Draft

ADVISORY BOARD ON
RADIATION AND WORKER HEALTH

National Institute for Occupational Safety and Health

Evaluation of Monitoring Practices for Claimants at Argonne National Laboratory–West

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Prepared by

Amy Meldrum, MS
Bob Barton, CHP

SC&A, Inc.
1608 Spring Hill Road, Suite 400
Vienna, Virginia 22182

Saliant, Inc.
5579 Catholic Church Road
Jefferson, Maryland 21755

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PROJECT MANAGER:	John Stiver
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ABBREVIATIONS AND ACRONYMS

ABRWH	Advisory Board on Radiation and Worker Health
ANL-E	Argonne National Laboratory–East
ANL-W	Argonne National Laboratory–West
ANP	Aircraft Nuclear Propulsion Facility
ATR	Advanced Test Reactor
BWR	boiling-water reactor
CATI	computer-assisted telephone interview
CPP	Chemical Processing Plant
CFA	Central Facilities Area
DOE	U. S. Department of Energy
DOL	U.S. Department of Labor
EBR	Experimental Breeder Reactor
EE	energy employee
EEOICPA	Energy Employees Occupational Illness Compensation Program Act
ER	Evaluation Report
GE	General Electric
HP	health physics
ICPP	Idaho Chemical Processing Plant
INEL	Idaho National Engineering Laboratory
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LFC	location file card
mrem	millirem
MTR	Materials Test Reactor
NIOSH	National Institute for Occupational Safety and Health
NOCTS	NIOSH OCAS Claims Tracking System
NRF	Naval Reactors Facility
PBF	Power Burst Facility
PPE	personal protective equipment
R&D	research and development
RWMC	Radioactive Waste Management Complex

SEC	Special Exposure Cohort
TAN	Test Area North
TBD	technical basis document
TLD	thermoluminescent dosimeter
TRA	Test Reactor Area
TREAT	Transient Reactor Test Facility

1.0 INTRODUCTION AND BACKGROUND

The National Institute for Occupational Safety and Health (NIOSH) released its evaluation for Special Exposure Cohort (SEC) Petition 224 on February 18, 2016 (NIOSH 2016). In that evaluation report (ER), NIOSH determined that insufficient individual monitoring data, area exposure, and/or source term information exist to reconstruct internal and external doses to Argonne National Laboratory–West (ANL-W) personnel prior to December 31, 1957. Subsequent to this date, NIOSH has determined that sufficient individual external dosimetry and internal monitoring for fission and activation products[1] exist to allow for the feasibility of sufficiently accurate dose reconstructions under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA).

The findings of NIOSH's SEC ER were presented and discussed with the Advisory Board on Radiation and Worker Health (ABRWH, hereafter referred to as "the Board") on March 23, 2016. At that time, the Board voted unanimously to accept NIOSH's conclusion that dose reconstruction was infeasible for the period of April 10, 1951, through December 31, 1957. Concurrently, the Board tasked SC&A, Inc. with the review of NIOSH's SEC ER findings concerning dose reconstruction feasibility post-1957.

As part of that review, SC&A evaluated personal radiation monitoring data (internal and external) for a set of 50 randomly selected ANL-W claimants. This represents approximately 14% (50 out of 352) of the overall claimant population as of the writing of this report. The purpose of this study was to determine the extent and sufficiency of internal and external monitoring records for the purposes of reconstructing external dose from penetrating (photon and neutron) and non-penetrating (beta) radiation, as well as internal exposure from fission and activation products. Section 2 provides a general overview of the 50 randomly selected claimants, including job titles, primary employer, and covered employment dates. Further detail on each individual claimant is found in Appendix A.

However, as described in Section 2, SC&A did not feel the random selection of 50 claimants provided a clear characterization of the change in monitoring practices experienced by workers before and after the current SEC end date (December 31, 1957). Therefore, SC&A performed a focused review of 10 additional workers with a specific emphasis on available radiation monitoring both before and after this date. In addition, potential statements made in the energy employees' (EEs') computer-assisted telephone Interview (CATI) reports and U.S. Department of Labor (DOL) case files were also reviewed for qualitative information concerning the evolution of monitoring coverage at ANL-W during this period of interest.

SC&A's evaluation of the 50 randomly selected claimants, as well as the focused review of 10 claims spanning the SEC end date, resulted in the following four findings and six observations:

[1] NIOSH has adopted alternate methods for reconstructing internal exposures to alpha-emitting radionuclides (separated from fission products) that use area monitoring, not individual personal monitoring, and thus are beyond the scope of this report.

Finding 1: SC&A identified one claim that had a nearly 12-year period from 1964 to 1975 for which no external dosimetry exists. The EE was on a routine in vivo measurement schedule during this same period. It is recommended the claim be specifically investigated to determine why external monitoring records are not available for this time period, as well as to determine whether this is an isolated incident or evidence of a potential deficiency in external monitoring records as a whole. (See Section 3.1.1.)

Finding 2: Among internally monitored workers, a noted gap in routine monitoring was observed between 1973 and 1979. This time period should be investigated to understand and characterize potential changes in either the health physics program or operations at the site. It is recommended that NIOSH evaluate the adequacy of records during this period for the purpose of developing a coworker model to account for and bound unmonitored intakes during this period.

Finding 3: SC&A examined one claimant who had covered employment at ANL-W from 1956 into 1989. External monitoring records for the EE are not available until October 1963. Evidence suggests that the EE had non-zero external exposures prior to this time. The EE was monitored internally at ANL-W in 1958, 1960, 1962, and 1963. This claim should be investigated further with the site to determine the cause for the apparent gap in external dosimetry records.

Finding 4: Based on observed trends in sampled claimant data, it appears that significant changes in the external dosimetry program were put into effect at the end of March 1958 and not December 1957. NIOSH should consider a recommendation extending the SEC period into the first quarter of 1958.

Observation 1: SC&A observed some cases within its random sample for which only annual external dose summaries are available for some or all covered employment. In order to perform accurate best-estimate dose reconstructions, the individual dosimeter results are necessary for the correct application of assigned missed dose. This is especially true for neutrons, which were often monitored sporadically compared to the standard beta/gamma dosimetry practices. Finally, potential external badging gaps that may occur within a given year are unknown without obtaining the individual dosimetry cycle data.

Observation 2: Inspection of the cases exhibiting apparent gaps in the external dosimetry data (or lack of external dosimetry entirely) reveals that they often carry significant uncertainty regarding work history, location, duties, and associated exposure potential (see Tables 3 and 4 of Section 3.1). In many cases, reasonable explanations can be reached to understand why these observed gaps exist. In other cases, not enough information exists to make a reasonable determination why monitoring may appear to be deficient. It is not apparent whether further research, by either the U.S. Department of Energy (DOE) or DOL, would provide any additional clarity on such cases.

Observation 3: Case 40[2] illustrates an example situation where establishing covered employment for some claimants is extremely difficult, as there is often conflicting information. Therefore, when evaluating apparent temporal gaps in radiation monitoring, potentially valid explanations such as incorrect employment information must be considered and analyzed. This is especially true for subcontract workers. (See Section 3.1.2.)

Observation 4: Even among sampled workers who were most likely to require extremity monitoring on a semi-regular basis, extremity monitoring is often sparse from year to year for many workers. Nonetheless, it may be instructive for NIOSH to evaluate available extremity monitoring data to determine if the typical methods employed in DCAS-OTIB-0013 (DCAS 2010) are applicable and claimant favorable for ANL-W claimants.

Observation 5: Among sampled workers monitored for neutrons, records are often sparse on a year-by-year basis. SC&A noted that many of the worker job types in the random sample who were monitored for neutrons shared those same job designations with unmonitored workers. SC&A acknowledges that many, but not all, neutron dosimetry results are below the detection limit. The ER would benefit from a more substantive discussion and documentation of how workers were selected for neutron monitoring, and what particular activities warranted this designation. Additionally, examples of special investigations into unmonitored neutron exposures, as well as their frequency and causation, would be appropriate in establishing that assignment of unmonitored neutron dose is not necessary for ANL-W claims.

Observation 6: Based on a review of workers who were not monitored internally, it appears there are at least a few cases in which internal monitoring likely should have occurred but either did not occur or the records have been lost/destroyed. It is recommended that NIOSH explore the development of coworker intakes for fission products to account for such situations. This would also be consistent with current recommendations concerning coworker modeling for the Idaho National Laboratory (INL) site.

[2] Note: the case number designations used in the body of this report are for the purposes of this analysis only and do not represent actual claimant identifiers either directly or indirectly.

2.0 OVERVIEW OF RANDOMLY SELECTED CLAIMANT POPULATION

SC&A undertook a random selection process on the pool of claimants who had covered employment outside of the current SEC period. However, SC&A determined that certain claimants were likely not germane to the goals of this particular study and so discarded them. The rationale for discarded claims was mostly related to severe limitations in covered employment (i.e., only a few days or weeks). However, a few claims were also discarded because of dual covered employment at INL and ANL-W (with monitoring at INL), or because the EE was clearly only at ANL-W in a visitor capacity. This is not to say that all claims exhibiting these characteristics were discarded, as evidenced by the final population of 50 described in Appendix A. Professional judgment was used on the part of the reviewers to assess if a particular claim was useful for the purposes of this SEC investigation.

Figure 1 displays how many of the 50 randomly selected cases were employed at ANL-W by year. As seen in the figure, the years with the most claimants employed ranged from the mid-1960s to the early 1980s, with a maximum of 35 of 50 claimants in 1976. There were very few claims selected that had employment both before and after 1957.[3] Clearly, the evolution of radiation monitoring coverage and practices during the timeframe 1957–1958 is of particular import to the chosen SEC period. Therefore, SC&A elected to select an additional 10 claims with employment both before and after 1957 in order to characterize any observed changes in monitoring practices. These 10 additional claimants are discussed separately from the 50 randomly selected claims, in Section 5.11.

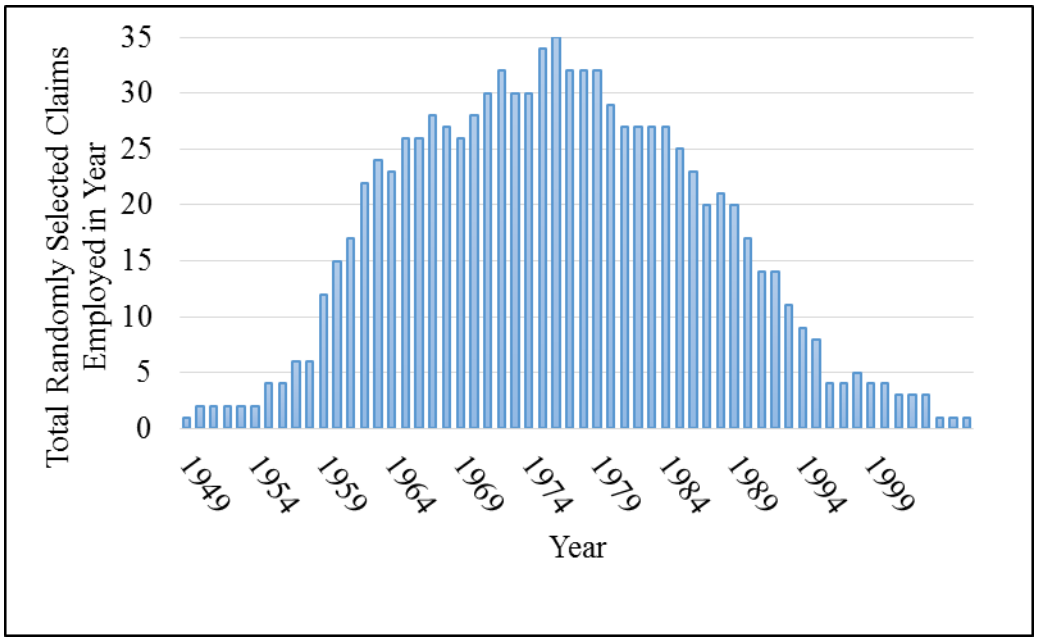


Figure 1. Total Number of Randomly Selected Claims Employed by Year

[3] Claims with employment only during the SEC period were removed prior to the random selection process.

Figure 2 provides a breakdown of the EEs' employer for all 50 randomly selected claims. Not surprisingly, over three quarters of the claims were employed by ANL-W (the prime contractor). About 18% worked for various subcontractors during their ANL-W employment. The 4% contained in the "other" portion represents two randomly selected claims who worked for Aerojet Nuclear Corporation. These were not included in either the prime contractor or subcontractor category for ANL-W because it is assumed those workers were actually employed by the INL prime contractor and were "borrowed out" to ANL-W. Both claims exhibited relatively short employment durations at ANL-W.

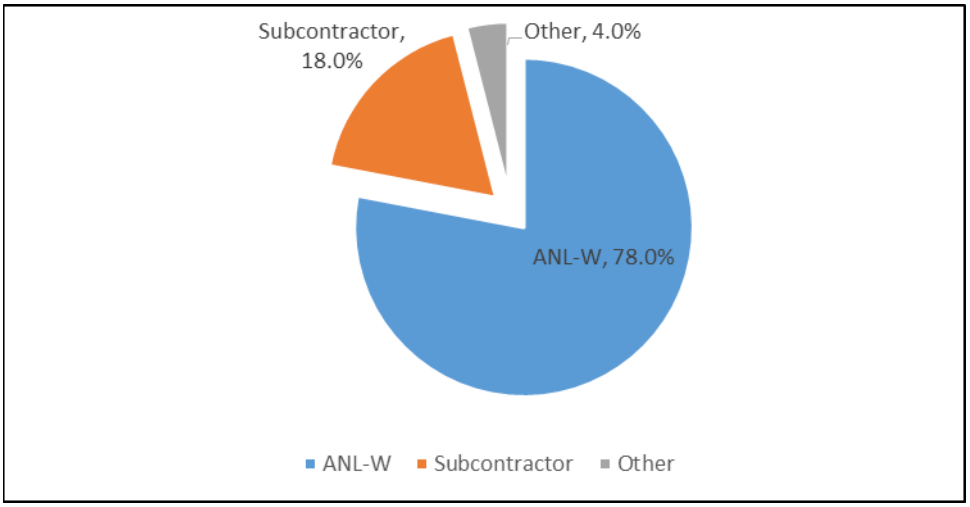


Figure 2. Breakdown of 50 Randomly Selected Claims by Employer

Figure 3 presents a breakdown of the 50 claims by job category. Although the actual job titles of all 50 claimants varied significantly, reasonable judgments were made in placing a specific job title into the broader categories. Table 1 shows how the actual job titles were categorized. As seen in Figure 3, the top three job categories were "maintenance/construction," "reactor operations," and "engineer/technician." These positions constitute 70% of the randomly selected claimant population, which is certainly acceptable as these would be the positions expected to have been involved with the work that had the highest exposure potential. Other categories included scientists, custodians, security, administrative positions, and health physics. As seen in Table 1, the "other" category represented a single claimant who mostly performed photographic documentation work at the site. While the 50 selected claimants can be considered a random cross-section of the ANL-W claimant population, it is unknown at this time what the overall distribution of job categories would be for all claimants.

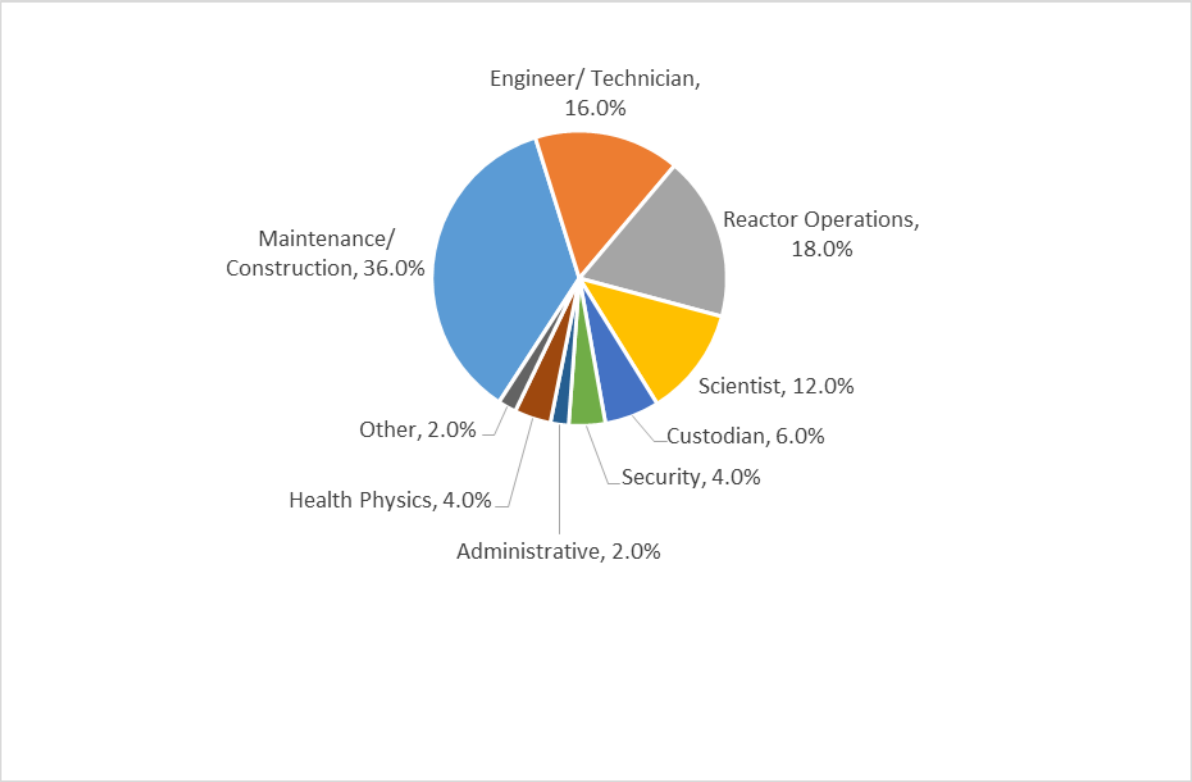


Figure 3. Breakdown of 50 Randomly Selected Claims by Job Title

Table 1. Overview of Job Titles Actually Included in Each Job Category by SC&A

Job Category	Job Titles Included
Maintenance/ Construction	Pipefitter (2), Maintenance (2), Ironworker, Maintenance [redacted], Millwright/Electrical Helper/Machinist, Plumber/Pipefitter, [redacted] Mason, Maintenance/Supply Manager/Production [redacted], Heavy Equipment Operator, Roofer, Mason, [redacted] Maintenance, Carpenter, Laborer/Yardman, Maintenance [redacted] /Technician
Engineer/ Technician	Engineering Technician [redacted] (4), [redacted] Electrical Engineer/Shift [redacted], Electronics Tech, Civil Engineer, Electrical Engineer
Reactor Operations	Operator Technician, Computer Scientist/Reactor Tech/[redacted] of Operations, Nuclear Power Plant Operator (2), Hot Cell Worker, Production [redacted], Reactor Operator, Reactor Operator/Technician/Operations Support Engineer/Chief Technician, [redacted] Operator
Scientists	Research [redacted], Nuclear Engineer, Scientist/[redacted], [redacted] Analytical Technician/Scientist (chemist), Research Technician, Analytical Chemist
Custodians	Custodian (3)
Security Personnel	Security Inspector [redacted], Laborer/Security Officer
Health Physics	Health Physics Tech (2)
Administrative Personnel	[redacted]
Other	Research Technician/Photographer/Industrial & Tech Photography [redacted] /Graphic Arts [redacted]

3.0 EXTERNAL MONITORING

SC&A compiled and analyzed the available external monitoring data for 50 randomly selected claims (with the exception of certain claims discarded for the reasons described in Section 2). This section provides the results of that evaluation. It is partitioned by the specific type of monitoring analyzed: standard beta/gamma dosimetry (Section 3.1), extremity monitoring (Section 3.2), and neutron dosimetry (Section 3.3).

3.1 TYPICAL BETA/GAMMA DOSIMETRY

The most common type of external monitoring at ANL-W is the standard sensitive beta/gamma dosimeter (both film badges and thermoluminescent dosimeters [TLDs] were used at the site). The majority of claimants reviewed in this effort can be considered to have comprehensive and complete beta/gamma dosimetry records. In fact, several cases displayed the characteristic of being assigned multiple dosimeters for different areas during a single badging period (see Cases 3–5, 10, 17, 21, 29, 35, 41, 42, 44, and 50).

However, it was observed that a few of the randomly selected cases only contained annual summaries of external dosimetry monitoring (see Cases 6, 9, 11, 19, and 43). It is assumed that the dosimetry records provided by DOE for these cases were transmitted relatively early in the EEOICPA program, before NIOSH began specifically requesting the individual dosimeter cycle reports. This issue was also observed during previous examination of INL cases.

In other cases, the EEs had individual dosimetry cycle records for all but a portion of their employment. The annual summaries for these claims indicate they were, in fact, monitored, even though individual dosimetry cycle data may be lacking (see Cases 8, 17, 25, 36, and 38). For these cases, it is unclear why the individual dosimetry cycle records were not complete, even though the annual summaries indicated monitoring occurred.

While the lack of individual dosimetry cycle data does not pose an issue in an SEC context, for the purposes of performing best-estimate dose reconstructions it is necessary that the individual results be obtained so that any missed dose assignment is accurately applied. This is especially important for neutrons, which were often monitored sporadically, if at all. However, the annual summaries simply provide a numerical value, which is often just a placeholder (i.e., listed as zero).

Additionally, it is not possible to determine whether monitoring gaps potentially exist within each year provided in the annual summary without receipt of the individual dosimetry cycle reports verifying if a badge was used during each applicable badging period. The only information that can be taken directly from the annual summary records is the determination that at some point during the year the EE was monitored externally.

Observation 1: SC&A observed some cases within its random sample for which only annual external dose summaries are available for some or all covered employment. In order to perform accurate best-estimate dose reconstructions, the individual dosimeter results are necessary for the correct application of assigned missed dose. This is especially true for neutrons, which were often monitored sporadically compared to the standard

beta/gamma dosimetry practices. Finally, potential external badging gaps that may occur within a given year are unknown without obtaining the individual dosimetry cycle data.

SC&A analyzed the number of badges read versus the number of days employed for the randomly selected claimants.[4] The average number of days of covered employment per dosimeter badge read was 112 days with a median of 44 days. In other words, at the median, the randomly sampled claim had 44 days between the exchange of an external dosimeter badge. The rank-ordered number of days worked per dosimeter badge is shown in Figure 4. As seen in the figure, aside from five claims (which can be considered outliers), the rest of the sampled workers had about 90 or less days worked per dosimetry badge exchange. Figure 5 shows the same data with the five outlier claims removed. These outlier claims are discussed in Table 2.

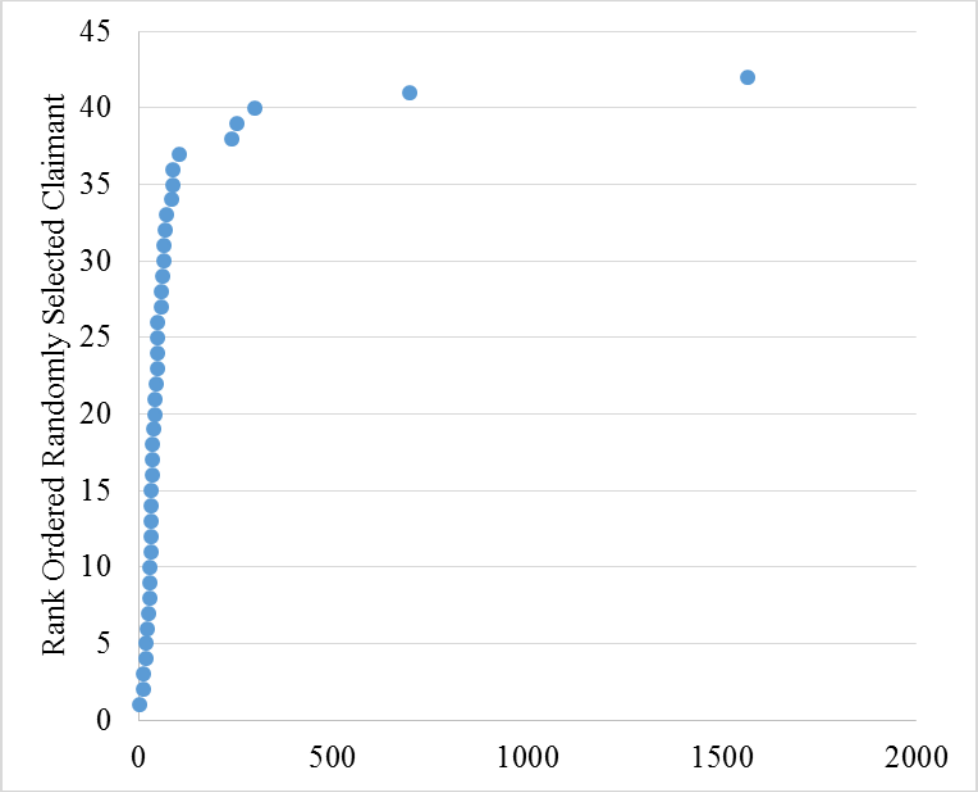


Figure 4. Rank-Ordered Plot of the Number of Days Worked per Badges Read for 42 Randomly Selected Workers

[4] Cases that were unmonitored or only had annual summary records were not included in this calculation. A total of 42 of the 50 randomly selected claims had cycle dosimetry data sufficient for inclusion.

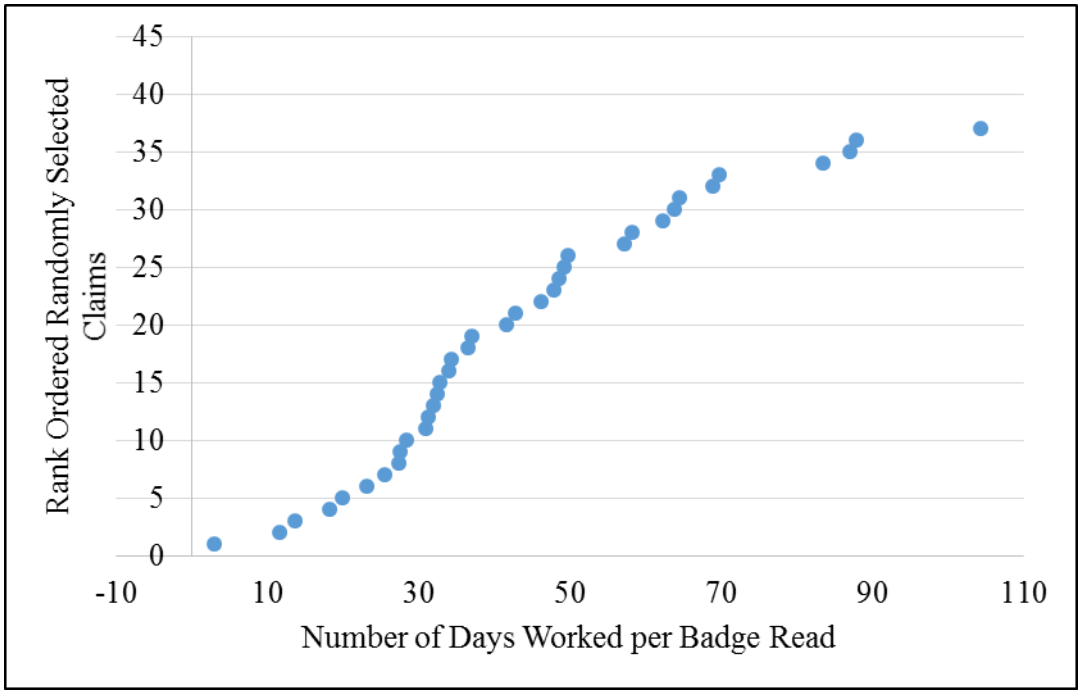


Figure 5. Rank-Ordered Plot of the Number of Days Worked per Badges Read for 42 Randomly Selected Workers with Five Outlier Claims Not Shown

Table 2. Description of Five Outlier Claims in Figure 4

Case #	Number of Days Worked per Badges Read	SC&A Comments
40	1,568	The EE was a pipefitter with 15 distinct covered employment periods while employed by multiple subcontractors. The EE only had two visitor badges associated with one month out of the nearly 9 years of employment. A discussion of the apparent gaps in the EE's employment is contained Table 3, with extensive detail provided in Section 3.1.1. In summary, there is considerable uncertainty in establishing the covered employment periods for this claimant.
15	698.5	The EE was a pipefitter/plumber in the 1990s. The EE was issued two visitor dosimeters but also 10 extremity (ring) dosimeters during that period. Extremity monitoring is discussed in Section 3.2 and is not included in the analysis of the standard beta/gamma monitoring. This claim is also discussed in Table 3.
2	299	The EE was a pipefitter who was actually unmonitored during the claimant's established employment,* as the observed dosimetry for ANL-W was prior to the covered employment designated by DOL. The ANL-W monitoring is actually enveloped by the period of covered employment assumed at INL. This claim is discussed in Table 3.
31	253	The EE was a roofer who had three distinct covered employment periods while employed by multiple subcontractors. This claim is discussed in Table 3. There is some question about at least one of the three employment periods actually occurring at ANL-W.
34	238.6	The EE worked in the radio alarm shop and performed maintenance on the [redacted] in multiple locations (including buildings at INL). The EE has multiple overlapping covered employment periods for both ANL-W and INL. Review dosimetry records provided by INL indicates that the EE was often badged out of Central Facilities Area (CFA) during many of these overlapping periods. This claim is also discussed in Table 3.

* Although technically this could be considered an "unmonitored" worker when strictly viewing the covered employment periods, the technical judgment was made to include this claimant with the group of workers who have monitoring data at ANL-W as opposed to the group of workers having never been monitored at ANL-W.

SC&A's review determined that there were 12 cases out of the 50 randomly sampled claims who had what appear to be gaps in external monitoring records based on a comparison of the EEs' covered employment and available dosimetry information. These 12 claims are described in Table 3. As discussed previously, claimants for whom gaps in individual dosimeter cycle records were observed, but who had annual dosimetry summaries covering these gaps, were not included in Table 3. Table 4 contains a similar discussion for sampled workers who were not monitored at all during the covered employment at ANL-W.

It is important to remember that a gap in the dosimetry records does not necessarily indicate a deficiency in the external monitoring program; rather, a gap could be an artifact of the uncertainty involved in accurately establishing a given claimant's covered employment periods and work sites. The reader is referred to the discussion of Case 40 in Section 3.1.2 (and Observation 3) on the difficulty of establishing exact work locations and time periods for some workers. This is especially true for subcontract workers.

However, in other cases it appears that gaps in external dosimetry are unwarranted. In these cases, either the EE likely should have been monitored or the dosimetry records for the

individual are currently incomplete. The reader is referred to the discussion of Case 1 in Section 3.1.1 and also Claim F in Section 5.6.

Table 3. Description of Randomly Surveyed Claimants with Apparent Gaps in External Beta/Gamma Dosimetry

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
1	[redacted]/1950–[redacted]/1989	Operator Technician	EE has gaps in external dosimetry from January 1964 through December 1975. Responses received from ANL-W indicate these gaps are likely a result of the EE going on [redacted]. SC&A does not agree with this determination for a variety of reasons, most notably the inclusion of the EE on a routine in vivo measurement schedule during this period. ***See Additional Discussion in Section 3.1.1.***
2	[redacted]/1970–[redacted]/1971 [redacted]/1971–[redacted]/1971	Pipefitter	No external monitoring occurred at ANL-W in 1970 or 1971. The EE has numerous covered employment periods at INL; however, none overlap with the assumed ANL-W employment. EE was monitored externally in 1962, which is outside the covered employment at ANL-W; however, the EE does have covered employment at INL for parts of 1962. Work specific to ANL-W was not mentioned by the EE in either the CATI or DOL case files. The EE worked for a subcontractor. No other information about potential exposures was identified in available records.
3	[redacted]/1960–[redacted]/1995	Computer Scientist, [redacted]	The EE was badged in multiple ANL-W areas for most of his career (see comment in paragraph 1 of Section 3.1). A single gap exists in the external monitoring records from July 1981 through September 1983. However, the badging record for July 1981 also indicates that it is a “termination” sample, and so it is entirely plausible the EE was not exposed at ANL-W during this period. The location file card also contains the note “term” in July of 1981.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
9	[redacted]/1978–[redacted]/1979	Ironworker	The EE's location file card (LFC) indicates assignment to EBR-II from [redacted]/1978 to [redacted]/1978, and a visitor badge was found covering this entire period. There are no external monitoring records in 1979. In the DOL case files, the EE stated the following: "*Claimant stated he worked at ANL-W for several months intermittently between 1978 and 1981 through the Ironworker's Union Local #732. As an ironworker he performed welding, grinding, burning, etc. of various metals and tying rebar at the Experimental Breeder Reactor-II (EBR-II) Facility… I worked at EBR 2 for three months. It was a high radiation area. I was working under the reator* [sic] *inside the contament* [sic]." The three-month period referred to above likely refers to the visitor badge located for 1978. SC&A did not observe any other direct indication of external exposure outside of this period.
15	[redacted]/1990–[redacted]/1993 [redacted]/1995–[redacted]/1995	[redacted]/Plumber Pipefitter	The EE has two visitor badges in February and March of 1993. The EE also wore 10 ring dosimeters from November 1992 through October 1993. Prior to November 1992, records indicate the worker underwent training for the following: Basic Respirator Fit (November 1990), Hot Fuel Examination Facility and Fuel Conditioning Facility (December 1991), and General Hazard Communication (May 1992). The EE was monitored via in vivo in March 1993, associated with the Fuel Conditioning Facility. In the DOL case files, the EE describes his work duties as follows: *"The claimant stated he worked for Bingham Mechanical as a* [redacted] *overseeing the demolition of the Tank Farm at Argonne National Laboratory-West (ANL-W) and as a plumber/pipefitter performing hands-on decontamination work in the hot cells for approximately six months between 1988 and 1990."* Given the timeframe of unmonitored employment (1990–1992), it seems somewhat unlikely to SC&A that the EE was exposed and not monitored. Additionally, the description of hands-on demolition work would be consistent with the available extremity monitoring records for 1992–1993.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
16	/1969–/1969 /1971–/1971 /1971–/1972 /1988–/1989	Mason	Employment at ANL-W was established via the security records for the individual, who worked for Ormond Construction, Carlson & Jacobson, Aiman Construction, and C&H Construction. The only external dosimetry for the EE is for 1988–1989. The CATI report with the survivor indicates that a radiation dosimeter was routinely worn but does not provide specific dates or information about exposure potential during unmonitored periods.
26	/1955–/1991 /1991–/1995	/Scientist	EE has a single monitoring result in July 1958, with no more external monitoring until January 1961. Per the CATI report with the EE, they worked from January 1955 to June 1960 at Argonne National Laboratory–East (ANL-E) not ANL-W. A site visitor request from ANL-E indicated that the EE was not monitored at ANL-E for 1958–1959; however, this does not mean the claimant was not working there. No information was observed to determine if the EE was exposed externally from the end of ANL-E in June 1960 (per the CATI) to the first monitoring result at ANL-W in January 1961.
27	/1949–/1988		External monitoring did not occur until October 1959. There was also an observed gap in monitoring records from October 1960 through September 1961. The CATI report with the EE indicates that from 1957 to 1959 the claimant's job was to for reactor construction. From 1959 to 1962, the CATI indicates the EE worked as a " " in a temporary building by the gate. While the CATI states that the EE had to occasionally enter hot cells and manipulator areas to assist with the cleanup, it appears these activities did not occur until the late 1970s. Given the job duties described ( ) and work location (at the gate), it seems unlikely that significant exposures occurred during this unmonitored period.
31	/1963–/1963 /1967–/1968 /1971–/1971	Roofer	Monitoring records exist for the 1963 employment period; however, no monitoring occurred from 1967 to 1968. The EE has verified employment with Hughes Roofing at ANL-W during this period. Records indicate that the EE was at NRF in 1971. The CATI report with the EE indicates they were routinely frisked for contamination and had to wear personal protection equipment (PPE) on occasion. The EE states they were badged, but they do not know if it was a radiation badge.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
34	[redacted]/1972–[redacted]/1973 [redacted]/1975–[redacted]/1975 [redacted]/1975–[redacted]/1976	Radio Alarm Shop [redacted]	The first external monitoring result provided for ANL-W occurred in December 1975. However, there are overlapping periods of covered employment at INL for the remaining unmonitored portions at ANL-W. Dosimetry records for INL indicate the EE was badged out of CFA during these periods.
40	[redacted]/1976–[redacted]/1977 [redacted]/1977–[redacted]/1978 [redacted]/1978–[redacted]/1980 [redacted]/1982–[redacted]/1982 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1986 [redacted]/2000–[redacted]/2003	Pipefitter	The only dosimetry directly associated with ANL-W were two visitor badges in October 1977, which is a partial match to the EE's LFC, which lists assignment to EBR-II from [redacted]/1977 through [redacted]/1977. Although there were no overlapping employment periods for INL, there is considerable confusion as to the actual work location of the claimant. It is possible that the apparent lack of monitoring data at ANL-W is actually an artifact of uncertainty in exact temporal and work site location information ***(see Section 3.1.2 for additional discussion)***.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
41	[redacted]/1959–[redacted]/1995 [redacted]/1996–[redacted]/2005 [redacted]/2005–[redacted]/2006	Reactor Operator/[redacted] [redacted] [redacted] Technician	The EE worked for the prime contractor, and the employment dates were verified by DOE. The EE's monitoring records are comprehensive for the vast majority of the EE's lengthy career; in fact, the EE was listed previously as one of the cases exhibiting badging in multiple locations at ANL-W during the same badging cycle. However, SC&A observed a few exceptions: 1978 and 1983. Annual summaries are not available, which may indicate whether the EE was actually monitored during these time-periods. There is a nearly illegible record that may represent a September 1978 entry that possibly is indicative of work at NRF (see Figure 6). While NRF is not specifically mentioned in either the CATI with the EE or the survivor, the survivor does state the following: *"…while working at Argonne National Laboratory – West her husband traveled to* [redacted] *for work with their reactors. She said he traveled extensively and these were the areas he traveled most of the time."* Site visitor requests were undertaken by NIOSH for [redacted]. However, no information was identified to explain the apparent gap in 1983. However, it is certainly possible the EE visited non-covered facilities during 1983 to explain the lack of dosimetry.

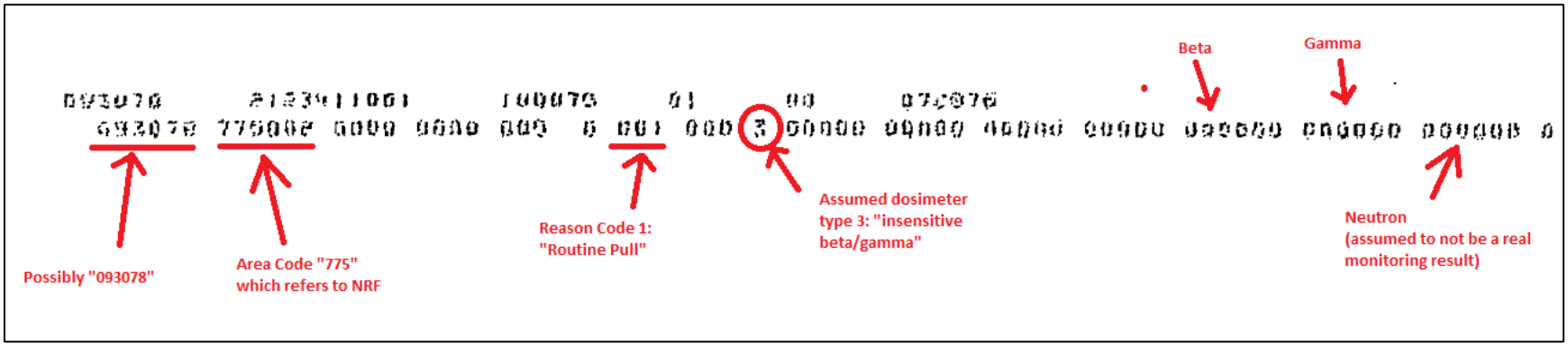


Figure 6. Screenshot of Potential 1978 Dosimetry Record Indicating "NRF"

Table 4. Description of Randomly Surveyed Claimants Who Were Unmonitored

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
12	[redacted]/1977–[redacted]/1977	Millwright, Electrical Helper	Employment was established based on security badging records, which show employment at ANL with Hunter Saucerman Construction. The claimant was not monitored in 1977. The DOL Initial Case (p. 30) contains statements indicating the location as EBR-II. Additionally, the DOL case files contain statements from the claimant that a radiation badge and pencil dosimeter were "always" used. The CATI report indicates the "Zipper" reactor as one of the EE's work areas. [redacted]. Additional information about potential exposure that may have occurred during 1977 could not be located.
20	[redacted]/1975–[redacted]/1975 [redacted]/1976–[redacted]/1976	[redacted], Scientist, [redacted]	The DOE response for this individual indicates the EE was not monitored internally or externally while at ANL-W. Multiple CATI reports with the EE's survivors did not provide any information related to potential exposures incurred at ANL-W. Based on a review of DOL case files, it appears the first employment period appears to be based on salary records. However, there is also some indication that the EE was actually employed by ANL-E. The second employment period in January 1976 was verified by DOE. Records indicate that the EE was also a [redacted] during the covered employment periods at ANL-W. No other information relevant to potential exposures at ANL-W was observed by SC&A.
32	[redacted]/1967–[redacted]/1967 [redacted]/1967–[redacted]/1967 [redacted]/1971–[redacted]/1971 [redacted]/1971–[redacted]/1972	Mason	The CATI report was performed with the survivor and indicated they did not know if they ever wore a badge at ANL-W. The EE worked as a mason and indicated they "*sawed and laid a lot of block.*" The EE's description of work performed at ANL-W appears to have been outside. In a letter the EE wrote to DOL, he stated the following: "*I sawed concrete block with a dry carbranden blade and face shield and we always just turned the saw* ***so wind or breeze would carry the dust away like always***" [emphasis added]. Note that the letter was handwritten and so legibility was an issue in transcribing the aforementioned quote. No other information was located in available records as to potential exposures incurred while working at ANL-W.

Observation 2: Inspection of the cases exhibiting apparent gaps in the external dosimetry data (or lack of external dosimetry entirely) reveals that they often carry significant uncertainty regarding work history, location, duties, and associated exposure potential (see Tables 3 and 4 of Section 3.1). In many cases, reasonable explanations can be reached to understand why these observed gaps exist. In other cases, not enough information exists to make a reasonable determination why monitoring may appear to be deficient. It is not apparent whether further research, by either DOE or DOL, would provide any additional clarity on such cases.

3.1.1 Discussion of Case 1

The EE has continuous covered employment from June 1950 through October 1989. However, the EE's first external monitoring result occurred in June of 1958, and is labelled as a "new hire" result; therefore, it is unclear if the covered employment is entirely accurate. Regardless, there is a sizable gap in external dosimetry records occurring from January 1964 through December 1975. Documentation received from the site indicated that either part or all of this gap is the result of the EE being put [redacted] (See Figure 7). As seen in the correspondence, the site pointed to the LFC as evidence that the EE had been put [redacted]. The LFC for the EE, as attached with this correspondence, is shown as Figure 8.

The LFC indicates the EE was "[redacted]" not [redacted]," as would be expected if the designation was [redacted]. "[redacted]" has been observed numerous times, for both ANL-W and INL claimants, representing a transfer of monitoring methods to a thermoluminescent dosimeter (TLD). In this case, the work area is also specified via the area codes "2" (indicating EBR-I), "26" (indicating EBR-II), and "265" (indicating EBR-II on a quarterly monitoring schedule). The DOL initial case files have the following affidavit from a coworker:

> *I have been employed by Argonne National Lab for 35 years.* [The EE] *was an operator on crew D when I started in 1966. He was promoted to operator* [redacted] *for several years, then worked in maintenance for several years until he was* [redacted].

The statement does not specifically state when the EE's status was designated as [redacted]. SC&A did not find any documentation in the DOE, DOL, or CATI files to indicate when the EE may have gone on [redacted]. However, the internal monitoring records for the claimant contain routine in vivo measurements in 1966, 1968, 1969, 1972, 1975, 1977, 1979–1984, 1986, 1988, and 1989. As stated previously, external monitoring data were resumed in December 1975.

Given the totality of the evidence, SC&A finds it unlikely that the EE was on [redacted] (and therefore not exposed at the site) for the approximately 12-year period for which no external dosimetry is currently available, particularly since the EE continued to be monitored internally via routine in vivo measurements during this time. This claim should be investigated to determine why this apparent discrepancy exists and whether it is unique to this EE or may affect other workers' historical monitoring records.

[redacted]

From: [redacted]
Sent: Monday, August 30, 2004 3:30 PM
To: [redacted]
Subject: [redacted]

[redacted]

Information located in the claim file shows that [redacted] was an active employee at ANL-W until 1963/64. After that period of active employment, he went on [redacted] until 6-Nov-89. The ANL benefit department explained to me that a termination date is not determined until the date when an [redacted] employee can collect either retirement/pension benefits or Social Security. This would account for the lapse, 1964 - 1989, in the exposure report dates.

I faxed to you a copy of the 'locater file card' which was included with the exposure report. This shows the date that the employee went to [redacted]. This information was included with the report that was sent to NIOSH in 2002.

[redacted]
Argonne National Laboratory
Laboratory Records Coordinator
Information and Publishing Division

Figure 7. Screenshot of Correspondence from ANL-W Indicating the EE was on [redacted]

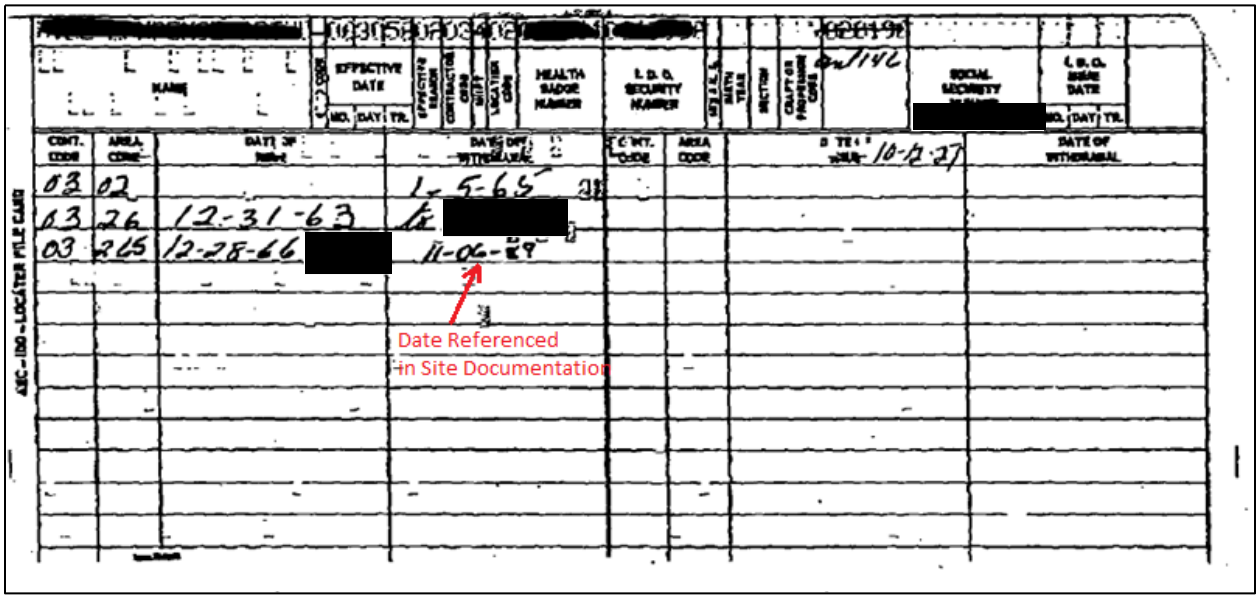


Figure 8. Screenshot of Location File Card for the EE as Alluded to in the Correspondence in Figure 7

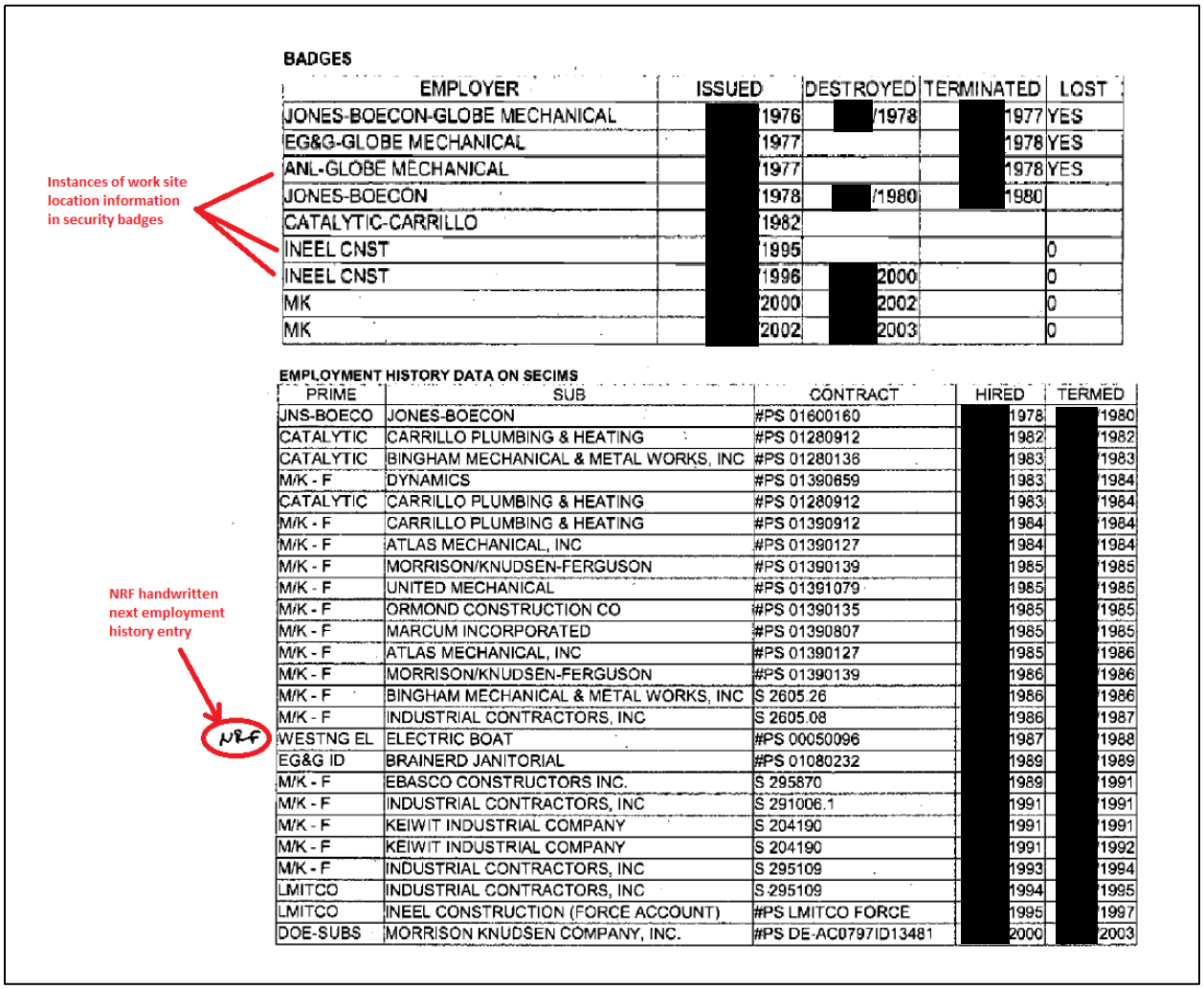
Finding 1: SC&A identified one claim that had a nearly 12-year period from 1964 to 1975 for which no external dosimetry exists. The EE was on a routine in vivo measurement schedule during this same period. It is recommended the claim be specifically investigated to determine why external monitoring records are not available for this time period, as well as to determine whether this is an isolated incident or evidence of a potential deficiency in external monitoring records as a whole.

3.1.2 Discussion of Case 40

The purpose of this discussion is to illustrate how difficult it often is to establish exact work locations, particularly for subcontract workers. Therefore, apparent gaps in the external monitoring for a particular claimant can be the result of several situations:

- The EE was potentially externally exposed and not monitored.
- The EE was potentially exposed and monitored, but the records are unavailable.
- The EE was not potentially exposed and thus not monitored.
- The EE was not actually working at that particular site during that particular time.

As shown in Table 3, Case 40 has multiple covered employment periods at ANL-W from December 1976 to January 1986, as well as another stint from 2000 to 2003. Beginning in January 1986 until October 1997, the EE has multiple covered employment periods at INL. As stated in Table 3, there appears to be considerable confusion over which site the EE actually worked and during which time. The work periods at ANL-W appear mostly based on security badging records, as well as employment records with multiple contractors. However, neither record definitively established the exact work site location in many instances (see Figure 9).



BADGES

EMPLOYER	ISSUED	DESTROYED	TERMINATED	LOST
JONES-BOECON-GLOBE MECHANICAL	[redacted]1976	[redacted]/1978	[redacted]1977	YES
EG&G-GLOBE MECHANICAL	[redacted]1977		[redacted]1978	YES
ANL-GLOBE MECHANICAL	[redacted]1977		[redacted]1978	YES
JONES-BOECON	[redacted]1978	[redacted]/1980	[redacted]1980	
CATALYTIC-CARRILLO	[redacted]1982			
INEEL CNST	[redacted]1995			0
INEEL CNST	[redacted]1996	[redacted]2000		0
MK	[redacted]2000	[redacted]2002		0
MK	[redacted]2002	[redacted]2003		0

EMPLOYMENT HISTORY DATA ON SECIMS

PRIME	SUB	CONTRACT	HIRED	TERMED
JNS-BOECO	JONES-BOECON	#PS 01600160	[redacted]1978	[redacted]1980
CATALYTIC	CARRILLO PLUMBING & HEATING	#PS 01280912	[redacted]1982	[redacted]1982
CATALYTIC	BINGHAM MECHANICAL & METAL WORKS, INC	#PS 01280136	[redacted]1983	[redacted]1983
M/K - F	DYNAMICS	#PS 01390659	[redacted]1983	[redacted]1984
CATALYTIC	CARRILLO PLUMBING & HEATING	#PS 01280912	[redacted]1983	[redacted]1984
M/K - F	CARRILLO PLUMBING & HEATING	#PS 01390912	[redacted]1984	[redacted]1984
M/K - F	ATLAS MECHANICAL, INC	#PS 01390127	[redacted]1984	[redacted]1984
M/K - F	MORRISON/KNUDSEN-FERGUSON	#PS 01390139	[redacted]1985	[redacted]1985
M/K - F	UNITED MECHANICAL	#PS 01391079	[redacted]1985	[redacted]1985
M/K - F	ORMOND CONSTRUCTION CO	#PS 01390135	[redacted]1985	[redacted]1985
M/K - F	MARCUM INCORPORATED	#PS 01390807	[redacted]1985	[redacted]1985
M/K - F	ATLAS MECHANICAL, INC	#PS 01390127	[redacted]1985	[redacted]1986
M/K - F	MORRISON/KNUDSEN-FERGUSON	#PS 01390139	[redacted]1986	[redacted]1986
M/K - F	BINGHAM MECHANICAL & METAL WORKS, INC	S 2605.26	[redacted]1986	[redacted]1986
M/K - F	INDUSTRIAL CONTRACTORS, INC	S 2605.08	[redacted]1986	[redacted]1987
WESTNG EL	ELECTRIC BOAT	#PS 00050096	[redacted]1987	[redacted]1988
EG&G ID	BRAINERD JANITORIAL	#PS 01080232	[redacted]1989	[redacted]1989
M/K - F	EBASCO CONSTRUCTORS INC.	S 295870	[redacted]1989	[redacted]1991
M/K - F	INDUSTRIAL CONTRACTORS, INC	S 291006.1	[redacted]1991	[redacted]1991
M/K - F	KEIWIT INDUSTRIAL COMPANY	S 204190	[redacted]1991	[redacted]1991
M/K - F	KEIWIT INDUSTRIAL COMPANY	S 204190	[redacted]1991	[redacted]1992
M/K - F	INDUSTRIAL CONTRACTORS, INC	S 295109	[redacted]1993	[redacted]1994
LMITCO	INDUSTRIAL CONTRACTORS, INC	S 295109	[redacted]1994	[redacted]1995
LMITCO	INEEL CONSTRUCTION (FORCE ACCOUNT)	#PS LMITCO FORCE	[redacted]1995	[redacted]1997
DOE-SUBS	MORRISON KNUDSEN COMPANY, INC.	#PS DE-AC07-97ID13481	[redacted]2000	[redacted]2003

Figure 9. Screenshot of Security Badging Records and Employment History Used in Developing Covered Employment Periods

The EE only has two visitor badges from October 1977 associated with ANL-W. These two badging records were actually included in the records response from INL. The records response from ANL-W indicated the individual could not be located in their records. These visitor badges coincide with part of the sole entry on the claimant's LFC indicating assignment to EBR-II from [redacted]/1977 to [redacted]/1977. Year-by-year dose totals (not pictured) indicate the EE was actually monitored to some extent from 1977 to 1980; however, the location is not provided. Career dose summaries provided by INL indicate that the EE may have only been at ANL-W as a visitor for part of 1977 (see Figure 10). This comports with the EE's available visitor badging.

External Dose Equivalent (mrem)

Period of Time	Deep	Shallow	Extremity
[redacted]1977 & [redacted]/1977 ANL Vis	0	0	nm
1977 thru 1980 INL	0	0	nm
1986 thru 1987 INL	0	0	nm
12/1987	NRF NOT REPORTED		
1991 INL	0	0	nm
10/1993 thru 10/1997 INL	1821	1897	nm
[redacted]/2001 INL	0	0	nm

nm=not monitored

See attached for yearly summary

Current Dose	None Reported
Internal Dose	None Reported

Figure 10. Screenshot of Career Dose Summary Provided by INL

The CATI report was performed with the survivor; however, ANL-W was not specifically mentioned. The description of work duties in the DOL case files is as follows:

> *The claimant stated he worked as a pipefitter at Argonne National Laboratory-West (ANL-W) site intermittently between 1975 and 2002. The claimant cannot recall the specific facility he worked at. He stated his work duties consisted of pipefitting pipelines throughout the facility.... The claimant stated he was exposed to radiation, contamination, airborne welding fumes and asbestos and chemicals.*

To assist in developing the covered employment for the EE, three separate affidavits were submitted by coworkers. However, these affidavits did not mention ANL-W specifically. One particular affidavit covered part of the covered employment at ANL-W (1978–1979); however, the affidavit only mentions the "FAST project in the calciner building at INEL." Page 265 of the DOL initial case provides pension records for the EE and actually indicates work periods at "INEL"; ANL-W is not mentioned.

Two separate EEOICPA occupational history interviews with the EE are provided in the DOL case file. The first provides a list of facilities that can be checked as "worked at"; ANL-W is not checked, but INL is checked. However, the second EEOICPA occupational history does indicate ANL and states the following:

> *The claimant stated he worked at the ANL-W site intermittently between 1975 and 2002 through the Plumber and Pipefitters Union. He was required to work at each of these facilities as job load dictated. He stated there is no way to identify a specific date or frequency when he worked at each of these facilities.*

Finally, page 308 of the DOL initial case file lists the following work areas, but does not provide dates:

> *Radioactive Waste Management Complex (RWMC), FAST Project and Tank Farm at the Idaho Chemical Processing Plant (ICPP), Loss of Fluid Test Reactor at Test Area North (TAN), Central Facilities Area (CFA).*

Observation 3: Case 40 illustrates an example situation where establishing covered employment for some claimants is extremely difficult, as there is often conflicting information. Therefore, when evaluating apparent temporal gaps in radiation monitoring, potentially valid explanations such as incorrect employment information must be considered and analyzed. This is especially true for subcontract workers.

3.2 EXTREMITY MONITORING

It was observed that several claimants had extremity monitoring (wrist or ring dosimeter) issued along with the regular dosimetry badge. Not surprisingly, this type of monitoring was relatively rare compared to the normal dosimetry badges being issued and was nonexistent for some claims. Excluding claims that were not monitored (3 total), as well as claims with only annual summary data (5 total), 30 of the remaining 42 claims had at least one extremity dosimeter result (~71%).

The percentage of regular badging cycles that also contained a ring dosimetry result for each worker was generally very low, with the exception of a case in which the claimant had 2 visitor badges and 10 ring dosimeters issued in the 1990s (Case 15). This case is discussed in Tables 2 and 3 in Section 3.1 and is not considered further in the extremity monitoring analysis presented here. Figure 11 plots the percentage of normal dosimeter badging cycles containing an additional extremity measurement for those cases that had at least one extremity badge (ring or wrist) during the covered employment. The five worker job titles with the highest percentage of extremity monitoring included with the standard dosimeter cycles were: Production [redacted], [redacted] Engineering Technician (two individuals), Maintenance, and a Health Physics Technician (see Cases 22, 30, 49, 5, and 29). Each of these cases describes performing cleanup activities, decontamination, maintenance, or general hot cell work. However, other job types who reported being involved in similar type cleanup work (such as custodians, operations support, and yardman laborers) may only have one or two extremity dosimeter cycles during a multi-year career (see Cases 25, 39, and 41).

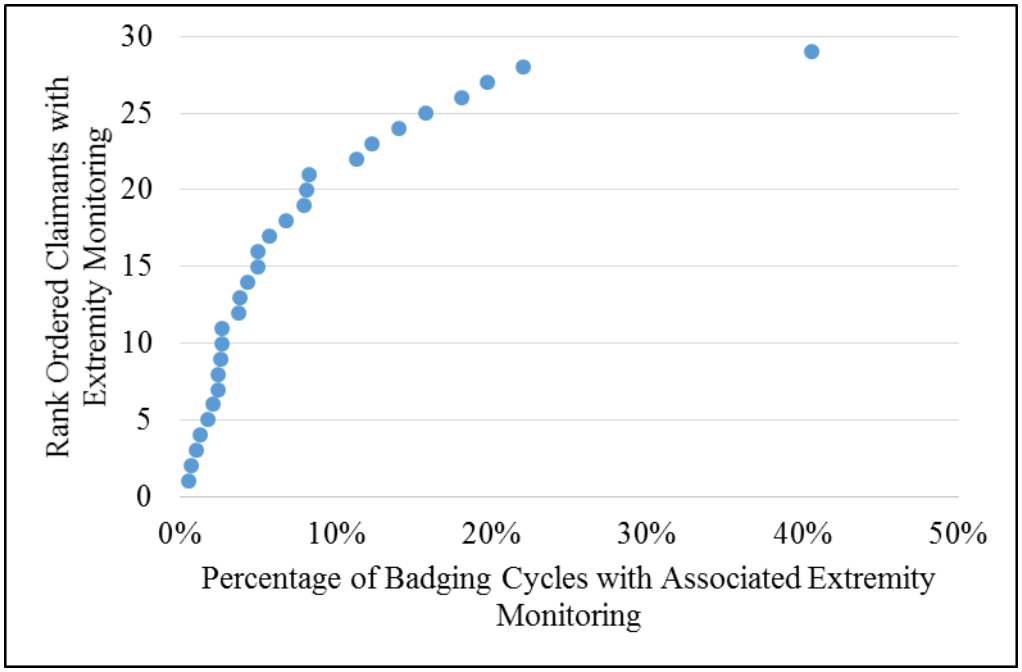


Figure 11. Percentage of Normal Badging Cycles with Associated Extremity Monitoring

For those workers who had extremity badging at some point during their career, SC&A compared the covered employment versus the actual number of those same workers who were issued extremity dosimeters by year. These would be the workers who would most likely be expected to perform work requiring extremity monitoring (for the purposes of this section, referred to as "extremity workers"). The results are shown in Figure 12.

As example, for those workers who have at least some extremity badging, 20 were employed in 1966; however, only 4 of these workers actually had any extremity monitoring during that year (20%). In the following year (1967), there were 20 claimants employed who had at least some extremity monitoring during their career, and 13 of them also had monitoring in 1967 (65%). Expanding on those two examples, Figure 13 plots the percentage of extremity workers issued an actual extremity badge by year.

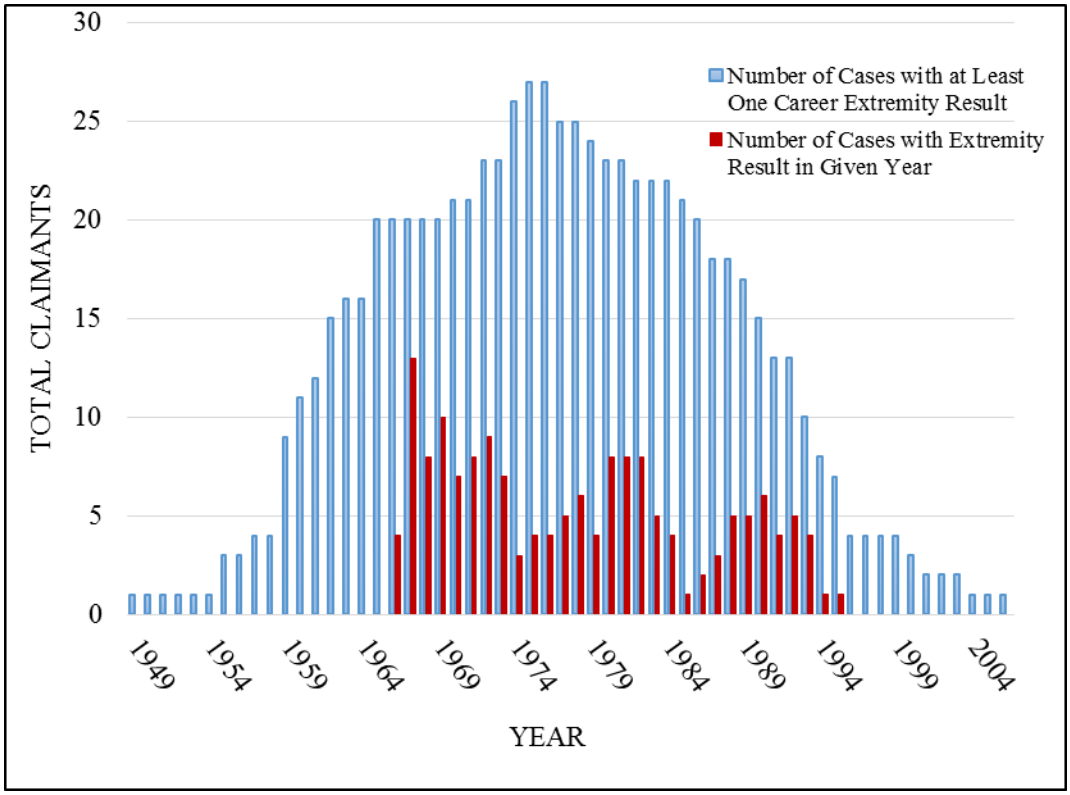


Figure 12. Number of Monitored Claims Employed in Year versus Number of Claims with Extremity Monitoring in Individual Year

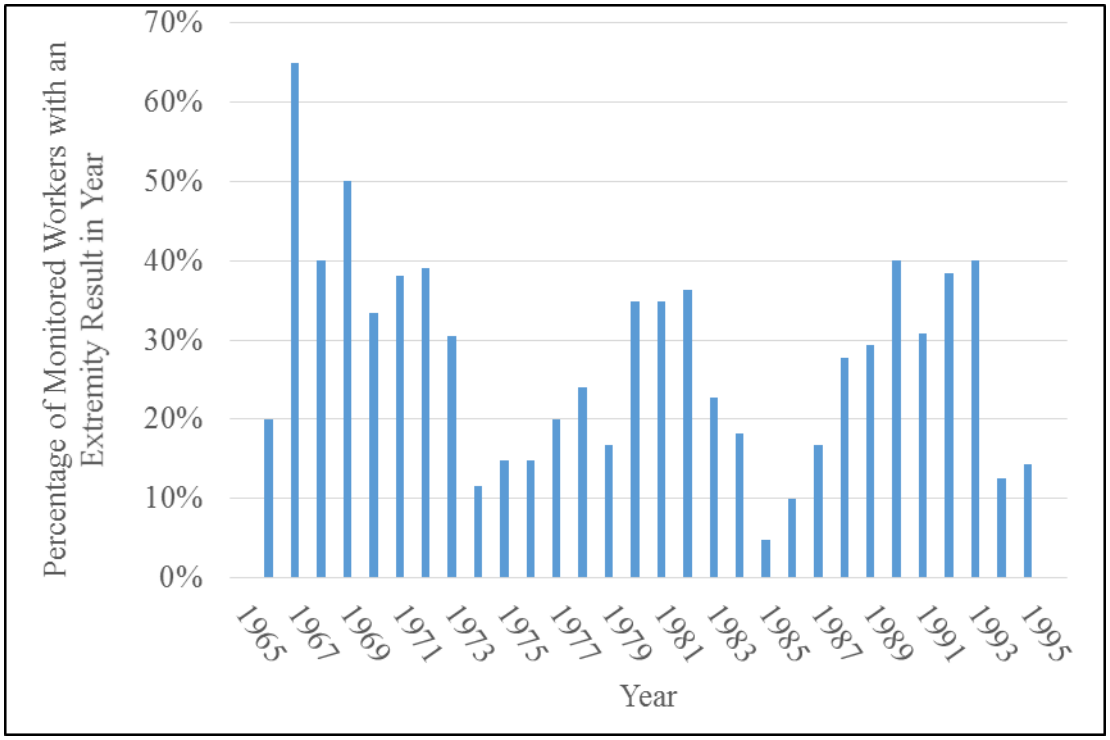


Figure 13. Percentage of Monitored Claims with Extremity Monitoring in Individual Year

As seen in Figures 12 and 13, even the workers most likely to require extremity monitoring among the sample of claimants often had several years with no extremity results. Although the subgroup of extremity workers had representative employment from 1949 through 2006, extremity results were only observed from 1966 through 1995. Per Figure 13, among the claimants who had at least one career extremity result and were employed in a given year, only 1967 had extremity monitoring for more than 50% of such cases.

It is SC&A's understanding that doses to the extremities (such as hands, wrists, and forearms) are typically reconstructed using dosimeter correction factors as established in DCAS-OTIB-0013, Revision 01, *Selected Geometric Exposure Scenario Considerations for External Dose Reconstruction at Uranium Facilities* (DCAS 2010, hereafter "OTIB-0013"). Based on the review of 50 randomly selected claims, the practice of extremity monitoring is seemingly sparse on an individual worker basis. Nonetheless, it would be beneficial to compare the ratios established between the extremity dosimeters and regular dosimeters to establish whether the correction factors in OTIB-0013 are specifically claimant favorable for ANL-W.

Observation 4: Even among sampled workers who were most likely to require extremity monitoring on a semi-regular basis, extremity monitoring is often sparse from year to year for many workers. Nonetheless, it may be instructive for NIOSH to evaluate available extremity monitoring data to determine if the typical methods employed in OTIB-0013 are applicable and claimant favorable for ANL-W claimants.

3.3 NEUTRON MONITORING

The evaluation of claimant records and review of the ANL-W technical basis document (TBD) for occupational external dose (ORAUT 2011) revealed that the determination of whether a particular worker was monitored for neutrons is somewhat complex and not easily defined for some periods of time. Available documentation of dosimetry reporting practices, as well as SC&A's experience gained in reviewing available monitoring records for ANL-W claimants, led to reasonable assumptions on how to determine if a worker was actually monitored for neutron exposure. These assumptions, and the basis behind them, are described in detail in Appendix B.

SC&A examined the sample of 50 claimants in order to characterize the neutron monitoring practices at ANL-W. As discussed in Section 3.1, 3 of the 50 claims had no monitoring at ANL-W and 5 of 50 only had annual summary data, which generally do not contain information to verify whether neutron monitoring occurred.[5] Of the remaining 42 claims, only 17 contained an identified neutron badging cycle during their covered employment. Figure 14 shows the number of neutron badging cycles for the 17 claims in rank order. As discussed in Appendix B, after 1985 it is unclear whether a blank result in the "neutron?" column coupled with a zero in the actual dosimetry result entry represents an actual neutron badging cycle. These results were not included in the 17 claims identified as having neutron monitoring; however, these entries are briefly discussed later in this section.

[5] One would only be able to determine that neutron monitoring occurred if there was a positive dose accrued during the year. However, information concerning the number of neutron badging cycles in the year would not be known.

As seen in Figure 14, most of the monitored workers had less than 50 neutron dosimetry cycles. Two of the 17 monitored claims had greater than 200 neutron dosimetry cycles. The job titles for these two individuals were “electronics tech” and a “reactor operator” (see Cases 29 and 37). The job titles for the other 15 monitored workers contained the additional job titles of: “research technician/photographer,” “maintenance,” “analytical chemist,” “custodian,” “carpenter,” and “health physics tech” (see Cases 1, 3–5, 10, 23, 28, 30, 35, 36, 41, 44–46, and 50). However, similar job titles were observed in the random sample of claims that had no identified neutron monitoring during their covered employment (see Cases 7, 8, 13, 14, 17, 24–26, 38, 42, and 47–49).

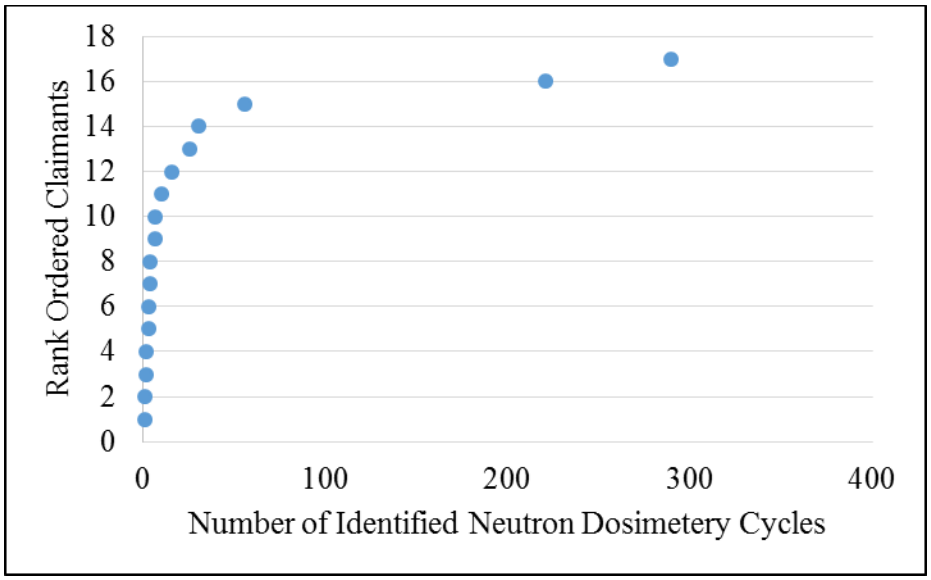


Figure 14. Number of Identified Career Neutron Dosimetry Cycles for Monitored Workers in Rank Order

Figure 15 plots the employment history for the monitored neutron workers (for this section referred to as “neutron workers”) versus the number of those workers who were actually monitored for neutrons by year. For example, in 1959 (the first year with observed neutron monitoring), four neutron workers were employed and three of them had neutron monitoring during the year (75%). Expanding on this example, Figure 16 plots the percentage of neutron workers issued an actual neutron badge by year. For most years, the number of neutron workers who were actually monitored for neutrons by year was less than 30%. Interestingly, the highest percentage of neutron workers who also were monitored in a given year was in the late 1950s and early 1960s.

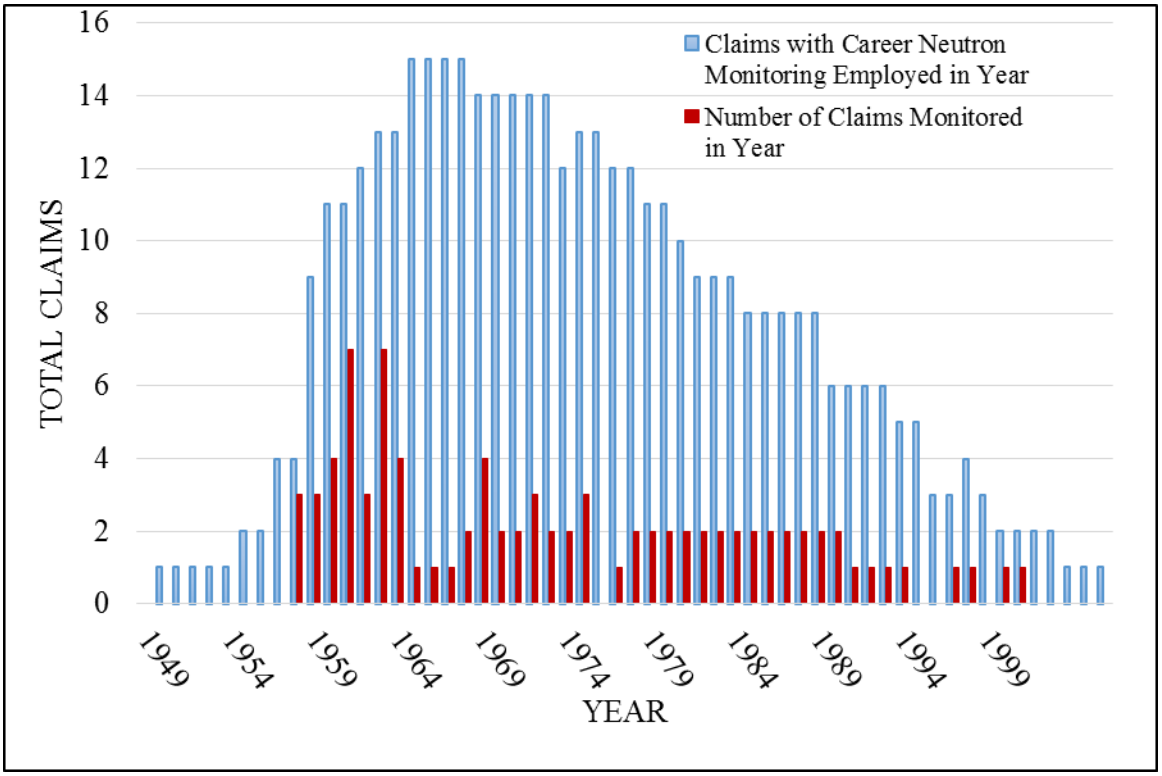


Figure 15. Number of Monitored Claims Employed in Year versus Number of Claims with Neutron Monitoring in Individual Year

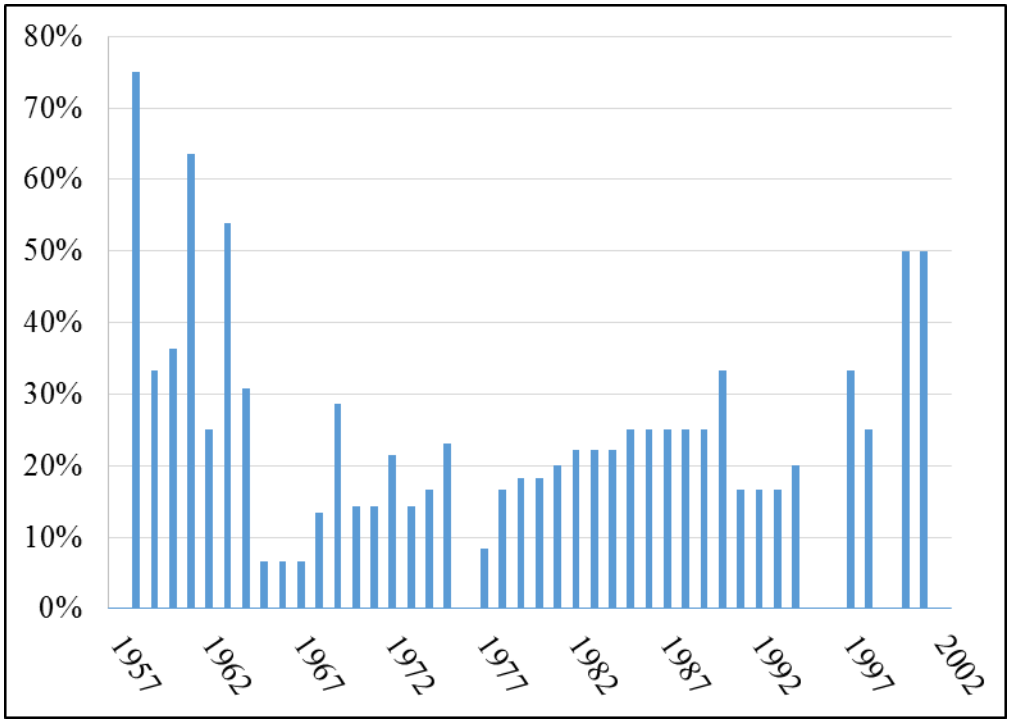


Figure 16. Percentage of Monitored Neutron Workers with Actual Neutron Monitoring by Year

About 16.4% (112/683) of all neutron badge results contained a positive reading. Seven of the 17 claims who had neutron monitoring did not have positive results. The claim with the highest number of neutron badges also had the highest number of positive results (64 positives out of 290 badges or ~22%). The highest overall percentage of positive results by worker was 33%; however, it was only indicative of a single positive result out of three overall badging periods during the EE's covered employment.

As stated previously, after 1985 the format of the dosimetry records contains a separate column labeled "neutron?" that will contain either a "Y" or "N," or is left blank. While the first two entries are self-evident, it is not known at this time what the blank entries represent. If it had been assumed that a blank entry actually represents a neutron badging cycle, then the number of monitored workers in the random sample increases from 17 to 23.

Per the TBD (ORAUT 2011) and SEC ER (NIOSH 2016), if the EE was not monitored for neutron exposure, then any such exposures would be deemed "incidental." However, it appears that the site also performed follow-up investigations into neutron exposures for unmonitored workers. The SEC ER specifically states the following:

> ***The available information also indicates that ANL-W investigated neutron exposures to unmonitored workers and estimated doses for those workers****. Given that the ANL-W likely monitored the workers with the highest potential to receive neutron doses, and given that the monitored workers' neutron doses were typically less than the dosimeters' limits of detection, it is unlikely that an unmonitored ANL-W worker received more than an incidental exposure to neutron radiation.* [Emphasis added.]

The implied policy is that no neutron doses are to be assigned to unmonitored workers (with the exception of the special investigations performed for specific unmonitored workers). The TBD (ORAUT 2011) and SEC ER (NIOSH 2016) would benefit by providing documentation as to how workers were selected and what specific jobs/tasks required neutron monitoring. Additionally, examples of special investigations into unmonitored neutron exposures, as well as the frequency and causation of the investigations, would be helpful in establishing that assignment of unmonitored neutron exposures via coworker doses or other methods are not necessary for ANL-W.

Observation 5: Among sampled workers monitored for neutrons, records are often sparse on a year-by-year basis. SC&A noted that many of the worker job types in the random sample who were monitored for neutrons shared those same job designations with unmonitored workers. SC&A acknowledges that many, but not all, neutron dosimetry results are below the detection limit. The ER would benefit from a more substantive discussion and documentation of how workers were selected for neutron monitoring, and what particular activities warranted this designation. Additionally, examples of special investigations into unmonitored neutron exposures, as well as their frequency and causation, would be appropriate in establishing that assignment of unmonitored neutron dose is not necessary for ANL-W claims.

4.0 INTERNAL MONITORING

By far the most common form of internal monitoring was in vitro (urinalysis) and in vivo measurements for gross beta and/or gamma. In vitro monitoring was primarily utilized earlier in the operational period until the 1965–1967 timeframe, when in vivo became the primary mode for internal monitoring.

In addition to the typical in vivo and in vitro monitoring, several of the sampled claimants had additional internal monitoring, such as fecal analysis for plutonium, urinalysis for uranium, thyroid counting, and even the rare tritium result. These "off-normal" monitoring results are rare and all appear to be incident driven and so are not applicable to the regular monitoring practices at ANL-W. Therefore, they are not included further in the discussion of internal monitoring practices in this report.

SC&A's review of 50 randomly sampled claims determined that 38 out 50 (76%) were monitored for fission product exposure. The unmonitored claims are shown in Table 5. As seen in the table, several of the unmonitored claims simply don't have sufficient information contained in the available documentation to make reasonable judgments as to whether the EE was potentially internally exposed and was not monitored or that the records are unavailable. For some cases, there is reasonable evidence to suggest minimal (if any) internal exposure potential would have been experienced by the worker. However, in other cases, the claimants describe performing work in contaminated areas (e.g., decontamination work in the hot cells), wearing PPE, and/or contamination incidents requiring the EE to take multiple showers (see Cases 24, 31, and 39).

Observation 6: Based on a review of workers who were not monitored internally, it appears there are at least a few cases in which internal monitoring likely should have occurred, but either did not occur or the records have been lost/destroyed. It is recommended that NIOSH explore the development of coworker intakes for fission products to account for such situations. This would also be consistent with current recommendations concerning coworker modeling for the INL site.

Table 5. Description of Randomly Surveyed Claimants Who Were Not Monitored Internally

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
2	[redacted]/1970–[redacted]/1971 [redacted]/1971–[redacted]/1971	Pipefitter	No external monitoring occurred at ANL-W in 1970 or 1971. The EE has numerous covered employment periods at INL; however, none overlap with the assumed ANL-W employment. EE was monitored externally in 1962, which is outside the covered employment at ANL-W; however, the EE does have covered employment at INL for parts of 1962. Work specific to ANL-W was not mentioned by the EE in either the CATI or DOL case files. The EE worked for a subcontractor. No other information about potential internal exposures was identified in available records.
9	[redacted]/1978–[redacted]/1979	Ironworker	The EE LFC indicates assignment to EBR-II from [redacted]/1978 to [redacted]/1978, and a visitor badge was found covering this entire period. There are no external monitoring records in 1979. In the DOL case files, the EE stated the following: "*Claimant stated he worked at ANL-W for several months intermittently between 1978 and 1981 through the Ironworker's Union Local #732. As an ironworker he performed welding, grinding, burning, etc. of various metals and tying rebar at the Experimental Breeder Reactor-II (EBR-II) Facility… I worked at EBR 2 for three months. It was a high radiation area. I was working under the reator [sic] inside the contament* [sic]." The three-month period referred to above likely refers to the visitor badge located for 1978. SC&A did not observe any other direct indication of exposure outside of this period.
12	[redacted]/1977–[redacted]/1977	Millwright, [redacted]	Employment was established based on security badging records, which show employment at ANL with Hunter Saucerman Construction. The claimant was not monitored externally in 1977. The DOL initial case (p. 30) contains statements indicating the location as EBR-II. Additionally, the DOL case files contain statements from the claimant that a radiation badge and pencil dosimeter were "always" used. The CATI report indicates the "Zipper" reactor as one of the EE's work areas. [redacted]. Additional information about potential exposure that may have occurred during 1977 could not be located.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
16	[redacted]/1969–[redacted]/1969 [redacted]/1971–[redacted]/1971 [redacted]/1971–[redacted]/1972 [redacted]/1988–[redacted]/1989	[redacted] Mason	Employment at ANL-W was established via the security records for the individual who worked for Ormond Construction, Carlson & Jacobson, Aiman Construction, and C&H Construction. The only external dosimetry for the EE is for 1988–1989. The CATI report with the EE's survivor does not contain any information pertinent to internal dose. SC&A found no other relevant information to establish potential internal exposure potential.
18	[redacted]/1972–[redacted]/1973	Heavy Equipment Operator	The EE was not monitored for internal dose while at ANL-W. The EE was monitored internally in association with CFA in November 1971, and then again in January 1977, at Advanced Test Reactor (ATR). External dosimetry supplied by INL indicates that the EE was badged out of both EBR-II and CFA during ANL-W employment. The EE also had overlapping visits to NRF during the relevant period. DOL case files include an [redacted] Report from June 1972 associated with CFA/Burial Grounds and again in May 1972 associated with Chemical Processing Plant (CPP). CATI was with the survivor, who did not have information on potential radioactive exposure.
20	[redacted]/1975–[redacted]/1975 [redacted]/1976–[redacted]/1976	[redacted], Scientist, [redacted]	The DOE response for this individual indicates the EE was not monitored internally or externally while at ANL-W. Multiple CATI reports with the EE's survivors did not provide any information related to potential exposures incurred at ANL-W. Based on a review of DOL case files, it appears the first employment period appears to be based on salary records. However, there is also some indication that the EE was actually employed by ANL-E. The second employment period in January 1976 was verified by DOE. Records indicate that the EE was also a [redacted] during the covered employment periods at ANL-W. No other information relevant to potential exposures at ANL-W was observed by SC&A.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
24	[redacted]/1962–[redacted]/1962	Carpenter/Millwright	The EE was monitored externally throughout the covered employment period with the Harty Company. The CATI with the EE indicates that their routine duties included: "*Installing hot cell windows for breeder reactors.*" The EE also states that they wore PPE (including occasional use of a respirator per the DOL case file) based on the job and that he submitted a urine sample on at least one occasion. The DOL case file indicates there might be additional ANL-W employment as follows: [redacted]/1971–[redacted]/1971 (Biggers Construction), [redacted]/1973–[redacted]/1973 (Atlas Mechanical). In the DOL case file, the EE described contamination incidents as follows: "*Contamination of personel* [sic] *clothing and several showers occurred often times.*"
31	[redacted]/1963–[redacted]/1963 [redacted]/1967–[redacted]/1968 [redacted]/1971–[redacted]/1971	Roofer	External monitoring records exist for the 1963 employment period; however, no monitoring occurred from 1967 to 1968. The EE has verified employment with Hughes Roofing at ANL-W during this period. Records indicate that the EE was at NRF in 1971. The CATI report with the EE indicates they were routinely frisked for contamination and had to wear PPE on occasion. The EE states they were badged but they do not know if it was a radiation badge. SC&A did not observe any other pertinent information related to potential internal exposures.
32	[redacted]/1967–[redacted]/1967 [redacted]/1967–[redacted]/1967 [redacted]/1971–[redacted]/1971 [redacted]/1971–[redacted]/1972	Mason	The CATI report was performed with the survivor and indicated they did not know if they ever wore a radiation badge at ANL-W. The EE worked as a mason and indicated they "*sawed and laid a lot of block.*" The EE's description of work performed at ANL-W appears to have been outside. In a letter the EE wrote to DOL, he stated the following: "*I sawed concrete block with a dry carbranden blade and face shield and we always just turned the saw* ***so wind or breeze would carry the dust away like always***" [emphasis added]. Note that the letter was handwritten and so legibility was an issue in transcribing the aforementioned quote. No other information was located in available records as to potential exposures incurred while working at ANL-W.

Case #	Employment Start Date – Employment End Date	Job Title in NOCTS	SC&A Review Comments
34	[redacted]/1972–[redacted]/1973 [redacted]/1975–[redacted]/1975 [redacted]/1975–[redacted]/1976	Radio Alarm Shop [redacted]	The first external monitoring result provided for ANL-W occurred in December 1975; INL records also indicate badging at CPP, Test Reactor Area (TRA), and Power Burst Facility (PBF). There are overlapping periods of covered employment at INL for the remaining unmonitored portions at ANL-W. Dosimetry records for INL indicate the EE was badged out of CFA during these periods.
39	[redacted]/1979–[redacted]/1979 [redacted]/1979–[redacted]/1979	Laborer/Yardman	The EE was monitored externally for both covered time periods. In each case, the EE received a shallow dose of 356 and 651 mrem, respectively. The EE stated the following concerning work duties in the CATI: "*In the labor pool, he sometimes did decon in the reactor and he did other rad con work. He made two entries into the Argonne West hot cell. Says he was in there less than two hours each time.*" In the DOL initial case, the EE reiterates that he entered the hot cell to perform decontamination work between 1977 and 1979.
40	[redacted]/1976–[redacted]/1977 [redacted]/1977–[redacted]/1978 [redacted]/1978–[redacted]/1980 [redacted]/1982–[redacted]/1982 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1986 [redacted]/2000–[redacted]/2003	Pipefitter	The only external dosimetry directly associated with ANL-W were two visitor badges in October 1977, which is a partial match to the EE's LFC which lists assignment to EBR-II from [redacted]/1977 through [redacted]/1977. Although there were no overlapping employment periods for INL, there is considerable confusion as to the actual work location of the claimant. It is possible that the apparent lack of monitoring data at ANL-W is actually an artifact of uncertainty in exact temporal and worksite location information ***(see Section 3.1.2 for additional discussion)***.

SC&A also examined the population of 38 monitored workers to identify any trends and/or gaps in the internal dosimetry program at ANL-W. SC&A found that of the 38 workers with internal monitoring data, 10 were monitored on a regular schedule (generally annual) and had no gaps in monitoring lasting longer than 2 years. Figure 17 displays the number of internally monitored workers versus the number who actually submitted bioassay samples or were counted via in vivo in each particular year. Figure 18 shows the percentage of internally monitored workers who submitted an internal dosimetry result in the given year.

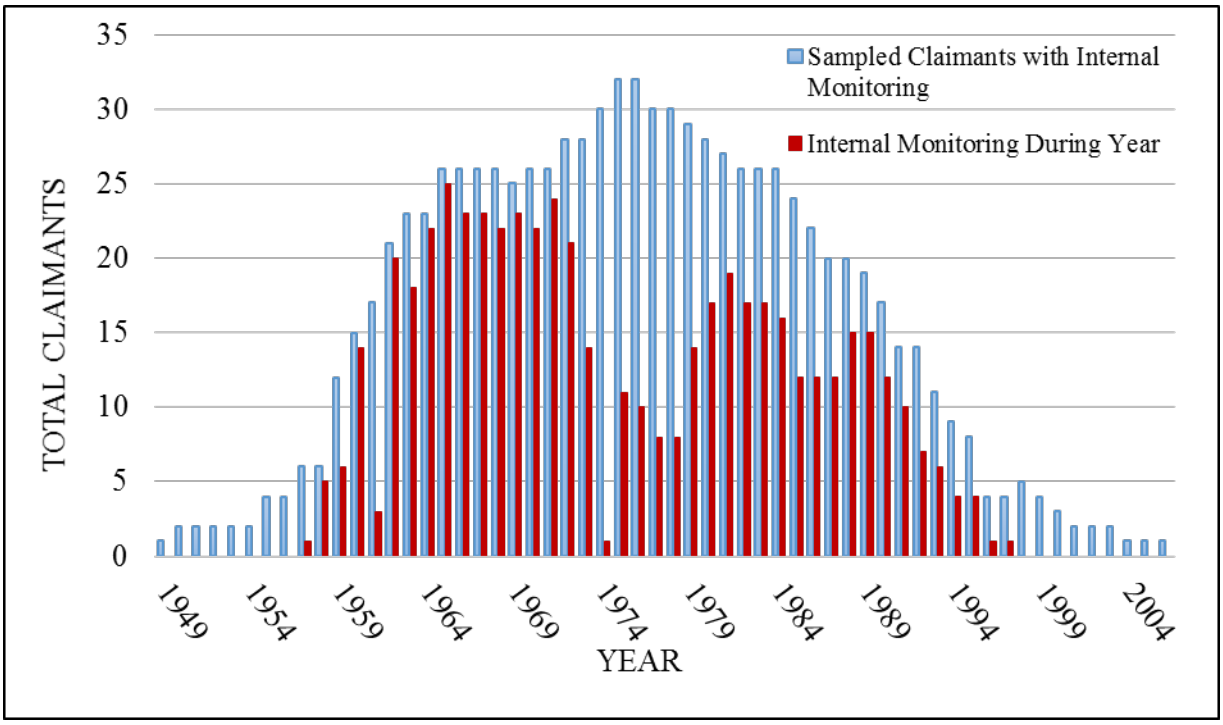


Figure 17. Monitoring Coverage by Year versus Employment for 50 Claims Involved in Internal Dosimetry Program

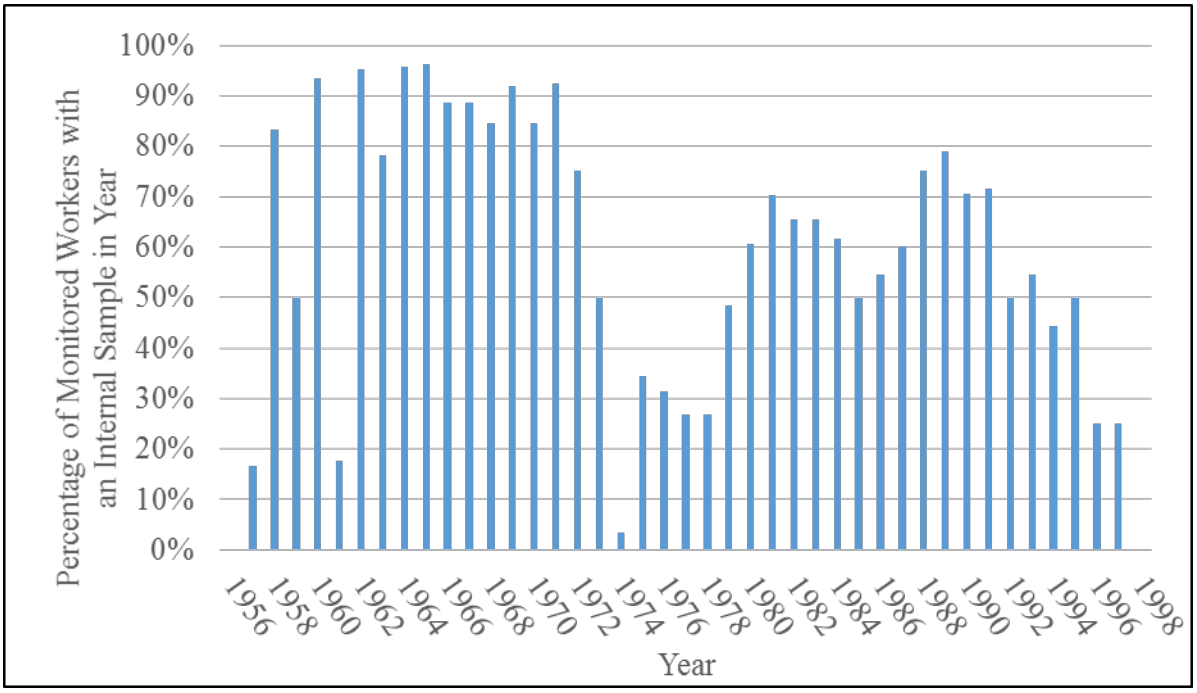


Figure 18. Percentage of Monitored Workers with Internal Fission Product Monitoring by Year

Notably, there appears to be a gap in internal monitoring records starting in approximately 1973 and carrying through to about 1979. In some cases, monitoring stopped altogether in the early 1970s, though no indication of a change in job title was evident from available records. Table 6 describes the cases that illustrate this observation.

Table 6. Description of Cases Exhibiting a Decrease in Internal Monitoring during the Mid-1970s

Case #	Employment	Job Title	Relevant Internal Monitoring
3	/1960–/1995	Reactor Tech,	Monitoring gap: May 1972–July 1981
5	/1965–/1994	Maintenance	Monitoring gap: August 1972–July 1975
10	/1959–/1976	Maintenance	Last monitoring result: March 1973
14	/1962–/1992	Hot Cell Worker	Monitoring gap: March 1972–July 1980
21	/1961–/1989	Laborer/	Last monitoring result: February 1973
27	/1949–/1988		Last monitoring result: April 1972 *(EE had a termination sample in 1988)*
28	/1969–/1995	Electronics Technician	Last monitoring result: May 1973 *Note: the EE was monitored extensively for beta/gamma and neutrons after the last bioassay and had numerous positive results.*
33	/1963–/1990	Civil Engineer	Last monitoring result: September 1972
36	/1965–/1999	Custodian	Monitoring gap: November 1973–July 1978
37	/1959–/1993	Reactor Operator	Monitoring gap: February 1973–July 1979
38	/1960–/1993	Engineering Technician	Monitoring gap: December 1972–April 1976
41	/1959–/1995 /1996–/2005 /2005–/2006	Reactor Operation/Technician	Last monitoring result: October 1973 *(Termination sample in 1995)*
42	/1965–/1984	Health Physicist Technician	Monitoring gap: July 1972–July 1979
44	/1959–/1980	Electrical Engineer	Last monitoring result: October 1972
45	/1957–/1984	Analytical Chemist	Monitoring gap: December 1973 to May 1976
49	/1970–/1986	Engineering Tech	Last monitoring result: September 1972

Finding 2: Among internally monitored workers, a noted gap in routine monitoring was observed between 1973 and 1979. This time period should be investigated to understand and characterize potential changes in either the health physics program or operations at the site. It is recommended that NIOSH evaluate the adequacy of records during this period for the purpose of developing a coworker model to account for and bound unmonitored intakes during this period.

5.0 FOCUSED REVIEW OF 10 CLAIMANTS WITH EMPLOYMENT SPANNING THE SEC END DATE

SC&A performed a focused review of 10 claimants who had an employment period at ANL-W that spanned the SEC end date of December 31, 1957. The claimants' external monitoring records were evaluated from the beginning of their employment through a few years after the SEC end date to investigate potential changes in monitoring coverage at ANL-W around the SEC end date. Internal monitoring records, CATI reports, and DOL case files were also reviewed for the claimants. Summaries of the 10 claims chosen for this analysis are given below.[6]

5.1 CLAIM A

The EE was employed at ANL-W from 1948 through 1982 as an engineer. According to a CATI report, the EE [redacted]. External dosimetry records were available for the EE beginning in 1952. Only a few dosimeters for the year 1952 were available and covered a few months discontinuously. The EE had only one dosimeter for 1953 and no dosimeters for 1954. However, in a CATI report, a survivor indicated that the EE had worked at ANL-E for some time around 1953–1954, which may explain a lack of monitoring during this time period. The external dosimetry for 1955 through 1957 seems fairly regular, as the EE usually had a dosimeter reading approximately once every two weeks. Starting on March 28, 1959, and looking through the end of 1959, the EE had badge readings nearly every week, with a few instances of two weeks between badges. The frequency of badging for this EE after 1958 appears to be greater than the frequency of badging for this EE prior to 1958. Internal monitoring records for this EE begin in 1958. Internal records are available in 1958, 1960, 1962–1966, 1968, 1969, and 1971–1973.

5.2 CLAIM B

The EE was employed at ANL-W from 1950 through 1961 as a mechanical engineer/scientist and had a one-day visit to ANL-W in 1987. The EE was employed by the NV Corporation, which is designated as a prime contractor in the DOL case files. The work performed during the period of interest is also described in the DOL case files:

> *1950–1961: Assistant & Associate Engineer/Project Engineer, Argonne National Laboratory*
>
> *Held a variety of* [redacted] *positions in the Naval Reactor and Reactor Engineering divisions. Sample technical lead responsibilities included:* [redacted]

[6] The claim letter designations were assigned by SC&A in order to delineate between the 50 randomly selected claims and the 10 focused claim reviews contained in Section 5. The letters do not reflect any personally identifying information for the claimant.

[redacted].

Based on this work description, it is clear that the EE also worked at INL and NRF, in addition to ANL-W, during the period of interest. The EEOICPA work history interview actually lists the employment periods at ANL-W as 1950–1954 (at the Transient Reactor Test Facility [TREAT]) and 1960–1961 (unknown location). The only external dosimetry information available for the EE is a printout with yearly summaries from 1952 through 1961 for ANL-W. Individual dosimetry information was not included in the EE's files; therefore, we do not know if the frequency this EE was monitored increased after 1958 compared to before 1958. The EE had two internal monitoring records in 1956 (from the Materials Test Reactor [MTR]) and one internal monitoring record in 1958 for TREAT. No records for other years of employment at ANL-W were included in the EE's files.

5.3 CLAIM C

The EE worked at ANL-W from the end of 1951 through 1990 as a research technician and [redacted], and again from 1991 through 1995, but the job title is unknown. The EE also worked at INL for two employment periods. The CATI report for this EE said:

> *Back then they were loose in their requirements compared to now. We were around the "nack" and when they took the rods out of the reactor they would spray them down with water. When the water would hit the nack it would explode. We were around it but did not wear any protective clothing. When I picked up a pellet they restricted me and told me I was overexposed. Once we put the pellet back there was no other action on any ones part. They told me that it was a "life" time exposure.*

The EE also mentioned in the interview that the incident regarding picking up the pellet occurred sometime between 1955 and 1959. The EE's DOL records indicate that while at Argonne, the EE was involved in health physics (HP) support, consultants, and photography assistance. The EE's interview also addressed photographing the reactors:

> *When I worked part time we were taking pictures and I would use x-ray machine. I x-rayed a reactor for about 2 to 3 months.*

External dosimetry records were available for the EE starting in 1952. The EE only had one dosimeter for 1952, and three dosimeters for 1953. In 1954, the EE had several dosimeters, but were not in regular intervals. From 1955 through 1957, the EE had few dosimeters, which did not cover regular intervals. Starting on March 29, 1958, the EE had a dosimeter nearly every week, often more than one dosimeter for different areas. Looking through the end of 1959, the weekly dosimeters continue through approximately September 1959, when the EE's dosimeters became bi-weekly. The frequency of badging for this EE starting in late March 1958 is certainly greater than the frequency of badging prior to 1958. ANL-W internal monitoring records for this EE begin in 1958. Records are available for the years 1958, 1960, 1963–1972, 1975, and 1990.

5.4 CLAIM D

The EE worked at ANL-W from 1954 through 1993 as a physicist. The CATI report indicates that the EE was the head physicist for loading the reactor at EBR-II. The EE's external monitoring records start in 1954. The EE had one dosimeter in 1954 and 1955, no dosimeters in 1956, and only four dosimeters in the first quarter of 1957. Starting on March 29, 1958, the EE had dosimeters approximately every week. Looking through the end of 1959, the weekly dosimeters continue through approximately September 1959, when the EE's dosimeters became biweekly. The frequency of badging for this EE was greater starting in March 1958 compared to before 1958. Internal monitoring records for the EE begin in 1958 and are available for the years 1958, 1960, 1962–1972, 1975, and 1988. The EE had one internal record for "ZPR" in 1958 and one for TREAT in 1960. The other internal records were for EBR-I or EBR-II.

5.5 CLAIM E

The EE worked at ANL-W from 1952 through September 1974 as an engineer and research technician. The EE worked at INL after employment at ANL-W. External monitoring records for the EE began in 1957. Starting on March 29, 1958, the EE had weekly dosimeter readings. Considering the EE's dosimetry reports through the end of 1959, weekly dosimeters continued through approximately September 1959, when they became biweekly. Internal monitoring records begin in 1958 and were available for the years 1958, 1960, 1962–1965, 1967, 1969, and 1970–1974. One internal record in 1958 was for TREAT. The frequency of badging for this EE was much greater starting in late March 1958. The employment history form within the DOL record has the phrase "1952 – 1954 (Break)" written in the ANL-W employment period, though no more information is available regarding such a "break." No interview was conducted with the EE or survivor.

5.6 CLAIM F

The EE worked at ANL-W from July 1956 through 1989 as a chemist. CATI reports indicate that the EE was the [redacted] of training and procedures and was later the [redacted] of the EBR-II facility. The EE worked at INL prior to this period from 1953 through 1955. The EE's external monitoring records for ANL-W began in October 1963, and were biweekly through March 1964. The ANL-W dosimetry file for this EE has internal results in 1958, 1960, 1962–1967, and 1969–1972. It is difficult to tell if the EE's external monitoring records for ANL-W were more frequent in the post-1957 time period, as external monitoring was only available beginning in 1963. The reason for the lack of monitoring records is not clear. Career dose summaries indicate that from 1956 through 1983, the EE accrued deep and shallow doses of 1,685 and 1,710 mrem, respectively. Available external dosimetry records from 1963 forward only indicate accrued deep and shallow doses of 110 and 0, respectively. Clearly, the exposure must have occurred prior to 1963; however, it is not known if it occurred prior to 1958. In the CATI report with a survivor, it was indicated that the EE wore a "routine" dosimeter. A survivor also said:

> *He would work a lot of overtime on occasion when there would be an experiment running.*

In the EE's dosimetry files labeled for INL, external monitoring from 1956 through 1957 is given. The records from 1956 are labeled as CFA; records from 1957 are mostly labeled as MTR (when an area was given). One of the INL dosimetry files in the EE's records contains an internal monitoring result in 1960 and in 1965 labeled "Argonne National Laboratory." Other internal monitoring results in these reports that were during the EE's employment period at ANL-W were labeled MTR and Aircraft Nuclear Propulsion Facility (ANP) in 1957 and 1958. A 1963 in vivo exposure questionnaire indicates the EE was at MTR for approximately 30 months but does not indicate when this employment occurred. Therefore, it is unclear whether the employment dates for ANL-W for this EE are entirely correct; the EE was on site but did not need to be monitored, the EE was monitored but the records are unavailable, or the EE was not monitored but should have been.

Finding 3: SC&A examined one claimant who had covered employment at ANL-W from 1956 into 1989. External monitoring records for the EE are not available until October 1963. Evidence suggests that the EE had non-zero external exposures prior to this time. The EE was monitored internally at ANL-W in 1958, 1960, 1962, and 1963. This claim should be investigated further with the site to determine the cause for the apparent gap in external dosimetry records.

5.7 CLAIM G

The EE worked at ANL-W from 1956 through 1961 as a [redacted]. The DOL records for this EE indicate he was a contractor. The EE's dosimetry records only included yearly summaries. One yearly summary page included the years 1956 through 1962 supplied by Argonne National Laboratory in Illinois. In this summary, the years 1959, 1961, and 1962 are labeled as "Not Detectable," and 1960 is labeled as "Not Monitored." Another yearly summary page only included the years 1960 and 1961. The CATI report for this EE indicated that the EE wore a dosimeter routinely "more than half the time." Also, in the CATI report and in the DOL records, the EE listed that from October 1956 through June 1958 he was employed at ANL-E, though the NIOSH OCAS Claims Tracking System (NOCTS) does not show this. The EE had two internal monitoring results, one each in 1960 and 1961. The CATI report mentions internal monitoring:

> *There were a couple of times when they had urine monitoring after someone in the group showed exposure.*

Without detailed dosimetry records, we are unable to tell if the EE's monitoring frequency increased starting in 1958.

5.8 CLAIM H

The EE worked at ANL-W from December 1956 through 1970 as an assistant mechanical engineer. The detailed work history for this EE as given in the CATI report is:

> *Duties:* [EE] *said he was involved in* [redacted] *work on reactor facilities and testing and operations. As they got into EBR-2, he was into a lot of* [redacted] *in the power plant and maintenance area. He was the* [redacted] *it working to a great*

extent. He did get involved in some of the work in a hot facility in EBR-2 with respect to the fuel reprocessing. They were carefully monitored (he thought) when involved with this work and their time being exposed to the materials was very limited.

At ZPR, they handled enriched and depleted uranium. Their goal was to come up with various configurations to demonstrated sub-criticality. He had to go into this facility and [redacted].

The overall EBR-1 facility, they did not go near a certain area because they blew up the first boiling water reactor, he said there was radioactive materials scattered all over this area.

The EE also indicated that his exposure potential was approximately 5–10 hours per week. The EE's external monitoring records began in 1956, with one badge in 1956 and two in 1957. The EE had two badges in January of 1958; then, beginning on March 29, 1958, the EE had a weekly dosimeter. Considering the EE's external monitoring through the end of 1959, weekly dosimeters continued until September 1959, when they became biweekly. Therefore, the EE's external monitoring frequency increased starting in late March 1958. Internal monitoring records for the EE began in 1958, with records in 1958, 1960, and 1962–1970.

5.9 CLAIM I

The EE worked at ANL-W from 1957 through 1961, where he "Worked in Hot Cells," and again from September 1970 through September 1974 as a [redacted] Engineer. The EE also had a short employment period at INL immediately after the first employment period at ANL-W. External monitoring for the EE began in 1956. Inspection of the EE's dosimeters from 1956 through 1959 and 1961 indicated that all were labeled as MTR and ANP. This is consistent with information contained on the EE's LFCs. The internal monitoring records from 1956 through 1961 were all labeled as ANP.

Internal records from 1972 through 1974 were labeled as EBR-II. The CATI report from the EE's survivor has the employment period from 1957 through 1961 as INEL, and 1970 through 1974 as the only employment period at ANL-W. The DOL records for the EE indicate only that [redacted] from 1956 through 1961. The DOL record indicates the EE worked at ANL in Idaho Falls from 1970 through 1974. The totality of evidence suggests the EE did not work at ANL-W until the 1970s and thus is not relevant to this section. Inspection of the DOL initial case indicates the dates contained in NOCTS are likely in error and should reflect work with [redacted] area of INL.

5.10 CLAIM J

The EE worked at ANL-W from January 1957 through 1989 as a health physicist. The EE also had an employment period at INL from 1952 through January 1957 as a [redacted] engineer. External monitoring records for this EE at ANL-W began in 1957. The EE had several dosimeters in a short period of time in March 1957, and one dosimeter in May 1957. In 1958, the EE had a few dosimeters in January and March 1958; then, starting on March 29, 1958, the EE

had weekly dosimeters. Looking through the end of 1959, the EE's dosimeters continued to be weekly and switched to biweekly around September 1959. The frequency of the EE's external monitoring increased after late March 1958. The EE had internal monitoring records for 1958–1972, and had a record in 1975 and 1985. The survivor's CATI report said:

> *…his father was a health physicist and he worked on radiation safety.*
>
> *…when the SL-1 Reactor blew up at the Idaho National Laboratory (between 1959 and 1961); his father was the first one to go in. He said he does not know if his father stayed in too long or if they were only permitted to go in a little bit at a time but he was restricted as a result of this explosion.*

5.11 SUMMARY OF 10 FOCUSED CLAIMS

Of the 10 claims selected for this focused review, 6 claims (A, C, D, E, H, and J) who had detailed dosimetry records for ANL-W both before and after the SEC end date showed a distinct increase in badging frequency on March 29, 1958. In fact, the style of the dosimetry reports seen in these claims changed on this date as well. Two claims (B, G) only had yearly summaries included in their dosimetry files; therefore, we were unable to discern if their badging frequency changed in 1958. Claim F only had dosimetry information for ANL-W for a short period starting in 1963 (see Finding 3). Claim I appears to have been actually working at ANP [redacted] during the assumed covered employment at ANL-W. It should be noted that significant increases in monitoring beginning at the end of March were also observed for Cases 5, 45, and 50 of the randomly selected claimant population discussed in Sections 2–4. This suggests the actual change in general radiation monitoring practices occurred at the end of March 1958, instead of December 1957.

Finding 4: Based on observed trends in sampled claimant data, it appears that significant changes in the external dosimetry program were put into effect at the end of March 1958 and not December 1957. NIOSH should consider a recommendation extending the SEC period into the first quarter of 1958.

Seven of the 10 claims had internal monitoring records that began in 1958 (A, C, D, E, F, H, and J). All of these seven claims had two internal monitoring records in 1958 (one in January and one in July). Claims A, C, D, E, F, and H did not have any internal monitoring records in 1959 or 1961. Claim J was the only one with an ANL-W internal monitoring record for 1959. Claims G and J had ANL-W internal monitoring records for 1961. Claims B and I had internal monitoring records starting in 1956 but were attributable to MTR and ANP. While internal monitoring may not have been performed on an annual basis starting in 1958 for each analyzed claim, it appears there are sufficient monitoring data to allow for coworker evaluations as necessary.

6.0 SUMMARY CONCLUSIONS

SC&A reviewed and compiled the data on 50 randomly selected ANL-W claimants for the purposes of evaluating and characterizing the internal and external monitoring practices in the post-SEC period (after December 31, 1957). During the course of that study, SC&A determined that the random sample did not sufficiently characterize the potential changes or evolution in the internal and external dosimetry program occurring in the transition from the SEC period. Therefore, SC&A performed a focused review of 10 additional claimants who were employed both during and after the current SEC. The combination of both studies resulted in a total of four Findings and six Observations.

Finding 1 identified deficiencies in a sampled worker's external monitoring data for which nearly 12 years appear to be unmonitored or the records unavailable. Evidence suggests that the individual continued to work at the site in the same work capacity and was even monitored internally during that timeframe. Therefore, it is important to assess why external dosimetry does not exist for this period and address any potential implications for other workers at ANL-W. Similar to Finding 1, Finding 3 identified a claimant for whom notable gaps existed in the available external dosimetry, while internal dosimetry existed for the EE over that same period.

Finding 2 identified what appears to be a gap in the internal monitoring records for the random sample of claimants from about 1973 to 1979. The reasons behind this sharp drop in internal monitoring for some workers should be assessed and available data analyzed for the potential use in coworker intake assignment.

Finding 4 identified an observed trend by which claimant external monitoring increased markedly at the end of March 1958 (as opposed to December 1957). NIOSH may want to consider recommending an extension of the SEC to cover this relatively short period.

Observation 1 noted that several cases only contained annual summaries of external dosimetry and did not contain information on individual dosimetry cycles. While not particularly important in an SEC context, actual dosimetry cycle information is important during the course of standard dose reconstruction methods and, therefore, such monitoring information should be obtained as necessary.

Observations 2 and 6 related to the examination of apparent gaps in external and internal dosimetry, respectively. The observation concluded that, for many cases, it is simply not feasible to make a reasonable determination whether a gap represents a deficiency in the monitoring program or is caused by other factors such as uncertainty in establishing covered employment. This issue is not unique to ANL-W and is often encountered when trying to analyze monitoring records for subcontract workers. This issue is also highlighted in Observation 3.

Observation 4 noted that extremity monitoring is often sparse, even among workers who would be expected to work in environments with special geometric considerations. SC&A recommends that the available extremity monitoring be compared with established correction factors to assure that application of general guidance during the dose reconstruction is appropriate and claimant favorable for ANL-W.

Observation 5 relates to the practice of neutron monitoring at ANL-W. It is SC&A's understanding that unmonitored neutron doses will not be assessed except in certain situations where the site had undertaken an investigation into unmonitored neutron exposure. While this may be a reasonable approach, given the explanations provided in the ANL-W TBD (ORAUT 2011) and SEC ER (NIOSH 2016), both documents would benefit from an expansion of the discussion to include examples of when such special investigations were conducted, their frequency, and under what circumstances. Furthermore, documentation concerning how certain workers were selected for neutron monitoring would aid in supporting the determination that unmonitored neutron dose assignment is unnecessary for ANL-W.

Finally, SC&A's evaluation of claimants with no internal dosimetry results indicates there are some examples where it appears the EEs should have been monitored internally. It is recommended that NIOSH evaluate the feasibility of developing coworker models for certain time periods and areas as appropriate. This was the subject of Observation 6 in Section 4. It is important to note that SC&A does not feel this is an SEC issue at this time.

7.0 REFERENCES

DCAS 2010. *Selected Geometric Exposure Scenario Considerations for External Dose Reconstruction at Uranium Facilities*, DCAS-OTIB-0013, Revision 01, National Institute for Occupational Safety and Health, Division of Compensation and Analysis, Cincinnati, Ohio. November 23, 2010.

NIOSH 2016. *SEC Petition Evaluation Report – Petition SEC-00224 – Argonne National Laboratory–West*, National Institute for Occupational Safety and Health, Cincinnati, Ohio. February 18, 2016.

ORAUT 2011. *Idaho National Laboratory and Argonne National Laboratory West – Occupational External Dosimetry*, ORAUT-TKBS-0007-6, Revision 03, Oak Ridge Associated Universities Team, Oak Ridge, Tennessee. April 19, 2011.

APPENDIX A: SUMMARY OF 50 RANDOMLY SELECTED CLAIMS

Case #	[redacted]	Covered Employment	Job Title(s)	External Monitoring	Internal Monitoring	Additional Comments
1	[redacted]	[redacted]/1950–[redacted]/1989	Operator Technician	Partial	Partial	Survivor believes EE started work in 1958, not 1950; gaps in external monitoring
2	[redacted]	[redacted]/1970–[redacted]/1971 [redacted]/1971–[redacted]/1971	Pipefitter	Partial	No	Only two dosimeters, from time period not with ANL-W employment; gaps in external monitoring
3	[redacted]	[redacted]/1960–[redacted]/1995	Computer Scientist, [redacted]	Partial	Partial	Gaps in external monitoring; few years without internal monitoring
4	[redacted]	[redacted]/1957–[redacted]/1981	Research technician, [redacted]	Yes	Partial	Few years without internal monitoring
5	[redacted]	[redacted]/1965–[redacted]/1994	Maintenance	Yes	Partial	Few years without internal monitoring
6	[redacted]	[redacted]/1962–[redacted]/1964	Research [redacted]	Yes	Yes	Annual summary only for external monitoring
7	[redacted]	[redacted]/1972–[redacted]/1979	Nuclear power plant operator	Yes	Partial	One internal monitoring record
8	[redacted]	[redacted]/1974–[redacted]/2000	Nuclear engineer	Yes	Partial	Few years without internal monitoring; annual summaries only for some external monitoring years
9	[redacted]	[redacted]/1978–[redacted]/1979	Ironworker	Partial	No	Gaps in external monitoring
10	[redacted]	[redacted]/1959–[redacted]/1976	Maintenance [redacted]	Yes	Partial	Few years without internal monitoring
11	[redacted]	[redacted]/1961–[redacted]/1990	Security inspector, [redacted]	Yes	Partial	Few years without internal monitoring; annual summaries only for some external monitoring years

Case #	[redacted]	Covered Employment	Job Title(s)	External Monitoring	Internal Monitoring	Additional Comments
12	[redacted]	[redacted]/1977–[redacted]/1977	Millwright, [redacted]	No	No	Not monitored at ANL-W
13	[redacted]	[redacted]/1974–[redacted]/1986	Custodian	Yes	Partial	Few years without internal monitoring
14	[redacted]	[redacted]/1962–[redacted]/1992	Hot Cell Worker	Yes	Partial	Few years without internal monitoring
15	[redacted]	[redacted]/1990–[redacted]/1993 [redacted]/1995–[redacted]/1995	[redacted] Plumber Pipefitter	Partial	Partial	Gaps in external monitoring; few years without internal monitoring
16	[redacted]	[redacted]/1969–[redacted]/1969 [redacted]/1971–[redacted]/1971 [redacted]/1971–[redacted]/1972 [redacted]/1988–[redacted]/1989	[redacted] Mason	Partial	No	Gaps in external monitoring
17	[redacted]	[redacted]/1959–[redacted]/1992	Maintenance, [redacted]	Partial	Partial	External monitoring stops in 1985; few years without internal monitoring
18	[redacted]	[redacted]/1972–[redacted]/1973	Visitor/Heavy Equipment operator	Yes	No	No internal monitoring; external covers employment
19	[redacted]	[redacted]/1975–[redacted]/1985	Engr. Tech [redacted]	Yes	Partial	Annual summary only for external monitoring; few years without internal monitoring
20	[redacted]	[redacted]/1976–[redacted]/1976 [redacted]/1975 - [redacted]/1975	[redacted] Scientist [redacted]	No	No	Not monitored at ANL-W
21	[redacted]	[redacted]/1961–[redacted]/1989	Laborer, [redacted]	Yes	Partial	Few years without internal monitoring
22	[redacted]	[redacted]/1972–[redacted]/1990	Production [redacted]	Yes	Partial	Few years without internal monitoring
23	[redacted]	[redacted]/1960–[redacted]/1962 [redacted]/1963–[redacted]/1973	[redacted] Electrical Eng, [redacted]	Yes	Partial	One year without internal monitoring
24	[redacted]	[redacted]/1962–[redacted]/1962	Carpenter/Millwright	Yes	No	No internal monitoring; external covers employment
25	[redacted]	[redacted]/1974–[redacted]/1976	Custodian	—	—	—
26	[redacted]	[redacted]/1955–[redacted]/1991 [redacted]/1991–[redacted]/1995	[redacted] analytical technician/scientist (chemist)	Partial	Partial	Gaps in external monitoring; few years without internal monitoring

Case #	[redacted]	Covered Employment	Job Title(s)	External Monitoring	Internal Monitoring	Additional Comments
27	[redacted]	[redacted]/1949–[redacted]/1988	[redacted]	Partial	Partial	Gaps in external monitoring; few years without internal monitoring
28	[redacted]	[redacted]/1969–[redacted]/1995	Electronics Tech	Yes	Partial	Few years without internal monitoring
29	[redacted]	[redacted]/1965–[redacted]/1973 [redacted]/1975–[redacted]/1978	Health Physics Tech	Yes	Partial	Few years without internal monitoring
30	[redacted]	[redacted]/1962–[redacted]/1964 [redacted]/1964–[redacted]/1989	Engineering technician, Engineering technician [redacted]	Yes	Partial	Few years without internal monitoring
31	[redacted]	[redacted]/1963–[redacted]/1963 [redacted]/1967–[redacted]/1968 [redacted]/1971–[redacted]/1971	Roofer	Partial	No	Gaps in external monitoring
32	[redacted]	[redacted]/1967–[redacted]/1967 [redacted]/1967–[redacted]/1967 [redacted]/1971–[redacted]/1971 [redacted]/1971–[redacted]/1972	Mason	No	No	Not monitored at ANL-W
33	[redacted]	[redacted]/1963–[redacted]/1990	Civil Engineer	Yes	Partial	Several years without internal monitoring
34	[redacted]	[redacted]/1972–[redacted]/1973 [redacted]/1975–[redacted]/1975 [redacted]/1975–[redacted]/1976	Visitor	Partial	No	Gaps in external monitoring
35	[redacted]	[redacted]/1959–[redacted]/1973	Carpenter	Yes	Partial	Few years without internal monitoring
36	[redacted]	[redacted]/1965–[redacted]/1999	Custodian	Partial	Partial	One year missing from external monitoring; few years without internal monitoring
37	[redacted]	[redacted]/1959–[redacted]/1993	Reactor Operator	Partial	Partial	No External monitoring for last two years; few years without internal monitoring
38	[redacted]	[redacted]/1960–[redacted]/1993	Engineering technician [redacted]	Yes	Partial	Few years without internal monitoring
39	[redacted]	[redacted]/1979–[redacted]/1979 [redacted]/1979–[redacted]/1979	Laborer, Yardman	Yes	No	No internal monitoring; external covers employment

Case #	[redacted]	Covered Employment	Job Title(s)	External Monitoring	Internal Monitoring	Additional Comments
40	[redacted]	[redacted]/1976–[redacted]/1977 [redacted]/1977–[redacted]/1978 [redacted]/1978–[redacted]/1980 [redacted]/1982–[redacted]/1982 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1983 [redacted]/1983–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1984–[redacted]/1984 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1985 [redacted]/1985–[redacted]/1986 [redacted]/2000–[redacted]/2003	Pipefitter	Partial	No	Gaps in external monitoring
41	[redacted]	[redacted]/1959–[redacted]/1995 [redacted]/1996–[redacted]/2005 [redacted]/2005–[redacted]/2006	Reactor Operator [redacted]	Partial	Partial	Gaps in external monitoring; few years without internal monitoring
42	[redacted]	[redacted]/1965–[redacted]/1984	Health Physicist Tech [redacted]	Yes	Partial	Few years without internal monitoring
43	[redacted]	[redacted]/1963–[redacted]/1968 [redacted]/1998–[redacted]/1998	Research Technician, Visitor	Yes	Yes	Annual summaries only for external monitoring
44	[redacted]	[redacted]/1959–[redacted]/1980	Electrical Engineer	Yes	Partial	Few years without internal monitoring
45	[redacted]	[redacted]/1957–[redacted]/1984	Analytical Chemist	Yes	Partial	Few years without internal monitoring
46	[redacted]	[redacted]/1974–[redacted]/2003	[redacted] Operator	Yes	Partial	Few years without internal monitoring
47	[redacted]	[redacted]/1974–[redacted]/1992	Main. Spec. electrician	Yes	Partial	Few years without internal monitoring
48	[redacted]	[redacted]/1962–[redacted]/1985	Nuclear power plant operator	Yes	Yes	—

Case #	[redacted]	Covered Employment	Job Title(s)	External Monitoring	Internal Monitoring	Additional Comments
49	[redacted]	[redacted]/1970–[redacted]/1986	[redacted] Engineering Tech	Partial	Partial	One year without external monitoring; few years without internal monitoring
50	[redacted]	[redacted]/1955–[redacted]/1968	Maintenance Personnel	Partial	Partial	One year without external monitoring; few years without internal monitoring

APPENDIX B: INTERPRETATION OF NEUTRON DOSIMETRY RECORDS

As noted in Section 3.3, the format of dosimetry records for ANL-W makes the determination of actual neutron monitoring somewhat difficult for certain time periods. ORAUT 2011 states the following concerning neutron dosimetry records:

> *With the advent of computers, the reports were all computer-generated with the effect that, even though many workers were not exposed to neutrons and did not receive neutron dosimeters, zeros were entered in the dose reports. A zero is not an indication that a dosimeter was assigned in a computer-generated report.*

Therefore, SC&A had to make reasonable assumptions to infer when an observed zero represented an actual neutron monitoring result. The assumptions were based on logical patterns observed in the monitoring records and are described in this appendix.

Specifically, the format of the observed dose records beginning in 1966 contain a neutron column that often contains a "zero"; however, this is likely not indicative of an actual neutron badging cycle, but rather a record of the annual neutron exposure total (see Figure 19). In the example record, SC&A highlighted what is assumed to be a "dosimeter type indicator" of "3." This is the most common indicator found in ANL-W dosimetry records and likely refers to the standard beta/gamma dosimeter. In other cases, this format of record contains a zero in conjunction with a "dosimeter type 1" (see Figure 20), which is assumed to represent an actual neutron badging cycle.

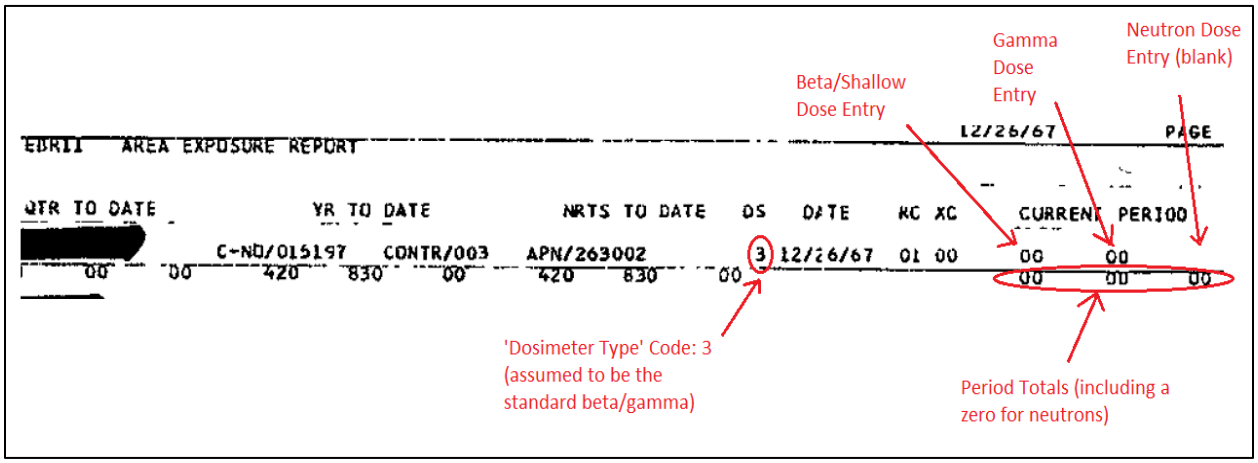


Figure 19. Screenshot of Typical Dosimetry Format Beginning in 1966 Assuming No Neutron Monitoring Result

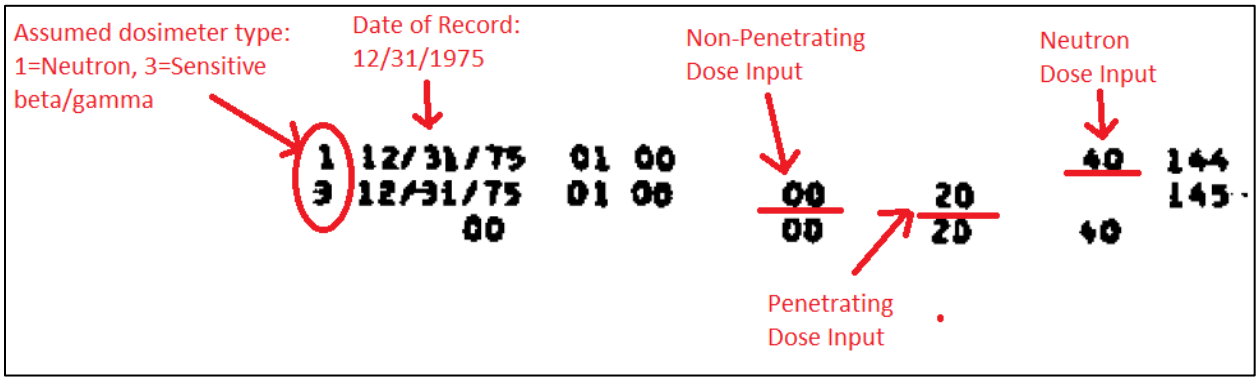


Figure 20. Screenshot of a Typical Dosimetry Record Format Beginning in 1966 Assuming Neutron Monitoring Occurred

The practice of labelling a neutron dosimeter as "Type 1" was also observed in a later format, as shown in Figure 21. In this example, it appears two dosimeter types were issued for the period ending on 12/31/1975 (Type 1 and Type 3). A positive result appears in the neutron column for this date. Note that while zeros are reported for the remaining badging cycles in the record, they are all labelled as Type 3, and thus the zero is not assumed to represent an actual neutron monitoring result.

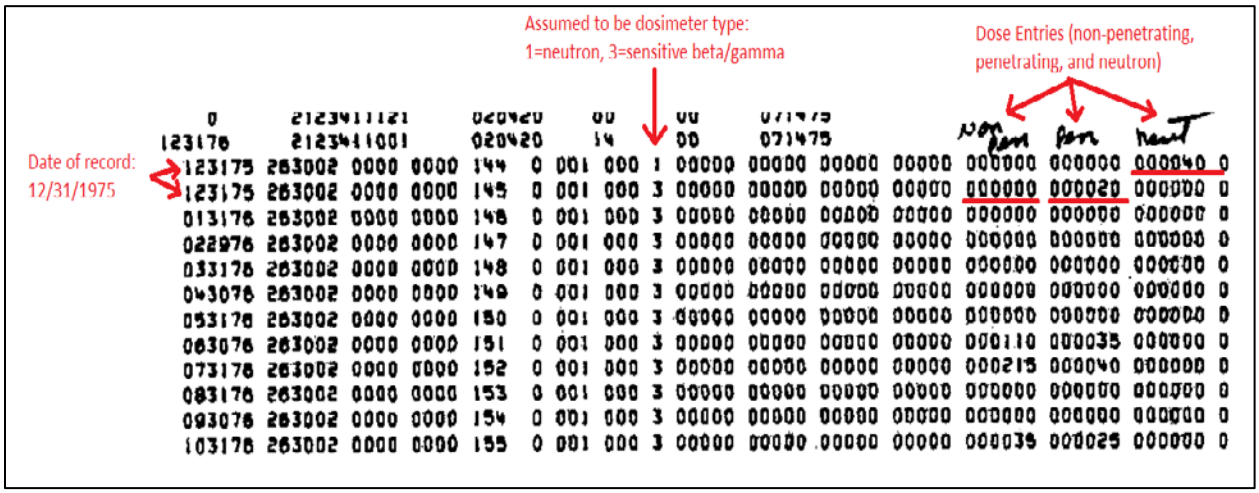


Figure 21. Screenshot of a Typical Dosimetry Record Format Beginning in December 1975 Indicating Neutron Monitoring Occurred on 12/31/1975

Beginning in 1986, the format for dosimetry records was changed again (see Figure 22). This new format contains an actual column labelled "Neutron? (Y/N)," which will contain a "Y" or "N," or is often left blank. SC&A was not able to ascertain whether neutron monitoring actually occurred in dosimetry entries that contain a blank entry. For the analysis described in Section 3.3, SC&A has considered such blank results as "unknown," and so they are not included in any of the quantitative analyses of Section 3.3, with the exception of noting how inclusion of blank entries would alter the total number of monitored claimants among the random sample.

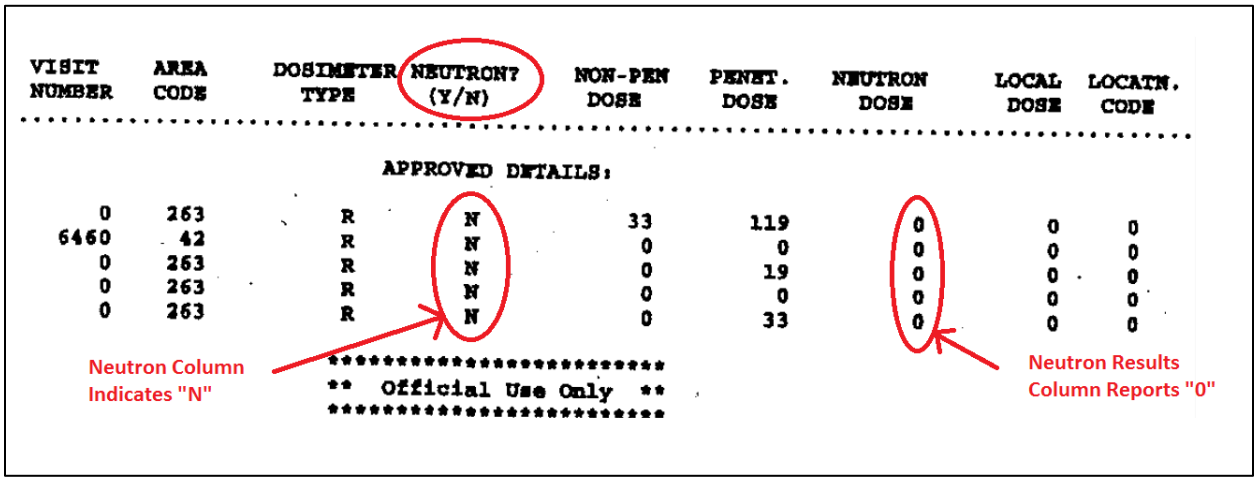


Figure 22. Screenshot of a Typical Dosimetry Record Format Beginning in 1986 Indicating No Neutron Monitoring Occurred.