-72)

RADIATION SURVEY LOGSHEET – GENERAL

SURVEY OFFICE: A-1100

DATE OF SURVEY: 11-4-86

JOB LOCATION: B-005

BLDG NO.: 773-A

LEVEL:

DEPARTMENT:

SWP, DPSOL, OR JOB PLAN NO.:

INSTRUMENT USED:
☑ JUNO R02
☑ ALPHA eberline
☑ THYAC
☐ NEUTRON
☐ CUTIE PIE
☑ smear

AIR SAMPLED:
☐ STAPLEX
☐ IMPACTOR
☐ DUCT
☐ KANNE
☐

TIME SPENT ON JOB: Day shift

TIME SURVEYED: 8 00 AM PM

EXPOSURE RATE ESTABLISHED
A 3/3 mrad/mR/hr @ gen area
B mrad/mR/hr @
C $\times 10^{-5}$ µCi ^{3}H/cc @
D $\times 10^{-5}$ µCi ^{3}H/cc @

TRANSFERABLE CONTAMINATION DETECTED
AVERAGE MAXIMUM

DESCRIPTION OF SURVEY
SEE SKETCH ☐ REVERSE SIDE ☐ ATTACHED

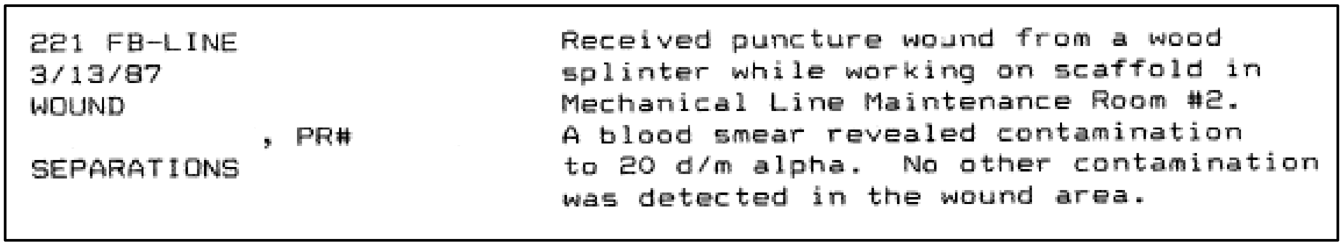
surveyed for , P.R.# ;
construction labor to clean up new insulation
in B-006. When a bag of waste was
placed in a B-25 waste box the air
activity increased from 20% to 70% scale.
was wearing one pair of coveralls,
cloth boot covers, plastic shoe covers, and
rubber gloves. was detected to
have the following contamination:
(a) 2000 d/m α on cloth shoe cover
(b) 82 d/m α in right nostril
(c) 35 d/m α in left nostril
Nasal irrigation was done and a whole
body count.
The bag of waste in the B-25 box was
not taped up and a survey of the gloves and
cloth wipes probed $> 1 \times 10^5$ d/m α. The waste was
taped over in the B-25.
See attached diagram for smear survey of
B-005.

Source: [DuPont 1986d]

Figure B-13. Radiation survey logsheet, November 4, 1986.

Result for March 13, 1987

A subCTW's hand was punctured while working in FB Line Mechanical Line Maintenance Room #2. Urinalysis for both Pu-239 and Am-241 was negative [DuPont 1983-1988, PDF p. 68; DuPont 1986–1989, PDF pp. 96–97]. Figure B-14 provides a description of the incident.



221 FB-LINE
3/13/87
WOUND
, PR#
SEPARATIONS

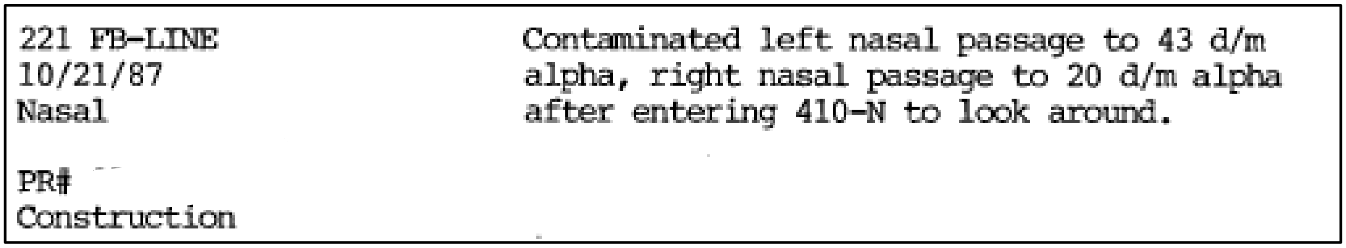
Received puncture wound from a wood splinter while working on scaffold in Mechanical Line Maintenance Room #2. A blood smear revealed contamination to 20 d/m alpha. No other contamination was detected in the wound area.

Source: [DuPont 1983–1988, PDF p. 68; DuPont 1986–1989, PDF pp. 96–97]

Figure B-14. Incident description, March 13, 1987.

Incident Result for October 21, 1987

A subCTW's right nasal passage was contaminated while working in FB Line, Room 410-N. Nasal smears were positive. Follow-up special urinalysis for Pu-239 and Am-241 revealed that the worker received intakes of both radionuclides [DuPont 1983-1988, PDF p. 120; DuPont 1986–1989]. The description of the incident is shown in Figure B-15.



221 FB-LINE
10/21/87
Nasal

PR#
Construction

Contaminated left nasal passage to 43 d/m alpha, right nasal passage to 20 d/m alpha after entering 410-N to look around.

Source: [DuPont 1983–1988, PDF p. 120; DuPont 1986–1989]

Figure B-15. Incident description, October 21, 1987.