MEMO

TO: BNL Work Group
FROM: Ron Buchanan, SC&A
DATE: May 22, 2012
SUBJECT: SC&A's Evaluation of SEC-00196 End Date of 1993, and Remaining Site Profile Findings for ORAUT-TKBS-0048, Revision 01

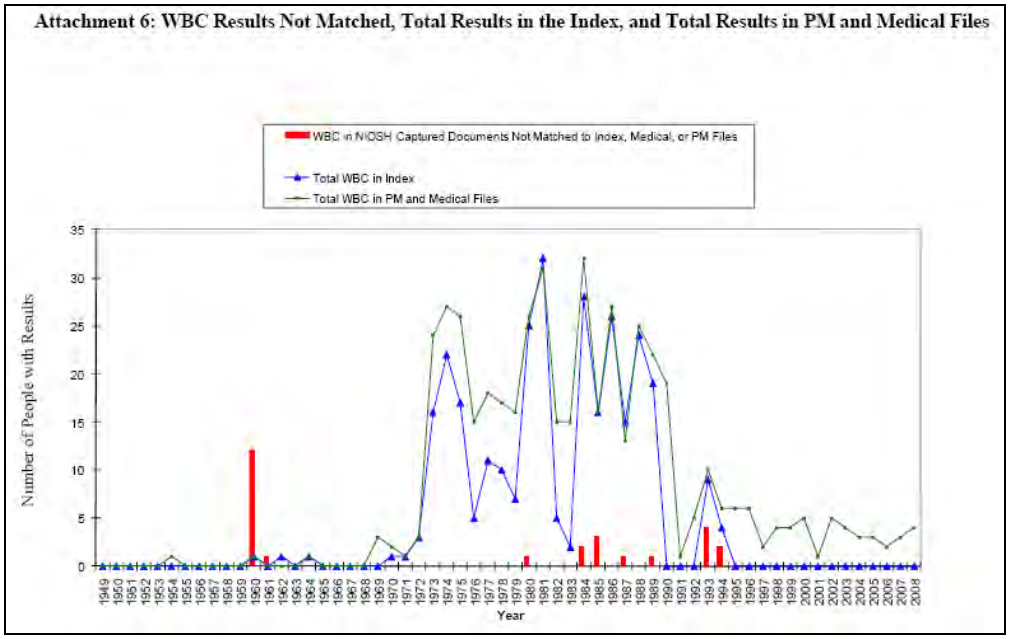
SC&A'S EVALUATION OF SEC-00196 END DATE OF 1993

SC&A evaluated the technical soundness of using December 31, 1993, as the end date for the Brookhaven National Laboratory (BNL) SEC-00196 recommended in the National Institute for Occupational Safety and Health (NIOSH) Evaluation Report (ER) (NIOSH 2012); the SEC was based on the lack of bioassay data records available for dose reconstruction (DR) purposes. The following is a summary of SC&A's findings.

Lack of Two 1994 Records in BNL Files

NIOSH had indicated in Attachment 6, page 116, of the SEC-00113 SEC ER (NIOSH 2009) that there were two whole-body count (WBC) records in NIOSH's document capture that were not in the BNL **Index**, **Medical**, or **PM** (Personnel Medical) files (which would contain the data used to respond to NIOSH's request to BNL for data for dose reconstruction). This is an indication that not all the bioassay data were complete for 1994 in the BNL files, as of 2009. NIOSH's Attachment 6 is shown as Exhibit A below.

Exhibit A



Search of Claims

BNL is a difficult site to assess the completeness of bioassay records because of its diverse facilities and changes over time. One possible method to assess if 1993 is a reasonable date for the SEC to terminate (on the basis of the lack of bioassay records) is to analyze the bioassay records for workers at a given facility that had a fairly stable staff and function in the 1990s, and had the potential for internal exposures. SC&A found that the High Flux Beam Reactor (HFBR), which operated between 1965 and 1999, was one of the few candidates available.

SC&A found that there have been 425 claims filed for the BNL site to date in the NOCTS database, with approximately 184 of those claims having employment periods during the 1994–1999 time frame. The NOCTS program lists Position Titles, but unfortunately does not allow the user to query on work location. Therefore, position titles that would most likely not be covered by the "*Bioassay Positions*" listed in the *1993 Internal Monitoring Procedure* (Reciniello 1993) were removed and the remaining claims (~65) analyzed on an individual basis. The NOCTS program was used to view the individual Computer Assisted Telephone Interviews (CATI) and DR reports to determine if the worker may have worked at the HFBR in a position that required bioassay monitoring. SC&A found [**less than 9**] workers who met the criteria of having filed a claim worked at the HFBR during 1994–1999, and had job titles that **could** indicate a possible need for routine bioassay monitoring. The "*Bioassay Positions*" listed in the *1993 Internal Monitoring Procedure* (Reciniello 1993) were *Reactor Operators, Reactor Supervisors, Reactor Maintenance Technicians, Water Chemistry Technicians, and S&EP Building Safety Services (BSS) Technicians assigned to the RD* [*Reactor* Division].

The *Internal Monitoring Procedure* (Reciniello 1993) recommended weekly bioassays for tritium, but only monthly tritium bioassays were found in the records, except for what appears to be more frequent monitoring around an incident or event. Additionally, the requirement of pre- and post-employment WBCs at the HFBR, as recommended by the *Internal Monitoring Procedure* (Reciniello 1993), does not appear to have been implemented. Some of the CATI and DR reports indicate monthly tritium bioassays and occasional WBCs, which agree with the bioassay records reviewed.

During the search of the [**less than 9**] claim files, SC&A located a document in one of the Energy Employee's (EE's) DOE files that lists the *1996 Tritium Dose Annual Summary* for the HFBR, categorized by groups and with the EE's *Name*, *Life Number* and ^{3}H *Dose (mrem)*. The groups and number of respective names are as follows:

- Operations Group – Operators = 13 names
- Operations Group – Shift Supervisors & Plant Managers = 16 names
- Health Physics = 10 names
- RCS & Water Chemistry = [**less than 9**] names
- RMG = [**less than 9**] names
- RIG = [**less than 9**] names.

A search of the BNL claims on NOCTS shows that only [less than 9] of these 55 workers had filed a claim; and that these [less than 9] workers were among the [less than 9] cases already identified for analyses by SC&A. Therefore, there were [less than 9] cases identified that were definitively on the 1996 HFBR required bioassay and WBC list, and [less than 9] additional cases that indicated a potential need for monitoring at the HFBR because of the work description and location in the CATI/DR reports.

Analyzing the [less than 9] claims, SC&A found the following:

Case A: The EE worked at the HFBR from 1971 through September 1995 as a [employee] at the Cold Neutron Facility (CNF), but was not listed on the *1996 Tritium Dose Annual Summary* HFBR list of required bioassays. The DR report of March 2007 states that:

> *Because* [the EE] *worked at the High Flux Beam Reactor and provided monthly urine samples which likely were for monitoring exposures to tritium, unmonitored tritium intakes may have occurred. The Department of Energy dosimetry records provide no indication of tritium bioassay results, which indicates that no positive values were recorded.* [Emphasis added.]

In this case, it appears that the EE was required to be monitored, but no tritium results were available in the DOE files through 1995. Additionally, the DR report states:

> *Employment records for* [the EE] *were reviewed, and no records of bioassay monitoring results were found.*

This indicates that there are no records of the annual WBCs for this EE through 1995, according to the 2007 DR report.

The EE states in the CATI that the EE had monthly tritium bioassays and one WBC.

SC&A's search of the DOE records (last posted June 2, 2011) found tritium bioassay records for 1990, 1991, 1992, and 1993, but none for 1994 and 1995, and WBC records for 1993, 1994, and 1995, but none for 1990, 1991, 1992, and 1993. The last DOE files were posted on June 2, 2011, 4 years after the DR report of March 2007; this may account for the lack of bioassay records during the preparation of the DR report.

Case B: The EE worked at the HFBR and the Brookhaven Medical Research Reactor (BMRR) from 1986 through 1999 as an [employee]. The EE was listed on the *1996 Tritium Dose Annual Summary* HFBR list of required bioassays. The DR report of May 2010 stated that:

> *Internal dose monitoring records were reviewed. All whole body measurement results for nonnaturally occurring radionuclides showed an activity less than the level of detection for the given radionuclides. There were many positive urine bioassay results recorded for tritium, with dose assigned during several years.*

This indicates that there were tritium bioassays and WBCs in the DOE files.

SC&A searched the DOE files (last posted September 27, 2011) and found records of the EE's tritium bioassay every year from 1990–1999, and WBCs each year from 1990–1999.

Case C: The EE worked at the HFBR, the BMRR, and then at other facilities from 1990 through the present as a [**employee**] and [**employee**]. The EE was listed on the *1996 Tritium Dose Annual Summary* HFBR list of required bioassays. The DR report of June 2007 states:

> *Employment records for* [the EE] *were reviewed, and no records of bioassay monitoring results were found other than for tritium in urine (discussed below).*
>
> *The bioassay records included several analyses for tritium in urine, with some values reported at or above the minimum detectable amount.*

This indicates that there were some tritium bioassays, but no WBCs in the DOE files through 1995 when the cancer was diagnosed, according to the DR report of 2007.

SC&A searched the DOE files (last posted September 27, 2011) and found records of the EE's tritium bioassay every year from 1990–1999, and WBCs each year from 1993–1999, but no records of WBCs were located for 1990, 1991, and 1992.

Case D: The EE worked in the target processing areas of the accelerators and the HFBR from 1989 through 2004 as a [**employee**]. The EE was not listed on the *1996 Tritium Dose Annual Summary* HFBR list of required bioassays. The DR report of April 2010 states:

> *Internal dose monitoring records were reviewed. Most measurement results for non-naturally occurring radionuclides showed an activity less than the level of detection for the given radionuclides and bioassay method. The bioassay records include monitoring for radionuclides in urine and whole body counts. All urine results reported less than detectable levels. All whole body counts also reported less than detectable levels except for two counts that indicated positive results for cobalt-57.*

This indicates that there were tritium bioassays and WBCs in the DOE files.

SC&A searched the DOE files (last posted September 27, 2011) and found tritium bioassay records for 1990, but none for 1991–1999. SC&A located WBCs for 1992, 1993, 1995, 1996, and 1999, but none for 1990, 1991, 1994, 1997, and 1998. This bioassay pattern may have been the result of the EE's work with irradiated targets, instead of being directly involved with HFBR operations.

Case E: The EE worked at the HFBR from 1994 to March 1999 as a [**employee**]. The EE was listed on the *1996 Tritium Dose Annual Summary* HFBR list of required bioassays. The DR report of November 2010 states:

Internal dose monitoring records were reviewed. There was indication that [the EE] *was monitored for tritium exposure during part of* [the EE's] *work at the HFBR (starting in 1994), although the records were incomplete.*

Except for tritium monitoring as discussed above, no records of bioassay monitoring were found.

This indicates that there were some, but incomplete, tritium bioassays, and no WBCs in the DOE files through 1999 when the cancer was diagnosed.

SC&A searched the DOE files (last posted June 2, 2011) and found records of the EE's tritium bioassay for 1996, 1997, 1998, and 1999, but none for 1994 or 1995, and WBC records for 1997 and 1998, but no WBC records for 1994, 1995, 1996, or 1999. The last DOE files were posted on June 2, 2011, 7 months after the DR report of November 2010; this may account for the lack of some of the bioassay records during the preparation of the DR report.

Summary of 1993 End Date Evaluation

Records of Tritium Bioassays

A plot of the number of monthly tritium bioassay records located in the DOE files for the [less than 9] workers that may have required bioassays are shown in Figure 1.

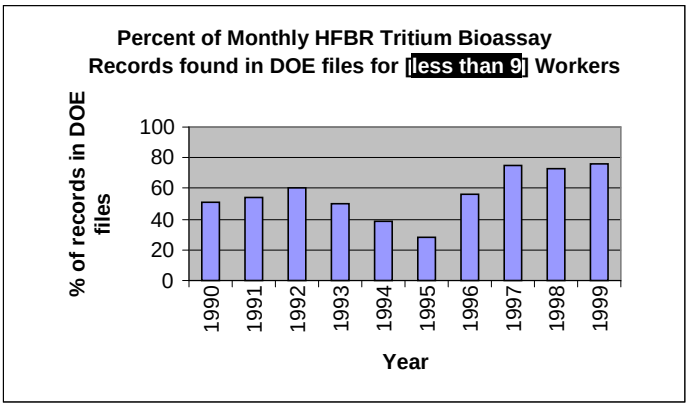


Figure 1. Percent of Recorded Monthly Tritium Bioassay for [Less than 9] Workers

A plot of the number of monthly tritium bioassay records located in the DOE files for the [less than 9] workers that were required to have bioassays, as per the *1993 Internal Monitoring Procedure* document (Reciniello 1993), are shown in Figure 2.

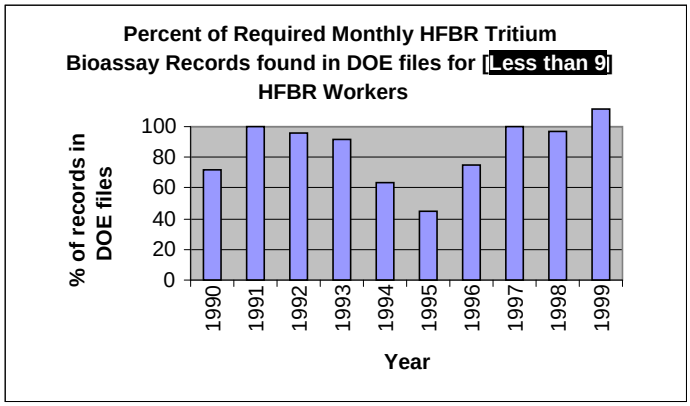


Figure 2. Percent of Recorded Monthly Required Tritium Bioassay for [Less than 9] Workers

Records of WBCs

A plot of the number of yearly WBC records located in the DOE files for the [less than 9] workers that may have required yearly WBCs are shown in Figure 3.

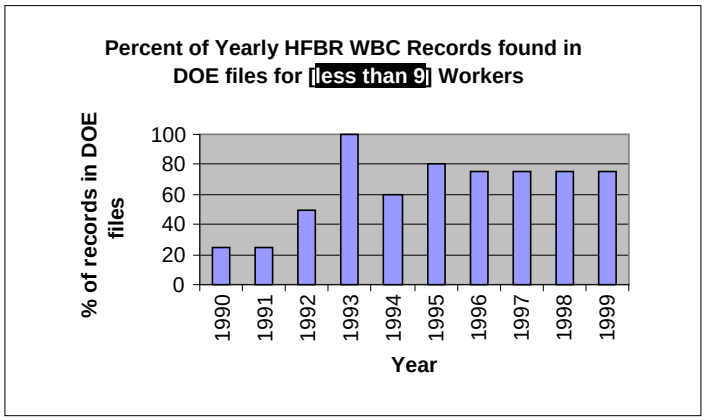


Figure 3. Percent of Recorded WBC for [Less than 9] Workers

A plot of the number of records of yearly WBCs located in the DOE files for the [less than 9] workers that were required to have yearly WBCs, as per the *1993 Internal Monitoring Procedure* document (Reciniello 1993), are shown in Figure 4. For the year 1999, one worker only worked a short time at the beginning of that year, which may not have resulted in a WBC being performed. If that was the case, there would have been 100% WBC records available for 1999.

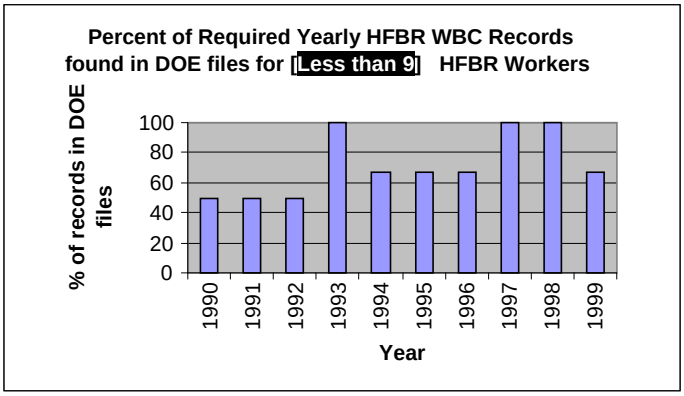


Figure 4. Percent of Recorded WBCs Required for [Less than 9] Workers

Conclusions

Unfortunately, analyzing this limited data does not provide an obvious date when the bioassay records became reasonably complete at BNL. However, it does indicate that 1993 may not be a technically sound year for the SEC to terminate, because the number of bioassay records for 1994, 1995, and 1996 fluctuate before leveling out around 1997, especially for the tritium bioassay data. The NIOSH ER (NIOSH 2012) used a BNL response to a 1993 assessment performed by the DOE Chicago office (HP Assessment 1993, p. 3) as the basis for showing that BNL's bioassay program and recordkeeping procedures were in compliance by 1994. The NIOSH ER (NIOSH 2012, p. 36) statement is as follows:

> *An assessment performed by the DOE Chicago Operations Office in December 1993 found the BNL HP program "in compliance with applicable DOE standards and acceptable professional practices."*

However, this assessment was general in nature, and only indicated that the procedures may have been in place, but as indicated in the present findings, not necessarily fully implemented and centralized, such that all the records are available today for DR purposes.

REMAINING PRIMARY FINDINGS

SC&A evaluated the remaining primary site profile issues in view of the SEC-00113 ER (NIOSH 2009), SEC-00196 ER (NIOSH 2012), and the revised BNL site profile Technical Basis Document (TBD) of 2010 (ORAUT 2010). The following is the current status of the site profile issues that were originally identified by SC&A in 2009 (SC&A 2009).

Finding 1: Bioassay Monitoring Not Adequately Established

ORAUT-TKBS-0048 (ORAUT 2006) does not provide sufficient information to determine which workers were monitored for what radionuclides and what criteria were used to select workers for special, routine, and spot bioassay monitoring. To perform an adequate dose

reconstruction, the dose reconstructor needs to know who, when, and why workers were bioassayed at a given DOE site. This information allows the dose reconstructor to determine if the worker should have been monitored, and prompts the dose reconstructor to search for such records, if applicable (especially important because of the lack of a centralized record system at BNL). Although bioassays for some radionuclides were conducted for some workers at BNL throughout the laboratory's operating history, sufficient documentation of written procedures and requirements for bioassays is not apparent before the 1990s; this leaves 40 years of uncertainty concerning bioassay requirements.

SC&A's Evaluation of Finding #1

This finding is negated through 1993 by the SEC. After 1993, SC&A found that, although NIOSH used the *1993 Internal Monitoring Procedure* document (Reciniello 1993) as a pivot point for when the bioassay program had a organized bioassay program, this document only applied to certain HFBR personnel, and did not appear to have been totally implemented. Therefore, the starting date of a functional site-wide bioassay program for the reactor, accelerators, isotope facilities, etc., has not necessarily been firmly established. As discussed in the previous section concerning the SEC end date of 1993, it appears that a reasonably constant bioassay monitoring program was not functional until around 1997.

Finding 2: Records of Bioassay Monitoring Not Centralized or Knowingly Complete

The site profile does not address the issue of the completeness and accessibility of the bioassay records. There were numerous bioassay data recording systems and filing methods at BNL. Many of these earlier records are still located in various departments, making it difficult (as confirmed by current BNL health physics personnel) for BNL to properly and completely respond to NIOSH requests for bioassay records to be used for dose reconstruction. It is not currently known by BNL health physics personnel if all the hardcopy records have been located, are legible, and are accessible for dose reconstruction. As various departments were formed and supplanted, and as department heads came and left BNL, the hardcopy records may have survived, or they may have been destroyed or removed from the site. There is presently no method available to determine if all the records for a given employee are available for dose reconstruction purposes, particularly before the records were centrally stored in electronic databases.

SC&A's Evaluation of Finding #2

This finding is negated through 1993 by the SEC. After 1993, SC&A found (using very limited case file data and the NIOSH ER for 1994) that there were still uncertainties in the availability of tritium and WBC bioassay records through about 1996. Because of changes in functions and facilities at the BNL during the 1990s, a date when bioassay records became reasonably complete is not obvious; however, the late 1990s (around 1997) appear to show an improvement in bioassay records, with a decrease in fluctuation.

Finding 13: The Site Profile has Inadequately Characterized the Number and Types of X-rays Received by BNL Employees in Early Years

The site profile (ORAUT 2006, page 50) states that BNL had machines capable of photofluoroscopic/fluoroscopic exams in 1951 and 1960, but on page 50, it is concluded that only the diagnostic unit was used for routine exams, and on page 52, it is stated that it seems unlikely that the greater dose units were used for routine exams. These potential exposures were not further addressed in the site profile. It references Brodsky 1964 as one of its reasons to conclude that only the diagnostic unit was used routinely for examinations. However, Sunderman (1947) summarized the health program used for BNL employees in September 1947. Sunderman recommended that employees of BNL be observed medically (1) upon hire at BNL, (2) routinely for employees requiring health maintenance, (3) when employees become sick or injured, and (4) when employees terminated. Candidates for employment were to receive "fluororoentgenograms of the chest, AP and LAT roentgenograms of the spine, and roentgenogram of one forearm." During Health Maintenance exams of employees, an annual fluororoentgenogram of the chest was completed.

SC&A's Evaluation of Finding #13

SC&A evaluated the revisions in Section 3, Occupational Medical Dose, of the April 26, 2010, edition of ORAUT-TKBS-0048 (ORAUT 2010) in view of the original Site Profile Issue #13 and found some relevant information had been added. The use of pre-employment PFG exams was addressed on page 48 of the revised TBD (ORAUT 2010), and summarized in Table 3-1 on page 49. Additionally, the issue of lumbar-spine and forearm x-ray exams was addressed on page 48. A summary of the default frequency and types of chest x-rays, as a function of time period, was summarized in Table 3-1, page 49.

SC&A found the revised information contained in Section 3 of the TBD (ORAUT 2010) useful, but did have the following comments:

1. Table 3-1: SC&A concurs with the recommendation in the last paragraph of page 48 of the revised TBD, which read as follows:

   > *Dose reconstructors should assign dose according to the number of PFG and 14-in. x 17-in. PA chest X-rays in the claim file records if they are provided. If these records are not provided, the dose reconstructor should assign dose from a preemployment PFG for start dates between 1947 and 1955, and annual 14-in. x 17-in. PA chests during this period. The default X-ray examination frequencies are found in Table 3-1.*

   However, the wording in Table 3-1 on page 49 (reproduced below) needs to be revised to more clearly reflect these recommendations.

Table 3-1. Default frequency of chest X-rays at BNL.

Period	Type of chest X-ray	Applicability	Frequency
1947–1955	PFG	All workers	Preemployment Periodic per the records No termination examination
1947–1955	14-in. × 17-in. PA	All workers	Preemployment if no PFG in the records Annual No termination examination
1956–1978	14-in. × 17-in. PA	All workers	Preemployment Annual No termination examination
1979–present	14-in. × 17-in. PA and LAT	All workers	Preemployment Every 7 years, unless records indicate otherwise No termination examination

A suggested wording change to correct this would be for the first "Preemployment" term be replaced with "Pre-employment, if PFG in the records, or no records exist" and the next "Pre-employment if no PFG in the records" term be replaced with "Pre-employment, if 14"x 17" in records for pre-employment."

This change would prevent assigning a 14″ x 17″ PA dose value when a PFG dose value should be assigned in cases where there are no records, or a 14″ x 17″ PA or PFG are not indicated in the records for a pre-employment exam.

2. On page 48 of the TBD (NIOSH 2010), NIOSH states that the "*claim files*" provide the following information:

   - The recommendations by Sunderman in 1947 (Sunderman 1947) were apparently not carried out.
   - Very few lumbar-spine exams and no forearm exams were found.
   - PFG exams were not used exclusively in the early years, and none after 1955.

   SC&A would like to obtain a list of some of these claim files from NIOSH to verify these statements.

3. Points in the revised TBD (ORAUT 2010) that need clarification:

   - Section 3.6, page 52, contains the statement "Organ doses are found in Tables 3-2 and 3-3 for various periods at BNL. In these tables…" SC&A finds that this should only refer to Table 3-2, not Table 3-3, because Table 3-3 contains skin exposure guidelines, not doses.
   - Section 3.6.3, on page 54, contains the statement "Skin doses from PFG, PA, and LAT chests are found in Table 3-3." However, Table 3-3 contains skin exposure guidelines, not doses. Apparently, this should be changed to Table 3-4.

- If these clarification points are correct, then Table 3-3 on pages 55–56 is not described in the TBD, or how it was derived, or the reference(s) from which it was taken.

These points need to be corrected or clarified to allow for the correct understanding of the recommendations for dose reconstruction.

Summary of Finding #13 Evaluation

Changes in the revised TBD addressed a number of the original concerns in this finding. However, the rewording and clarification items need to be addressed in the revised TBD, and SC&A would like NIOSH to provide some claim numbers which illustrate that very few lumbar-spine exams and no forearm exams were found, and PFG exams were not used exclusively in the early years, and none after 1955.

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