Attachment 1:

Nevada Test Site Building Trades Medical Screening Program: Summary Of Radiation Exposure Date Analyses, All Workers Interviewed By June 30, 2003, Construction Worker Exposure And Job Task Data Project, June 8, 2004.

NTS Review of Medical Surveillance Questionnaire Data and available Dosimetry Data

1.0 Project Description

The uncertainty surrounding radiation exposure information for construction workers is a great challenge in terms of completing dose reconstruction for individual workers as required in the Energy Employees Occupational Illness Compensation Program Act (EEOICPA). This project proposed to review findings from former worker medical surveillance programs regarding work and site history information and determine if any of the information could be useful in former worker dose reconstruction efforts.

2.0 Study Aims

This study included four primary tasks: 1) Perform a detailed analysis of work history questionnaire used during the medical surveillance program, 2) perform an assessment of work history variables as predictors of radiation dose, and 3) perform a review of available electronic dosimetry databases for completeness and validity of data, and 4) review a small sample (20 case files) of NTS in-depth dose reconstruction hard copy case files.

3.0 Overview of Site and Cohort of Interest

3.1 Site Description

During 41 years of operation from 1951 through 1992 there were 828 underground nuclear tests and 100 above ground tests. Of the 828 underground tests, 67 were Tunnel tests, 765 drill-hole tests and 9 crater tests (DOE, 1994). The drill-hole tests were fired several hundred meters below ground surface. The drill hole tests were fielded primarily for the purposes of developing new weapons systems. The NTS drill hole tests were conducted beneath Yucca Flat (Areas 1,2,3,4,6,7,8,9, and 10) and Frenchman Flat (Areas 5 and 11) for lower yield experiments, and beneath Pahute Mesa (Areas 19 and 20) for higher yield experiments. Horizontal tunnel tests occurred within tunnel complexes excavated in Rainier and Aqueduct Mesas (Area 12), Oak Spring/Butte (Area 15), and Shoshone Mountain (Area 16). (Smith, DK 2003)

At the peak of underground testing in the mid-1980's as many as 15,000 workers were employed at the Site, about one-third of them construction workers. Digging, maintaining and re-entering the tunnels and shafts used for nuclear testing at the Nevada Test Site was the daily work principally of six unions: Laborers Local 872, (Tunnel Workers), Operating Engineers Local 12, Electrical Workers Local 357, Plumbers and Pipefitters Local 525, Ironworkers Locals 416 and 433, and the Carpenters Local 1780, who together represented as many as 5000 Test Site workers at the peak of Test Site activity.

Since the nuclear testing moratorium took effect in 1992, the work force at the NTS has dwindled to 2,600 full-time employees, and many of the construction workers have moved on to the Yucca Mountain Project and other large projects in the Western United States. Under the direction of the Department of Energy (DOE), Nevada Test Site use has diversified into many other programs such as hazardous chemical spill testing, emergency response training, conventional weapons testing, and waste management and environmental technology studies.

Atmospheric weapons testing resulted in environmental radiation contamination in which parts of the NTS workforce were exposed following post-shot activities at ground zero as well as accidental contact with contaminated zones. Underground nuclear weapon testing, in contrast to atmospheric testing, was designed to maximize hazard containment. Nevertheless, accidental radiation releases occurred throughout the underground testing period. The DOE has attempted to identify all of the isotopes identified in each of the more than 900 nuclear tests conducted at the Nevada Test Site together with the release amount in curies, the maximum activity, and gamma exposure detected offsite, the maximum distance that radiation was detected offsite, and other statistics (DOE 1996).

Releases usually contain multiple isotopes. Isotopes identified in the various releases associated with nuclear tests include the following: Ar-37, Ar-39, Ba-139, Ba-140, and Ba-140/La-140, Be-7, Ce-141, Ce-144, Cs-137, Cs-138, Cs-139, H-3 (tritium and tritiated water), I-131, I-132, I-133, I-134, I-135, and I-132/Te-132, K-40, Kr-85, Kr-85m, Kr-87, Kr-88, Kr-89, Kr-91, La-140, La-142, Mn-54, Mn-56, Mo-99, Na-24, Nb-95, Rb-88, Rb-88m, Rb-89, Rh-105, Ru-103, Ru-105, Ru-106, and Ru-106/Rh-106, Sb-122, Sb-124, Sr-89, Sr-91, Sr-92, Tc-99, Te-132, W-181, W-187, W-188, Xe-127, Xe-129m, Xe-131m, Xe-133, Xe-133m, Xe-135, Xe-137, Xe-138, Xe-139, Xe-140, Y-91, Y-91m, Zr-95/Nb-95, and Zr-97/Nb-97. (DOE 1996)

Radiation Exposures:

"The release of radioactivity from an underground test can occur:

- Accidentally as a result of a containment failure;
- Accidentally or deliberately as a result of post-event operations; or
- Deliberately as a result of post-event controlled purging of gases from a tunnel."(DOE 2000)

DOE identifies the following types of radiological releases and potential exposures associated with nuclear tests at the Nevada Test Site:

- "A 'test' release (or an 'uncontrolled' release for DoD tunnel tests) has been defined as a spontaneous release that occurred after a test but before post-shot drilling operations began." "The pre-LTBT shaft and tunnel tests, where a sampling conduit to the atmosphere was designed and placed in the test complex for sampling of the particulate matter released, have been defined as 'test/prompt particle sampling releases. The cratering Plowshare tests, where the test was designed to produce a throw-out of earth, have been designated as 'test-crater' releases. Releases from surface tests have been categorized as 'test/surface'.

Those surface and near-surface tests, that were non-nuclear tests designed to determine the extent of debris scattering, have been defined as 'test/plutonium dispersal' releases."

- A "controlled" release was "a planned, filtered, release frequently performed to reduce airborne radiation levels in the working environment" predominantly from tunnels, although this type of release "also occurred from shaft tests".
- "'Drillback' releases occurred during post-shot drilling operations to recover samples; these releases were either filtered or unfiltered. After drillback operations were completed, a 'cementback' occurred where the drill hole was sealed with a plug and cemented to the surface." Releases also occurred during "cementback" operations.
- "'Gas sampling' releases occurred during gas sampling operations, either before or after any post-shot drilling operations commenced."
- "'Late-time seepage' releases occurred when noble gases have leaked from test sites after all operations in the area have ceased. These releases "could exist from a few hours to even weeks after all other operations in the area have ceased." (DOE 1996)

Other activities cited that brought radioactive isotopes to the surface from the explosion site include:

- "Cable pull" defined as "Recovery of a cable placed near a nuclear explosion. The cable ran to the surface and was pulled free shortly after zero time. The debris captured on the bottom end of the cable was analyzed to assess device performance."
- "Catcher pull" defined as "Recovery of a debris catcher, placed near a nuclear explosive, by pulling on the attached cable and thus returning the catcher to the ground surface. This operation is usually accomplished within minutes to hours of zero time." (DOE 1996)

A recent report (Bowen, SM 2001) shows estimates of the radiation source term (decay corrected to 1992) from all the underground tests in each area. The table indicates a significant amount of plutonium-238 and plutonium-239 (both most likely from the device component) with the total for all areas which included underground testing estimated as 3.95E4 Curies of Pu-238 and 1.6E5 Curies of Pu-239. (Bowen, SM 2001)

According to Bowen most of the plutonium would have been trapped in the cooling melt after the nuclear explosion with only a small proportion in the escaping cavity gases. (Bowen, SM 2001) Information regarding the amounts of plutonium that may have been released during tunnel venting could not be located for this project. Similarly little information regarding the potential exposures to plutonium within the tunnels could not be ascertained although Skrable (1995) does note that soil samples taken prior to the decontamination work in the E-tunnel in 1994 had Cesium (Cs-137) to Plutonium (Pu-239) ratios ranging from 10:1 to 400:1 on an activity basis. In the early NTS years, a many gross alpha nasal swipes were collected. Overall, however, a small percentage of workers at the NTS were monitored for plutonium.

3.2 Former Worker Cohort

The cohort being considered in this report consists of the individuals who participated in the BU medical surveillance program from September 1998 through March 21, 2003. The screened cohort consists of 2753 individuals with a mean age of 62 and an average of approximately 12 years of NTS work experience. The cohort consists of construction trades workers and is focused on underground and excavation workers. Each participant in the medical surveillance program completed a comprehensive work history questionnaire which asked very specific tasks about test site work activities related to above ground testing and tunnel tests. A copy of the latest version of this questionnaire is provided as attachment A.

3.3 **Construction Worker Radiation Exposures at the Nevada Test Site:**

Construction workers at the Nevada Test Site may have been exposed to radioactivity in the following situations:

- In the construction of roads, buildings, and related infrastructure through areas of the site contaminated with residual, post-shot contamination;
- In the drilling of vertical shafts used for the placement of test nuclear explosive devices;
- In the underground mining of tunnels (long horizontal drifts mined into a mountain or mesa) and test chambers in close proximity to areas where previous test shots were detonated;
- During post-shot drilling operations to recover samples. "Drillback" releases often occurred at the drilling rig and lasted for periods ranging from hours to days, likely contaminating the drilling rig and associated equipment that construction workers would have to move to another site and re-use.
- And during shaft plugging where the drill hole was plugged and cemented to the surface ("cementback").

4.0 Description of BU medical surveillance questionnaire

2753 individuals who participated in the medical surveillance program completed the work history questionnaire. The questionnaire was self administered and then reviewed by project staff. The individuals screened were members the following trade unions: Laborers (630), IBEW (437), Operating Engineers (642), Ironworkers (138), Plumbers/Pipefitters (145), Carpenters (166), Sheetmetal (37), Teamsters (222), Painters (23), Guards - IGAN (128), Other Union (158), and Non-Union (445).

The questionnaire also requests information on reported exposures (dust, beryllium, solvents, noise, and other hazards), tasks that workers performed (e.g., tunnel work and type of work conducted during tunnel work), the area(s) where they worked, and specific questions related to potential radiation exposure (some of these questions were only recently added to the questionnaire and therefore there was not a great deal of data for some of these questions). The work questions were developed following interviews and focus groups with former and current NTS workers, and NTS industrial hygienists and health physicists. The questionnaire has been modified and updated based on new information and feedback from these groups. . Appendix A (Summary Of Worker Demographics and Work History Information On Radiation Hazards) includes a summary of the findings in the questionnaire.

Medical questions are also included. Subjects are asked about a history of cancer, radiation treatment, and general health and respiratory status.

5.0 Analysis of the NTS dosimetry database and the BU Work History Questionnaire

The goal of the analysis was to determine whether cumulative lifetime gamma dose calculated from the NTS dosimetry database is associated with certain parameters collected within the BU work history questionnaire. We attempted to measure the utility of these parameters to determine whether they could be used as a surrogate to estimate cumulative dose.

We linked the work history questionnaire data on participants in the medical surveillance program to available databases on external radiation dose (see below). Our review of electronic databases identified the external radiation databases listed in section 4.1 of this report as the databases having external exposure data of use for this project. We attempted to use an NTS personnel database to provide an accurate estimate of an individual's working history; start, stop, and restart dates, duration, and cumulative work years. However, we found that it was infeasible to use the personnel database to calculate total time worked. In general, construction workers start, stop, and restart employment frequently over their working lifetime as the demand for their work waxes and wanes. We weren't confident that the database accurately captured this phenomenon. We therefore decided to determine an individual's time worked based on the BU work history questionnaire parameters. A master dose file then was constructed from all the relevant databases listed in section 4.1 that contained external radiation data. The master dose file was linked to the work history questionnaire (using the SSN). The effect of several variables from the questionnaire (first hire decade, years worked, job classification, etc.) on cumulative dose then was measured.

A data dictionary showing all of the variable names and definitions associated with the work history database is included in Attachment B.

5.1 Description of NTS External Dosimetry Databases

The following databases were used in the assessment of cumulative external exposure:

NTPR database	1945-1962	45,308 records (film badge data)
19631983	1963-1983	140,769 records (film badge data)
1984	1984	34,728 records (TLD data)
1985	1985	36,290 records (TLD data)
1986	1986	34,387 records (TLD data)

Dosemast	1986-1993	74,817 records (TLD data)

The following databases were used to review internal dose:

Dead.mdb	1955-1963	32,072 records; 3257 unique last names
midbio.mdb	1964-1987	19,980 records; 2000 unique SSNs
1984	1984	220 records
1985	1985	29 records
1986	1986	41 records
Dosemast	1986-1993	74,817 records; 36 results greater than zero

The NTPR database contains 45,308 records for the time period from 1945 through 1962. This database was comprised primarily of deep dose data (film badge data with detection limit of 30 mrem). The data primarily consists of annual summary data for the period 1959-1962 and weekly, monthly or quarterly data for the period 1952-1958. Only about 500 records are dated prior to 1952. 22,630 records (50%) had greater than zero deep dose recorded with 1422 (3.1%) in excess of 1 rem. Beta dose monitoring was not prevalent during this time period with beta dose recorded for only 220 records in the database and with only 4 records greater than zero.

The 19631983 database contains 140,769 records (film badge data). This database primarily contains gamma dose data, beta dose data, and neutron dose data. There are 139,577 gamma dose records with only 4647 (3.3%) greater than zero. There are 129,035 beta dose records with only 864 (0.6%) greater than zero. There are 129,019 neutron dose records with only 1 record greater than zero. This database contains some annual summary data and some monthly or quarterly results.

The 1984 database contains 34,728 records including gamma dose results (34,009 records with 96 records (3.7%) greater than zero), beta dose results (34,009 records with 28 records (0.1%) greater than zero), body part dose results (648 records with 464 records greater than zero), neutron dose results (34,009 records with none greater than zero), and internal dose results (220 records with 3 (1.3%) results greater than zero).

The 1985 database contains 36,920 records including gamma dose results (35,710 records with 132 records (0.3%) greater than zero), beta dose results (35,710 records with 85 records (0.2%) greater than zero), body part dose results (567 records with 438 records (77%) greater than zero), neutron dose results (35,710 records with none greater than zero), and internal dose results (29 records with 8 results (28%) greater than zero).

The 1986 database contains 34,387 records including gamma dose results (33,601 records with 252 records (0.7%) greater than zero), beta dose results (33,601 records with 71 records (0.2%) greater than zero), body part dose results (477 records with 273 records (57%) greater than zero), neutron dose results (33,601 records with none greater than zero), and internal dose results (41 records with 41 results (100%) greater than zero).

The dosemast database contains 74,817 records for the years between 1986 and 1993. This database contains deep dose results (74,817 records with 709 (0.9%) greater than zero), shallow dose results (74,817 results with 610 (0.8%) greater than zero), eye dose (74,817 records with 41 greater than zero), extremity dose (74,817 records with 1062 (1.4%) greater than zero), tritium dose (74,817 records with 3 records greater than zero), and internal dose (74,817 records with 36 records greater than zero).

The dead.mdb database contains bioassay data for the period from 1955 through 1963 with a total of 32,072 records representing 3257 unique last names. Many individuals had only 1 bioassay result (1264 individuals). The type of analysis included in the database were as follows: I-131 (36 results), U-235 (16 results), Pu-239 (318 results), Gross Alpha (10,483 results), Gross Beta (4583 results), Gamma Spec (21 results), Gross Fission Products (1326 results), I-133 (12 results), I-135 (12 results), Plutonium (35 results), Sr-90 (15 results), Tritium (7376 results), and Uranium (95 results).

The midbio.mdb database contains bioassay data for the period from 1964 to 1987 with a total of 19,980 records representing 2000 unique social security numbers. Approximately 1100 individuals had only 1 or 2 results in the database.

5.2 Analysis Results

An initial query of the data indicated that there were 1997 individuals with a work history questionnaire who had at least one record within the combined external dose database. The overall number of individuals with a work history questionnaire is 2753. The table below summarizes the lifetime cumulative gamma dose based on the NTS dosimetry database for individuals who were monitored.

Summary of lifetime cumulative gamma dose
for BU screening participants

Cumm Gamma Dose (mrem)	Number of Individuals	Percentage of screening participants (2753)
No Records	756	27%
0	1275	46%
>0 - 100	170	6%
101 – 499	189	7%
500 – 2,000	156	6%
2,001 – 5,000	135	5%

We next assessed the effect of t the decade an individual started work at the NTS on their cumulative dose. The cumulative gamma dose and beta dose records for individuals who participated in the BU screening program was examined by the decade they began work. For gamma dose records, in the 1950s 19.6% of the individuals (55) had a cumulative dose of zero, in the 1960s 32% (218) were zero, in the 1970s 77% (364) were zero and in the 1980s 88% (1430) were zero. For beta dose in the 1950s all cumulative doses were either zero or had no records at all (273 missing records), in the 1960s 85% (457) were zero and 143 individuals had no records, in the 1970s 88% (418) were zero with no missing records and in the 1980s 90% (1461) were zero. Although we were unable to determine whether an individual had a complete dosimetric record, hard copy data (if available) could be compared with the individual's reported work period (or work period specified in the personnel files) to determine if there is missing data. We were able to do this on a smaller scale for 20 cases that an in-depth records review had been performed. Of the 20 cases, 4 had no external radiation records within the electronic database, 3 had partial records (not for the entire time they worked at the site and not for the entire time indicated in the hard copy case file), and 13 had dose data covering the entire period indicated in their work history. The completeness of the database and hard copy records is discussed further in section xxx – In-depth Case Review.

We next examined cumulative lifetime dose as a function of job type. The self-reported job titles listed in the BU work history form were categorized into job groups as follows: Operating Engineers, Pipefitter, Sheet Metal Worker, Teamsters, Painters, Carpenters, Laborers, Electrical workers, Ironworkers, Other Union, and Non-Union. Table 1 shows the average cumulative lifetime dose by job class. The average dose is calculated for all workers with any dosimetry record and includes zero values in the average. It is interesting to note the number of workers with dosimetry records available by craft. It is particularly interesting to note that the non-union and other union job categories are the jobs with the largest percentage of missing records.

Table 2 shows the average cumulative lifetime gamma dose and beta dose by first year employed at the NTS. As expected these numbers generally trend down over time.

Tables 3.1 through 3.10.4 show the cumulative lifetime gamma dose and beta dose by decade first employed and years worked by job classification.

Several other parameters from the questionnaire were examined to determine their utility in determining the completeness of the dosimetry records for purposes of completing a dose reconstruction. If an individual indicates that he/she participated in a specific test or specific tunnel work task (e.g. tunnel re-entry), this could be used to determine if there were any missed dose records. According to NTS project staff, as well as former NTS workers tunnel and reentry access logs were well maintained and could be a useful and available reference for determining if an individual was involved in particular events. The logs could provide a way to determine potential missed doses from internal exposures, including radon exposures (see discussion of radon exposure below) during tunnel work. It also appears that radiological characterization data is available by area and even by underground test (828 total) and is contained within two separate databases at the LANL and LLNL. Since these databases contain test specific nuclear performance data including yield and residual nuclear fuels it is classified as Secret Restricted Data (Bowen, 2001)

Table 4 shows the lifetime cumulative dose for individuals who reported that they had been decontaminated for radioactive material contamination during their work at the NTS and for those who indicated they had not been decontaminated (variable a12). It is interesting to note that 872 individuals reported that they had been decontaminated at least once and 1871 individuals reported that they had not been decontaminated. The average lifetime cumulative gamma dose for those who indicated they had been decontaminated for radioactive material contamination was approximately 1400 mrem as compared to approximately 300 mrem for those who hadn't gone through any decontamination.

Table 5 shows the lifetime cumulative dose for individuals who reported doing any tunnel work during their career (questionnaire variable a8) and the second part of table 5 shows the relationship of cumulative dose as a function of the number of tunnels (variable a8a). The third section of this table shows the cumulative dose as a function of the tunnel re-entry task (variable a8d5). The fourth section of the table shows the number of tunnel events where they did re-entry work (worked in tunnel after the test was performed) (variable a8b The average cumulative dose trended as would be expected (increasing with increasing number of events and with increasing number of re-entries). When controlling for years worked and decade starting work, preliminary analysis suggests no clear relationship between the numbers of tunnel events that individuals reported working in with their recorded external gamma dose. We suspect that a recall bias may impact this response leading to an attenuation of an effect.

Table 6 shows the lifetime cumulative dose for individuals who reported being involved in work during any above ground testing (variable a7) and the second part of the table indicates cumulative doses as a function of the number of tests during which they worked (variable a7a). The third part of this table shows the cumulative dose as a function of the number of times an individual performed nuclear event cleanup (variable a7b). Again, this preliminary analysis was not controlled for total number of years worked or for decade hired. The average cumulative dose trended as would be expected (increasing with increasing number of events and generally with the number of event responses). The average cumulative gamma dose calculated for those who reported being involved in an above ground test was approximately 1900 mrem as compared to approximately 120 mrem for those who were not involved. When controlling for years worked and decade starting work, preliminary analysis suggests no relationship between the number of atmospheric tests that individuals reported working in with their recorded lifetime cumulative gamma dose.. However, comparing the cumulative gamma dose for the 1950s compared to the number of above ground tests that individuals reported participating in, the average cumulative gamma dose increased with increasing number of above ground tests from 952 mrem for 1 event (n=121) to 3,565 mrem for 21-30 events (n=44).

Table 7 shows the lifetime cumulative dose for individuals who reported doing any shaft work during their career and the second part of table 5 shows the relationship of cumulative dose as a function of the shaft re-entry task. This preliminary analysis is not controlled for total number of years worked. Again the average cumulative dose trended as would be expected (higher cumulative averages for individuals who were involved in shaft work compared with those who were not and higher cumulative dose for those who performed re-entry work in the shafts).

Based on this preliminary analysis of the work history questionnaire variables compared with cumulative lifetime gamma dose for the Boston University cohort (2753 medical screening participants) we felt that development of a statistical model to estimate dose based on the work history questionnaire variables was not achievable. There are several reasons we feel that this should not be performed with data available for our study including:

5.3 Internal Dosimetry Analysis

We also made an attempt to examine the impact of the workplace survey variables on lifetime internal dose (50 year CEDE). With the exception post-1989 databases, the NTS databases did not include much internal dose data. In order to evaluate internal dose, we used dose summary reports (Radiation Exposure History) that were provided by the Dosimetry Research Project to individuals who participated in the medical screening program. BU created a database with the summary dose information for all participants who provided their dose summary report to the program. The database included external dose information for 1752 individuals and internal dose information for 100 individuals. The jobs/unions with the most significant internal dose, based on this data, were the operating engineers and the laborers. They accounted for more than half of the former workers with internal dose records. 69 of 70 individuals reported working in tunnel tests, 43 of 70 indicated they had been involved in above ground tests (1951-1962), and 42 of 69 indicated that they had been decontaminated. Individuals who reported to participate in tunnel tests, atmospheric testing, or being decontaminated had higher average lifetime internal dose records than those who did not take part. Since there was only internal dose information for 100 individuals, (the data did not include potential dose from radon exposures) in our opinion analysis of the work history parameters as a function of total lifetime internal dose would not be useful.

Based on this preliminary analysis of the work history questionnaire variables compared with cumulative lifetime gamma dose for the Boston University cohort (2753 medical screening participants) we felt that development of a statistical model to estimate dose based on the work history questionnaire variables was not achievable. There are several reasons we feel that this should not be performed with data available for our study including:

1. We believe that potentially a relatively large portion of an individual tunnel workers dose could have been due to internal dose and we did not have summary internal dose data in the NTS database (database included primarily bioassay data). The available dose data did not account for radon exposure. However, radon was a significant exposure in the tunnels. The NTS project reported on available radon data. Radon measurements were collected and analyzed for several tunnels in 1984 and reported in the document, "Survey of Radon and Radon Daughter Concentrations in Selected Rainier Mesa Tunnels." In the tunnels, the radon working levels fall well below the EPA standard of 0.33 when

the ventilation equipment is working. However, the levels immediately begin to rise once the system is shut down. The radon levels, which were reported for several tunnels in area 12, were much higher on average for G tunnel that, according to the report, was the result of "a lower ventilation rate in conjunction with the more highly fractured nature of the 'welded tuff' rock formation." The lowering and/or elimination of ventilation was a common circumstance in the tunnels as the "button-up" phase approached. During these final steps prior to an event, access to the bypass and line-of-site tunnels were restricted at times to that of small crawl tubes that were not able to maintain the necessary ventilation level for safe working conditions. The decrease in ventilation rate is likely to have lead to increased radon levels in these instances. Further, ventilation in the early years has been described as "poor" by former workers in a focus group, which is likely considering that several crews worked in different headings of a single tunnel at one time and often worked in less ventilated side drifts.

2. Based on the in-depth case reviews (see section 7) it was apparent that approximately 25% of cases we reviewed either had no external dose records in the electronic database or were missing some time periods of monitoring results and we could not determine missing periods of dosimetry data for the larger cohort
3. It was unclear whether the primary work related variables were predictive of overall cumulative gamma dose. Even for the job type variable we could only evaluate the average lifetime cumulative dose as a function of job type for all individuals who listed a job. However, an individual could have had several jobs and that individual's overall cumulative dose would have been included in several different job type evaluations. A more detailed analysis of the cumulative dose as a function of job for the period the individual worked that job, could not be achieved given the questionnaire's data limitations.

Through our analysis we did identify several items that we believe might be helpful in estimating annual doses for former workers for compensation cases.

1. Some questions in the most recent BU work history questionnaire may be useful in verifying dosimetry data and also in determining presence at certain events for which dose information is not included in the individual's hard copy records. This could be especially useful for estimating radon dose or possibly dose associated with other radionuclides that were present in the event area. The primary questions, which may be useful in this verification process, include: questions related to event (tunnel, shaft, or above ground test) work and which event they worked in, question of whether they ever were decontaminated (and possibly when and where), question regarding badge use (just recently added to BU questionnaire so not evaluated in this report).
2. Event access logs and possibly the entire event log may prove to be very important especially since it appears that at least in some cases only some workers were monitored for internal exposures.

3. It appears that the NTS electronic database may not be very useful in considering worst case estimates since it appears to have fairly extensive data gaps and the bioassay data within the database clearly needs to be validated and verified prior to use.
4. It is apparent that the use of co-worker data for estimation of missing data will have to be very specific (for instance data of a co-worker during a given event could possibly be useful for estimating missing data) since the work performed by these construction workers varied greatly and the areas they worked and the type of work that they did between events seems to have varied greatly.
5. Caution should be exercised in using area-monitoring data for determining internal doses since it was apparent that bioassay findings from the E-tunnel decontamination work were inconsistent with the area monitoring data (Skrable, 1995). Further, Skrable concluded that the area air sampling results were not representative of the workers exposures and that they received their major exposure by creating airborne activity through their own work.

6.0 Preliminary Assessment of the NTS dosimetry database against hard copy records

As part of the task of determining whether there were data gaps and the extent of the data gaps we obtained several radiological safety reports (primarily from different events) from 1957 through 1988. In reports that included summary radiation exposure information in a format that could be easily compared with the electronic data, we attempted to cross walk the hard copy summary records against the database information.

Preliminary analysis of the database records compared with available radiological safety reports suggests possible missing information in the electronic records. <u>This suggests that further validation and verification of database information against original records is needed.</u>

Some examples of possible discrepancies between radiological safety report data and database records include the following:

- Comparison of a 1957 Radiological Safety summary report (REECO 1957) with the NTS dosimetry database suggests discrepancies in the cumulative gamma doses. The table below shows a summary of these results:

Gamma Dose (mrem)	Personnel (57 Rpt)	Personnel (NTS dbase)
0	4,724	252
1-99	1,794	184
100-499	1,895	275
500-999	690	100
1,000-4,999	1,015	268
> 5,000	22	32

One factor that could partially account for these large differences is that Sandia, Los Alamos and Lawrence Livermore sites had individuals involved in work on the NTS site and the database we were reviewing included NTS/REECO workers only.

- The 1963 Operation Storax report (REECO 1964) indicated that 17 persons had a dose exceeding the 5 rem per year operational guideline. The maximum individual dose was 5,925 mrem. The NTPR database for the year 1962 indicated 1 individual greater than 5 rem, 34 individuals greater than 4 rem, and 89 individuals greater than 3 rem with a maximum individual dose of 5125 mrem and for the year 1963 the NTPR database indicated only 2 individuals with doses greater than 3 rem and a maximum dose of 3325 mrem. Again, this H&S report could be discussing more than just NTS personnel.
- A March 1983 report (REECO 1983) regarding the change from film badges to TLDs mentions that only approximately 100 individuals at the NTS are potentially exposed to neutrons and require neutron monitoring. It may be that this is a very conservative estimate however; it is interesting to note that according to the 19631983 database there is only one neutron dose record greater than zero. The missed neutron dose, at least for a select small population, may be something that requires more investigation.
- The 1986-1987 Musketeer H&S report (REECO 1988) indicates that 66,112 dosimeters were issued for 25,997 REECO/ESD personnel. The dosemast database includes only 13,474 records (quarterly dosimeter records).
- Operation Hardtrack Report (REECO 1958) indicated that there was some alpha contamination in the U-12f tunnel. Preliminary review of the 'dead' bioassay database indicates 12 individuals received some kind of alpha testing (possibly nasal wipe) with all results being recorded as zero. This may be an example of potential missed plutonium intakes. Further assessment would be necessary.
- One of the case files reviewed contained several pages from a logbook from the U12B 1962 event. One entry in the log stated as follows: "Each shift will obtain a 24 hour sample (urine) from one person, preferably someone who has spent time in the main drift". This seems to indicate the importance of cross-checking event logs when performing an individual dose reconstruction.
- We reviewed an event database (area_arc_sort.dbf), which included event name, year, individual's names, and organization. We did a query of this database against the 19631983 dosimetry database and determined that there were 2833 unique last names that were RECCO employees and of those unique last names, only 1313 (46%) were found in the 19631983 database. It should be noted that this query likely overestimated the number of individuals for whom data existed in the database since we only used last name (no unique id available) and we did not look at the year for which dosimetry data was available compared to the year the last name was listed in the event database. Review of this type of information, event logs or databases, will probably be even more important for the case of internal dose especially if all workers in certain events were not monitored (see previous item).
- A specific event from the event database (area_arc_sort.dbf) was reviewed to determine the number of workers who were monitored for plutonium exposures.

We queried the internal dose database (dead) to determine whether individuals listed in the U16a event in 1962, which has been cited as an event which involved a plutonium release, were monitored for plutonium or gross alpha. It was determined that only 3 of 221 RECCO employees in the event database had been monitored for plutonium in 1962 and none of the RECCO employees were monitored for gross alpha. This suggests the need to verify by access logs who worked in certain areas or during certain events.

7.0 In-depth Case Review

Boston University obtained full case files for 20 individuals who had participated in the medical surveillance program. The cases, which were obtained during the early stages of the medical screening program, were not selected based on a specific sampling approach. The intent was to obtain a cross section based on types of exposures encountered and complexity of the exposure history. We compared the data in the full case file with that in the database to determine the accuracy of the database. We also reviewed the work history of the individual (based on the self administered occupational health questionnaire – see Attachment A) to determine if the individual had dosimetric data for all the years they worked at the site.

The in-depth review of the 20 individuals' NTS dose reconstruction case file suggests that some data exist in microfiche format that is not included in the electronic database. While this may not affect individual reconstruction efforts it may hinder efforts to understand the overall worker population.

In general, the data for the 20 cases reviewed agreed with the electronic database. However, there were several individuals for whom all or part of their external dose data was not included within the electronic database. There were also some cases where the individual did not have dosimetry data (in the hard copy records or the electronic database) for all of their reported work history (self reported on the Boston University questionnaire). Additionally, there were some instances where NTS noted in the individual's case file that there was not dosimetry information for their entire work history (based on the NTS hire date). There could be several explanations for these findings including: 1) individual misreported his work history, 2) individual worked for a period of time and then left and then came back, 3) individual worked in an area not requiring dosimetry, and 4) individuals worked in an area requiring dosimetry but the data could not be located.

The external dosimetry data included within the full case file included computer printout data or microfiche printouts. In some cases, when the computer printouts had no value listed for a dosimeter reading, the computer punch cards were reviewed. The actual film and TLD analysis data was not reviewed. Again, when electronic data existed it was in good agreement with the hard copy file.

The internal dosimetry data within the hard copy records was generally in good agreement with the electronic data with a few important exceptions (e.g., a case with a thyroid dose in the 10's of rads with no iodine sampling in the electronic database, cases where apparently I-131 was miscoded and appeared to be Pu-238 in the electronic database, etc.). A sample of the tritium dose calculations was reviewed and independently calculated doses were in agreement (using same assumptions as NTS staff used). For the tritium dose calculations the work history was not often verified to determine whether assumptions regarding the nature of the exposure were appropriate (acute or chronic) however, it appears that given the small overall doses conservative assumptions were made. This may be more problematic with radionuclides of greater dose consequence.

A number of the cases reviewed had hard copy data and dose estimates for a plutonium intake in 1994 (this data was not in the database but the electronic database only included data through 1993). These cases all seem to be related to the same event at the E-Tunnel and the dose calculations included in the case files referenced an outside consultant report (Skrable, 1995). One question this report raises is the effectiveness of the NTS urine monitoring program and the potential for un-detected doses from plutonium exposures. It also notes that for this specific job (E-Tunnel decontamination) it appears that using Cesium-137 measurements from area air sampling as a surrogate measure for plutonium levels (based on a ratio established from soil sampling data) was not an effective way of controlling exposures since there were workers with significant doses even though the area air sampling action levels were not exceeded. This question should further be considered for the historic data (1960s) where there are a great deal of alpha nose wipes which were collected and were determined to be less than detectable and for which no dose was assigned.

Other important discrepancies that we feel are worth noting and may be of importance to the efforts underway for dose reconstruction at the NTS site are outlined below. A detailed account of each case is included in Appendix B (Case File Results Review).

Some important points:

1. For many of the years included in the dosimetry database the data is only summary data (usually annual summations). This especially appears to be the case for 1961-1971.
2. Seven of the twenty case files reviewed have no records prior to 1965. Their work history questionnaires indicate that they were working on site prior to 1965. The discrepancy could indicate missing data for the early years or it could be that these individuals were not in areas requiring monitoring in those early years of their careers or that they misreported their initial hire date.
3. Data related to internal dose had more discrepancies including the following: differences in the data with regard to tritium sampling, one instance where a thyroid dose was assigned but there was no data in the database, a possible discrepancy in the 'analysis type' field in the database where some samples appear to be coded with an incorrect code (coded for Pu-238 when the hard copy records indicate no exposure to Pu-238 but rather to I-131), and finally some

problems in the bioassay databases which appear to be data entry type problems (e.g., Pu-239 bioassay results in the dead bio database which make no sense – 2.7X105-24). Any sense of the magnitude of the problem?

4. Three individuals who had alpha nasal smears taken (pre-1965) did not have an internal dose assigned. This discrepancy may indicate that there is a population of individuals for whom there could be a significant missed dose for plutonium especially in the early years of testing.
5. None of these workers has an estimate of an occupational dose from radon exposures. Since the majority of the workers had at some point worked as tunnel workers it seems that this could have been a significant exposure.
6. The **Dosimetry Research Project Database** (DRP) was established by the U.S. DOE under the direction of the DOE's Nevada Operations Office in January 1978. The DRP was established to collect, organize, and tabulate dosimetry and exposure source documents; create and maintain a master dosimetry file; respond to exposure history requests; and publish an historical report on Radiation Safety in the Nuclear Testing Program. The DRP has not been used previously to estimate individual and/or group cumulative exposure for compensation purposes. This project has attempted to validate the DRP against a limited set of paper records as well as against the reported experience of several thousand former NTS construction worker participants in the DOE funded medical screening and surveillance program. The difficulties encountered using a system based on inconsistent job categories, frequent start and stop employment dates, and other data problems specific for a construction-based work force suggest the impracticality of using this system for compensation.

8.0 Recommendations

Based on our review of the NTS dosimetry data along with a sampling of the associated hard copy records we offer the following recommendations with regard to a dose reconstruction program for NTS workers.

1. A supplemental set of site-specific questions regarding work at the test site including information on area or event and some questions related to radiation monitoring may be useful in determining the completeness of the dosimetry records.
2. Access logs for all events seem to be an essential piece of data to verify presence at different events and may be important since it appears that not all workers were monitored (at least for internal exposures) during events.
3. Validation of electronic database would be recommended prior to aggregate use of the data.
4. External and bioassay data should be verified against laboratory records. It appears that even for the in-depth NTS dose files this verification was not performed.
5. Caution should be used in using co-worker data since the nature of the construction workers work, especially between events, appears to be highly variable.

9.0 References

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Scenarios

Nevada Test Site

Background Information

The Nevada Test Site is located in the Nevada desert; dusty conditions were the norm during all aboveground and underground work activities. Explosions from tests would have created dust (including silica) that would have carried isotopes deep into the lung.

Radiation Hazards:

DOE identifies all of the isotopes identified in each of the more than 900 nuclear tests conducted at the Nevada Test Site together with the release amount in curies, the maximum activity, and gamma exposure detected offsite, the maximum distance that radiation was detected offsite, and other statistics (1). DOE indicates that 100 atmospheric nuclear tests were conducted at the Nevada Test Site during the period from January 1951 and July 1962, and from January 1951 through September 1996, more than 800 underground nuclear tests resulting in more than 900 detonations were also conducted at the Nevada Test Site. (2)

Releases usually contain multiple isotopes. Isotopes identified in the various releases associated with nuclear tests include the following: Ar-37, Ar-39, Ba-139, Ba-140, and Ba-140/La-140, Be-7, Ce-141, Ce-144, Cs-137, Cs-138, Cs-139, H-3 (tritium and tritiated water), I-131, I-132, I-133, I-134, I-135, and I-132/Te-132, K-40, Kr-85, Kr-85m, Kr-87, Kr-88, Kr-89, Kr-91, La-140, La-142, Mn-54, Mn-56, Mo-99, Na-24, Nb-95, Rb-88, Rb-88m, Rb-89, Rh-105, Ru-103, Ru-105, Ru-106, and Ru-106/Rh-106, Sb-122, Sb-124, Sr-89, Sr-91, Sr-92, Tc-99, Te-132, W-181, W-187, W-188, Xe-127, Xe-129m, Xe-131m, Xe-133, Xe-133m, Xe-135, Xe-137, Xe-138, Xe-139, Xe-140, Y-91, Y-91m, Zr-95/Nb-95, and Zr-97/Nb-97. (1)

Radiation Exposures:

"The release of radioactivity from an underground test can occur:

- accidentally as a result of a containment failure;
- accidentally or deliberately as a result of post-event operations; or
- deliberately as a result of post-event controlled purging of gases from a tunnel."(2)

DOE identifies the following types of radiological releases and potential exposures associated with nuclear tests at the Nevada Test Site:

- "A 'test' release (or an 'uncontrolled' release for DoD tunnel tests) has been defined as a spontaneous release that occurred after a test but before postshot drilling operations began." "The pre-LTBT shaft and tunnel tests, where a sampling conduit to the atmosphere was designed and placed in the test complex for sampling of the particulate matter released, have been defined as 'test/prompt particle sampling releases. The cratering Plowshare tests, where the test was designed to produce a throw-out of earth, have been designated as 'test-crater' releases. Releases from surface tests have been categorized as 'test/surface'. Those surface and near-surface tests, that were non-nuclear tests designed to determine the extent of debris scattering, have been defined as 'test/plutonium dispersal' releases."

- A "controlled" release was "a planned, filtered, release frequently performed to reduce airborne radiation levels in the working environment" predominantly from tunnels, although this type of release "also occurred from shaft tests".
- "'Drillback' releases occurred during postshot drilling operations to recover samples; these releases were either filtered or unfiltered. After drillback operations were completed, a 'cementback' occurred where the drill hole was sealed with a plug and cemented to the surface." Releases also occurred during "cementback" operations.
- "'Gas sampling' releases occurred during gas sampling operations, either before or after any postshot drilling operations commenced."
- "'Late-time seepage' releases occurred when noble gases have leaked from test sites after all operations in the area have ceased. These releases "could exist from a few hours to even weeks after all other operations in the area have ceased." (1)

Other activities cited that brought radioactive isotopes to the surface from the explosion site include:

- "Cable pull" defined as "Recovery of a cable placed near a nuclear explosion. The cable ran to the surface and was pulled free shortly after zero time. The debris captured on the bottom end of the cable was analyzed to assess device performance."
- "Catcher pull" defined as "Recovery of a debris catcher, placed near a nuclear explosive, by pulling on the attached cable and thus returning the catcher to the ground surface. This operation is usually accomplished within minutes to hours of zero time." (1)

Construction Worker Radiation Exposures at the Nevada Test Site:

Construction workers at the Nevada Test Site could reasonably have been expected to be exposed to radioactivity in the following situations:

- In the construction of roads, buildings, and related infrastructure through areas of the site contaminated with residual, postshot contamination;
- In the drilling of vertical shafts used for the placement of test nuclear explosive devices;
- In the underground mining of tunnels (long horizontal drifts mined into a mountain or mesa) and test chambers in close proximity to areas where previous test shots were detonated;
- During postshot drilling operations to recover samples. "Drillback" releases often occurred at the drilling rig and lasted for periods ranging from hours to days, likely contaminating the drilling rig and associated equipment that construction workers would have to move to another site and re-use.

- And during shaft plugging where the drill hole was plugged and cemented to the surface ("cementback").

References:

1. DOE publication "Radiological Effluents Released from U.S. Continental Tests 1961 through 1992" (DOE/NV-317 (Rev. 1) UC-702).
2. DOE publication "United States Nuclear Tests July 1945 through September 1992", (DOE/NV—209 REV 15, December 2000),

Nevada Test Site Building Trades Medical Screening Program

Summary Of Worker Demographics and Work History Information On Radiation Hazards

All Workers Screened by December 31, 2002

Construction Worker and Job Task Data Project

NIOSH Contract #200-2002-00433

Frequency of Worker Reported Exposures - By Trade Union				
Exposures	Frequency of Exposure by Worker Report	Proportion of Workers Reporting Exposure	Mean Exposure Frequency Score	Std Dev of Exposure Frequency Score
Laborers				
Loud Noise	609	98.38	3.51	0.75
Vibration	599	97.24	3.33	0.86
Shotcrete	473	83.13	2.72	0.98
Rock Dust	573	94.24	3.14	0.93
Diesel Smoke	589	95.93	3.21	0.95
Oil Fumes	527	87.98	2.70	1.12
Welding Fumes	536	88.74	2.55	1.06
Asbestos	359	68.51	2.14	1.08
Solvents	475	80.78	2.23	1.07
Epoxy	452	77.80	2.43	1.04
Sulfa-set	456	79.17	2.75	1.00
Grout	511	85.88	2.81	0.99
Solvents - Skin	437	74.57	2.14	1.02
Epoxy - Skin	402	69.67	2.24	1.01
Sulfa-set - Skin	422	73.91	2.58	1.04
Grout - Skin	470	80.48	2.65	1.02
Beryllium	112	41.48	2.29	0.96
Operating Engineers				
Loud Noise	636	99.38	3.51	0.74
Vibration	609	96.21	3.27	0.94
Shotcrete	345	59.79	2.26	1.03
Rock Dust	511	86.36	2.78	1.01
Diesel Smoke	617	97.01	3.36	0.82
Oil Fumes	555	89.95	2.96	1.04
Welding Fumes	551	87.60	2.59	1.08
Asbestos	337	59.75	2.07	1.06
Solvents	525	83.73	2.59	1.10
Epoxy	352	59.36	1.86	0.95
Sulfa-set	289	49.40	1.94	0.98
Grout	388	63.82	2.16	1.00
Solvents - Skin	501	80.42	2.61	1.09
Epoxy - Skin	294	49.41	1.73	0.91
Sulfa-set - Skin	257	43.56	1.83	0.97
Grout - Skin	333	55.22	1.96	0.95
Beryllium	75	21.93	2.01	0.98
IBEW				
Loud Noise	417	95.86	2.82	0.99
Vibration	365	85.28	2.50	0.99
Shotcrete	265	68.30	2.18	0.97

Rock Dust	366	87.35	2.40	0.97
Diesel Smoke	396	92.31	2.73	0.94
Oil Fumes	343	82.45	2.31	1.02
Welding Fumes	395	92.07	2.33	0.94
Asbestos	258	70.49	1.84	0.86
Solvents	363	87.26	2.08	0.86
Epoxy	311	76.98	2.06	0.92
Sulfa-set	224	58.64	1.84	0.86
Grout	256	65.14	1.94	0.90
Solvents - Skin	325	77.20	2.02	0.89
Epoxy - Skin	270	66.18	1.83	0.79
Sulfa-set - Skin	191	49.61	1.57	0.76
Grout - Skin	207	52.41	1.57	0.77
Beryllium	81	32.66	1.93	0.83
Ironworkers				
Loud Noise	132	96.35	3.27	0.87
Vibration	116	86.57	2.75	1.08
Shotcrete	71	61.21	2.06	1.04
Rock Dust	112	85.50	2.38	1.01
Diesel Smoke	119	88.81	2.72	0.96
Oil Fumes	108	83.72	2.42	1.09
Welding Fumes	136	99.27	3.56	0.73
Asbestos	93	76.23	2.48	1.06
Solvents	103	79.23	2.22	1.04
Epoxy	82	66.67	2.00	0.94
Sulfa-set	69	56.10	1.83	0.87
Grout	75	59.06	1.99	0.91
Solvents - Skin	102	76.69	1.94	0.89
Epoxy - Skin	76	69.38	1.79	0.87
Sulfa-set - Skin	62	50.41	1.61	0.73
Grout - Skin	66	52.38	1.67	0.79
Beryllium	28	41.29	1.86	0.93
Plumbers / Pipefitters				
Loud Noise	138	98.57	3.17	0.89
Vibration	123	88.49	2.79	1.04
Shotcrete	99	76.15	2.31	0.98
Rock Dust	118	86.13	2.65	1.02
Diesel Smoke	133	96.38	2.78	1.08
Oil Fumes	110	85.94	2.32	1.12
Welding Fumes	137	98.56	3.43	0.80
Asbestos	112	85.50	2.34	1.05
Solvents	126	92.65	2.55	1.02
Epoxy	107	80.45	2.09	0.97
Sulfa-set	91	70.00	1.88	0.96
Grout	98	73.13	2.02	1.02
Solvents - Skin	130	94.20	2.41	1.02
Epoxy - Skin	97	71.85	1.78	0.93

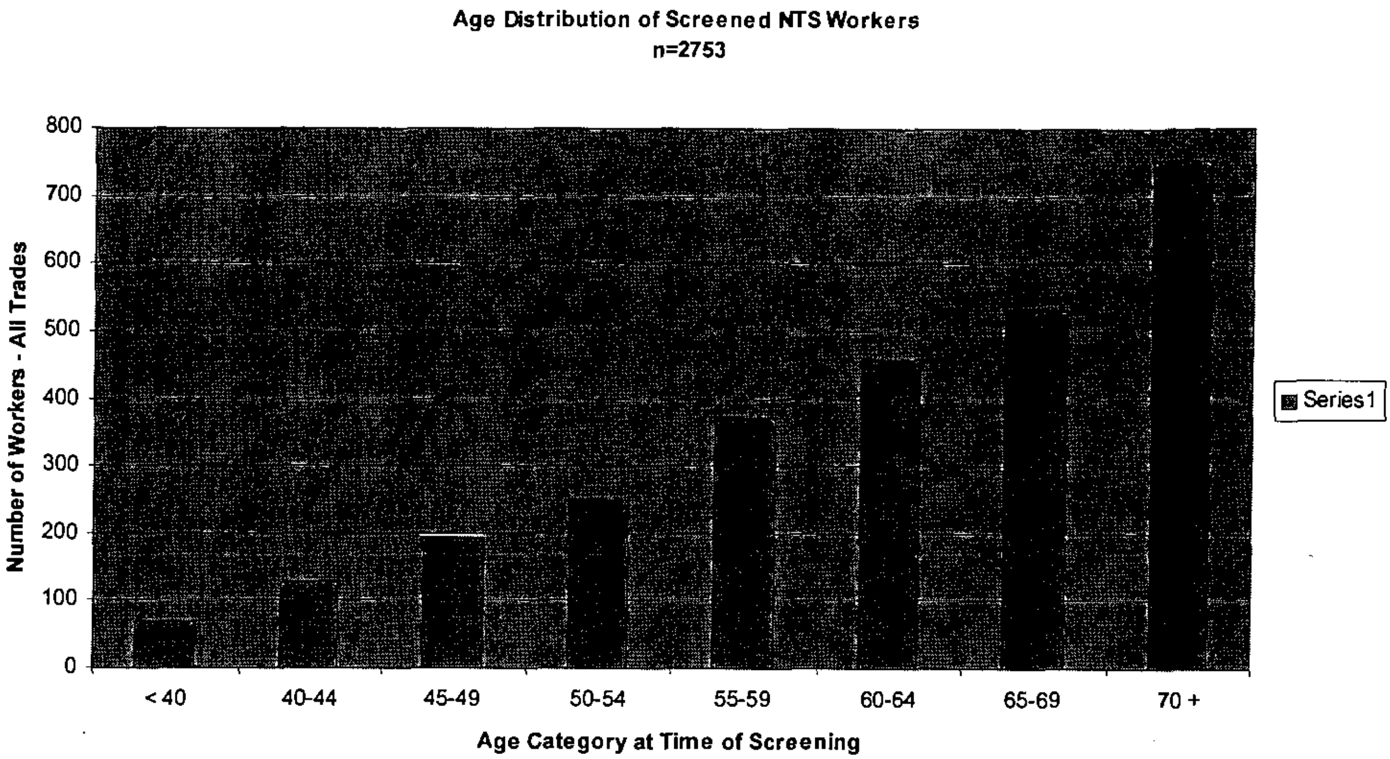
Sulfa-set - Skin	70	53.85	1.49	0.79
Grout - Skin	76	57.58	1.64	0.83
Beryllium	53	59.55	2.45	1.15
Carpenters				
Loud Noise	160	98.16	3.14	0.94
Vibration	145	90.06	2.75	1.10
Shotcrete	105	72.41	2.30	0.99
Rock Dust	135	85.44	2.50	1.00
Diesel Smoke	141	89.24	2.77	1.02
Oil Fumes	122	80.26	2.29	1.05
Welding Fumes	144	91.14	2.90	1.06
Asbestos	106	80.30	2.08	0.99
Solvents	114	76.51	2.00	0.96
Epoxy	111	73.51	2.02	0.91
Sulfa-set	97	66.44	2.24	1.02
Grout	116	74.84	2.52	0.99
Solvents - Skin	106	69.28	1.85	0.88
Epoxy - Skin	104	68.87	1.79	0.90
Sulfa-set - Skin	89	60.54	1.87	0.94
Grout - Skin	103	69.13	2.08	0.97
Beryllium	25	30.12	2.44	1.00
Sheetmetal Workers				
Loud Noise	35	97.22	3.17	0.89
Vibration	33	94.29	2.61	1.03
Shotcrete	14	45.16	1.71	0.73
Rock Dust	21	61.76	2.00	0.95
Diesel Smoke	28	84.85	2.14	0.93
Oil Fumes	22	64.71	1.82	1.01
Welding Fumes	35	97.22	2.63	0.97
Asbestos	27	84.38	1.96	0.98
Solvents	28	82.25	2.00	0.77
Epoxy	19	57.58	1.68	0.75
Sulfa-set	9	29.03	1.44	0.73
Grout	12	38.71	1.75	1.06
Solvents - Skin	28	80.00	1.54	0.51
Epoxy - Skin	16	48.48	1.31	0.48
Sulfa-set - Skin	9	28.13	1.22	0.44
Grout - Skin	10	31.25	1.30	0.67
Beryllium	4	18.18	2.25	0.96
Teamsters				
Loud Noise	205	94.91	3.00	0.98
Vibration	185	86.45	2.79	1.15
Shotcrete	88	46.32	2.11	1.03
Rock Dust	142	69.95	2.47	1.09
Diesel Smoke	199	93.87	3.12	0.99
Oil Fumes	164	79.23	2.54	1.12
Welding Fumes	130	63.11	2.02	1.04

Asbestos	97	51.87	2.04	1.09
Solvents	134	64.42	2.28	1.07
Epoxy	97	49.24	1.93	0.96
Sulfa-set	67	36.41	1.70	0.98
Grout	96	48.48	2.13	1.04
Solvents - Skin	123	59.42	2.15	1.14
Epoxy - Skin	75	37.88	1.59	0.81
Sulfa-set - Skin	51	27.42	1.59	0.90
Grout - Skin	75	37.69	1.84	0.99
Beryllium	29	21.01	2.10	0.98
Painters				
Loud Noise	21	91.30	2.90	1.22
Vibration	17	73.91	2.76	1.20
Shotcrete	5	25.00	2.20	0.45
Rock Dust	10	50.00	2.50	1.08
Diesel Smoke	14	63.64	2.64	1.22
Oil Fumes	14	63.64	2.29	1.20
Welding Fumes	11	52.38	2.09	0.94
Asbestos	11	57.89	3.18	0.98
Solvents	19	90.48	3.53	0.77
Epoxy	19	90.48	2.84	1.01
Sulfa-set	6	33.33	1.50	0.84
Grout	9	47.37	2.11	1.05
Solvents - Skin	21	95.45	3.29	1.01
Epoxy - Skin	18	81.82	2.83	1.04
Sulfa-set - Skin	5	31.25	1.80	0.84
Grout - Skin	9	47.37	1.89	0.93
Beryllium	1	7.14	3.00	
IGAN				
Loud Noise	122	96.83	2.81	0.92
Vibration	98	79.67	2.34	0.98
Shotcrete	84	71.79	2.01	0.84
Rock Dust	106	84.80	2.26	0.91
Diesel Smoke	114	90.48	2.35	0.89
Oil Fumes	95	76.61	2.11	0.96
Welding Fumes	100	80.00	2.19	0.86
Asbestos	66	57.39	1.85	1.03
Solvents	73	60.33	1.96	0.98
Epoxy	65	55.08	1.82	0.95
Sulfa-set	58	50.43	1.83	0.92
Grout	89	71.77	2.20	0.87
Solvents - Skin	43	35.25	1.67	0.99
Epoxy - Skin	35	28.93	1.37	0.77
Sulfa-set - Skin	33	27.50	1.42	0.79
Grout - Skin	51	41.13	1.63	0.82
Beryllium	42	48.28	1.95	0.94
Other				

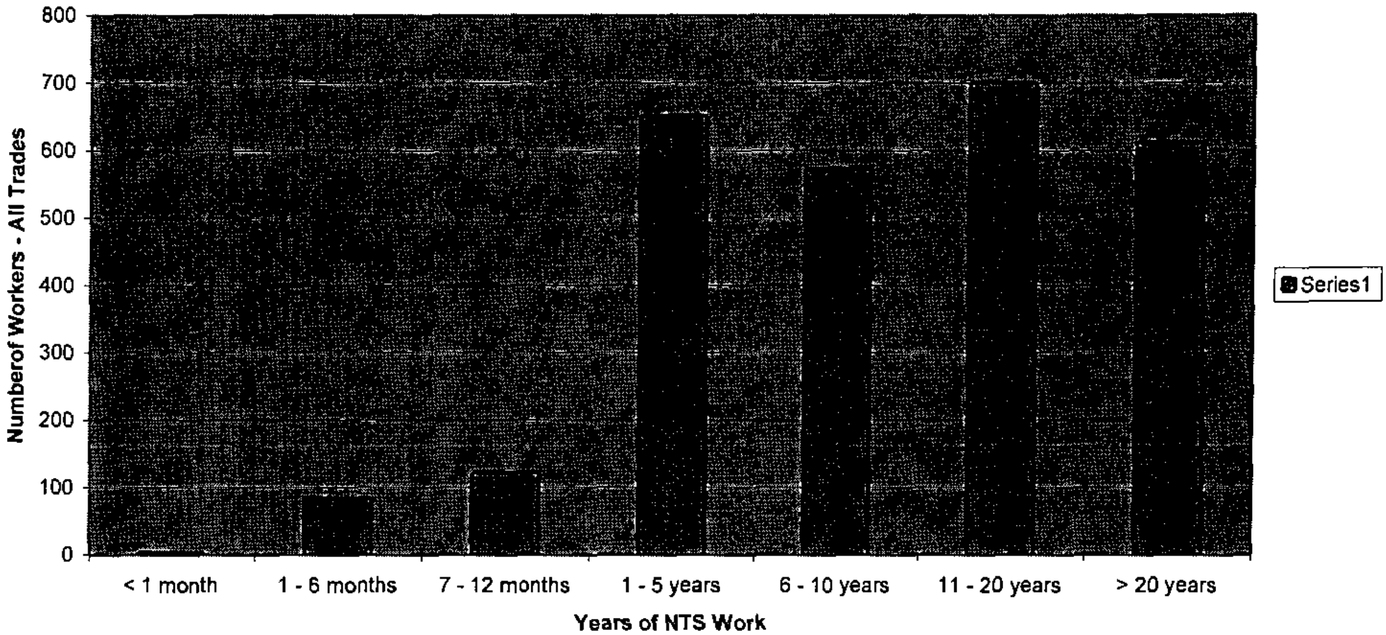
Loud Noise	138	90.20	2.98	1.12
Vibration	117	76.97	2.79	1.14
Shotcrete	63	46.67	2.25	1.09
Rock Dust	103	69.59	2.64	1.10
Diesel Smoke	120	78.43	2.65	1.10
Oil Fumes	104	70.27	2.51	1.11
Welding Fumes	100	65.79	2.26	1.07
Asbestos	81	60.00	2.35	1.09
Solvents	100	68.49	2.64	1.11
Epoxy	66	47.83	2.17	1.00
Sulfa-set	60	44.12	2.00	0.96
Grout	76	53.15	2.22	1.01
Solvents - Skin	84	58.74	2.51	1.10
Epoxy - Skin	47	35.07	2.06	0.99
Sulfa-set - Skin	44	32.84	1.77	0.99
Grout - Skin	49	36.03	2.06	1.03
Beryllium	31	31.00	2.42	1.15
Non-union				
Loud Noise	410	93.61	2.64	1.04
Vibration	349	80.23	2.40	1.07
Shotcrete	242	59.02	1.99	0.94
Rock Dust	315	74.64	2.21	0.99
Diesel Smoke	379	86.93	2.51	0.98
Oil Fumes	336	78.14	2.24	1.00
Welding Fumes	343	79.58	2.08	0.98
Asbestos	217	56.81	1.72	0.89
Solvents	325	76.29	2.07	0.93
Epoxy	272	65.23	1.89	0.87
Sulfa-set	207	51.62	1.82	0.86
Grout	269	64.35	2.05	0.94
Solvents - Skin	272	63.40	1.93	0.93
Epoxy - Skin	211	50.24	1.71	0.87
Sulfa-set - Skin	155	37.99	1.61	0.85
Grout - Skin	197	47.93	1.80	0.93
Beryllium	123	43.01	2.01	0.90

Mean Age & Periods of NTS Work - All Trades							
[illegible]	Mean Age	Age Std Dev	Mean Yrs at NTS	NTS Yrs Std Dev	Mean Yr First Employed at NTS	Mean Yr Last Employed at NTS	Mean Yrs Since Last NTS Work
All Trades	62.43	10.98	11.94	8.39	1969.82	1984.09	15.18

Mean Age & Periods of NTS Work by Trade Union								
Trade Union	Number of Workers	Mean Age	Age Std Dev	Mean Yrs at NTS	NTS Yrs Std Dev	Mean Yr First Employed at NTS	Mean Yr Last Employed at NTS	Mean Yrs Since Last NTS Work
Laborers	630	61.11	10.68	12.21	8.36	1969.55	1984.79	15.13
IBEW	437	64.06	10.30	9.40	7.68	1969.95	1983.75	16.49
Operating Engineers	642	61.72	11.48	12.56	8.42	1969.51	1985.06	14.93
Ironworkers	138	61.74	11.67	10.98	7.85	1969.22	1983.19	16.76
Plumbers / Pipefitters	145	62.73	11.37	9.68	7.43	1970.47	1986.23	14.30
Carpenters	166	63.56	11.78	9.40	8.20	1968.55	1981.60	18.52
Sheetmetal	37	58.41	10.65	8.33	7.17	1974.19	1984.32	15.89
Teamsters	222	63.80	9.90	14.75	7.95	1969.81	1988.37	12.04
Painters	23	64.83	8.48	11.39	7.53	1970.48	1984.35	16.00
IGAN	128	62.92	10.67	16.95	7.61	1969.27	1989.16	11.17
Other	158	60.13	11.29	12.60	8.22	1968.59	1984.58	15.88
Non-union	445	63.76	9.77	14.57	8.75	1967.47	1985.76	14.89


Age Distribution of Screened NTS Workers
n=2753
800
700
600
500
400
300
200
100
0
Number of Workers - All Trades
< 40
40-44
45-49
50-54
55-59
60-64
65-69
70 +
Age Category at Time of Screening
Series1

Total Time Worked at NTS
n=2746



Frequency of Worker Reported Construction Tasks			
Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
Worked During Atmospheric Nuclear Testing Period		n=2753	
	Yes	756	27.46
	No	1997	72.54
Number of Atmospheric Nuclear Events While Within NTS		n=698	
	0	37	5.3
	1-10	442	63.32
	11-20	76	10.89
	21-30	38	5.44
	31-40	27	3.87
	>40	78	11.17
Involved in Clean-up for Atmospheric Nuclear Events		n=678	
	0	308	45.43
	1-10	236	34.81
	11-20	48	7.08
	21-30	23	3.39
	31-40	16	2.36
	>40	47	6.93
Ever Worked in Tunnel / Tunnel Yard Area		n=2750	
	Yes	2039	74.15
	No	711	25.85
Number of Tunnels Tests Worked On		n=1967	
	0	101	5.13
	1-10	1257	63.9
	11-20	346	17.59
	21-30	117	5.95
	31-40	50	2.54
	>40	96	4.88
Number of Tunnel Tests For Which Performed Re-entry Work		n=1929	
	0	653	33.85
	1-10	959	49.71
	11-20	180	9.33
	21-30	62	3.21
	31-40	22	1.14
	>40	53	2.75
Tunnels Worked On:		n=2039	
	A	107	5.25

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
	B	319	15.64
	E	704	34.53
	G	817	40.07
	I-J-K	295	14.47
	N	1400	68.66
	P	811	39.77
	T	1130	55.42
	U	91	4.46
	X	156	7.65
	Y	80	3.92
	16	526	25.8
Mining in Tunnels		n=1997	
	Performed	650	32.55
	Present	365	18.28
	Neither	982	49.17
Construction in Tunnels		n=2008	
	Perfomed	1044	51.99
	Present	287	14.29
	Neither	677	33.72
Pre-Shot LOS Pipe Work in Tunnels		n=1137	
	Performed	399	35.09
	Present	239	21.02
	Neither	499	43.89
Pre-Shot LOS Pipe - Installed / Modified Flanges in Tunnels		n=426	
	Yes	144	33.8
	No	282	66.2
Pre-Shot LOS Pipe - Worked In / Around A-Box in Tunnels		n=247	
	Yes	167	67.61
	No	80	32.39
Pre-Shot LOS Pipe - Installed / Modified Cone at A-Box in Tunnels		n=243	
	Yes	44	18.11
	No	199	81.89
Worked at Test Chambers in Tunnels		n=246	
	Yes	189	76.83

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
	No	57	23.17
Pre-Shot LOS Pipe - Grind / Machine / Modify Materials in Test Chambers in Tunnels		n=249	
	Yes	86	34.54
	No	163	65.46
Pre-Shot LOS Pipe - Worked in Instrument Alcoves in Tunnels		n=250	
	Yes	205	82
	No	45	18
Pre-Shot LOS Pipe - Grind / Machine / Modify Materials in Instrument Alcoves in Tunnels		n=251	
	Yes	92	36.65
	No	159	63.35
Support in Tunnels		n=2004	
	Performed	858	42.81
	Present	308	15.37
	Neither	838	41.82
Button-Up in Tunnels		n=2004	
	Performed	830	41.42
	Present	194	9.68
	Neither	980	48.9
Re-entry in Tunnels		n=2009	
	Performed	798	39.72
	Present	189	9.41
	Neither	1022	50.87
Post-Shot LOS Pipe Work in Tunnels		n=1125	
	Performed	366	32.53
	Present	135	12
	Neither	624	55.47
Post-Shot LOS Pipe - Worked in Test Chambers in Tunnels		n=401	
	Yes	254	63.34
	No	147	36.66
Post-Shot LOS Pipe - Worked in Test Alcoves in Tunnels		n=227	
	Yes	162	71.37
	No	65	28.63

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
Post-Shot LOS Pipe - Support Users in Test Chambers / Instrument Alcoves in Tunnels		n=228	
	Yes	168	73.68
	No	60	26.32
Post-Shot LOS Pipe - Cut / Disassembled LOS Pipe in Tunnels		n=399	
	Yes	142	35.59
	No	257	64.41
Post-Shot LOS Pipe - Disposed of LOS Pipe / Contents in Tunnels		n=405	
	Yes	193	47.65
	No	212	52.35
Number of Post-Shot LOS Pipe Entries in Tunnels		n=487	
	0	113	23.2
	1-10	217	44.56
	11-20	49	10.06
	21-30	27	5.54
	31-40	13	2.67
	>40	68	13.96
"Other" Work in Tunnels		n=1725	
	Performed	600	34.78
	Present	34	1.97
	Neither	1091	63.25
Ever Worked in Shafts		n=2741	
	Yes	1189	43.38
	No	1552	56.62
Number of Shafts Worked On:		n=1143	
	0	35	3.06
	1-10	937	81.98
	11-20	93	8.14
	21-30	25	2.19
	31-40	11	0.96
	>40	42	3.67
Number of Shafts for Which Performed Re-entry Work			
	1 or more	590	55.04
Mining in Shafts		n=641	

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
	Performed	154	24.02
	Present	186	29.02
	Neither	301	46.96
Construction in Shafts		n=645	
	Perfomed	254	39.38
	Present	169	26.2
	Neither	222	34.42
Pre-Shot LOS Pipe Work in Shafts		n=643	
	Performed	180	27.99
	Present	137	21.31
	Neither	326	50.7
Pre-Shot LOS Pipe - Installed / Modified Flanges in Shafts		n=188	
	Yes	57	30.32
	No	131	69.68
Pre-Shot LOS Pipe - Worked In / Around A-Box in Shafts		n=107	
	Yes	70	65.42
	No	37	34.58
Pre-Shot LOS Pipe - Installed / Modified Cone at A-Box in Shafts		n=105	
	Yes	19	18.1
	No	86	81.9
Worked at Test Chambers in Shafts		n=107	
	Yes	73	68.22
	No	34	31.78
Pre-Shot LOS Pipe - Grind / Machine / Modify Materials in Test Chambers in Shafts		n=106	
	Yes	30	28.3
	No	76	71.7
Pre-Shot LOS Pipe - Worked in Instrument Alcoves in Shafts		n=108	
	Yes	80	74.07
	No	28	25.93
Pre-Shot LOS Pipe - Grind / Machine / Modify Materials in Instrument Alcoves in Shafts		n=106	
	Yes	33	31.13

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
	No	73	68.87
Support in Shafts		n=644	
	Performed	228	35.4
	Present	169	26.24
	Neither	247	38.35
Button-Up in Shafts		n=644	
	Performed	189	29.35
	Present	124	19.25
	Neither	331	51.4
Re-entry in Shafts		n=645	
	Performed	159	24.65
	Present	112	17.36
	Neither	374	57.98
Post-Shot LOS Pipe Work in Shafts		n=632	
	Performed	168	26.58
	Present	86	13.61
	Neither	378	59.81
Post-Shot LOS Pipe - Worked in Test Chambers in Shafts		n=188	
	Yes	104	55.32
	No	84	44.68
Post-Shot LOS Pipe - Worked in Test Alcoves in Shafts		n=102	
	Yes	62	60.78
	No	40	39.22
Post-Shot LOS Pipe - Support Users in Test Chambers / Instrument Alcoves in Shafts		n=103	
	Yes	67	65.05
	No	36	34.95
Post-Shot LOS Pipe - Cut / Disassembled LOS Pipe in Shafts		n=185	
	Yes	61	32.97
	No	124	67.03
Post-Shot LOS Pipe - Disposed of LOS Pipe / Contents in Shafts		n=186	
	Yes	97	52.15

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
	No	89	47.85
Number of Post-Shot LOS Pipe Entries in Shafts		n=258	
	0	75	29.07
	1-10	126	48.84
	11-20	14	5.43
	21-30	11	4.26
	31-40	2	0.78
	>40	30	11.63
"Other" Work in Shafts		n=380	
	Performed	108	28.42
	Present	48	12.63
	Neither	224	58.95
Ever Worked on Drillhole Event		n=2739	
	Yes	1444	52.72
	No	1295	47.28
Number of Drillhole Events Worked On:		n=1396	
	0	18	1.29
	1-10	654	46.85
	11-20	217	15.54
	21-30	153	10.96
	31-40	73	5.23
	>40	281	20.13
Number of Drillhole Events Involved with Drillback		n=1355	
	0	473	34.91
	1-10	443	32.69
	11-20	131	9.67
	21-30	89	6.57
	31-40	46	3.39
	>40	173	12.77
Assembled Rack		n=387	
	Yes	94	24.29
	No	293	75.71
Installed / Modified / Machined Cone on the Cage		n=390	
	Yes	29	7.44
	No	361	92.56

Task Description	Responses	Frequency of Task by Worker Report	Proportion of Workers Reporting Task (%)
Worked on Cage		n=387	
	Yes	74	19.12
	No	313	80.88
Participated in Drillbacks		n=390	
	Yes	197	50.51
	No	193	49.49

Frequency of Worker Reported Work in NTS Areas (n=2758)		
NTS Area	Number Workers Reporting Work in Area	Proportion Workers Reporting Work in Area
1	1175	42.6
2	1544	55.98
3	1852	67.15
4	1039	37.67
5	1389	50.36
6	1710	2758
7	1030	37.35
8	965	34.99
9	1148	41.62
10	1079	39.12
11	968	35.1
12	2403	87.13
14	843	30.57
15	1145	41.52
16	1174	42.57
17	1183	42.89
18	1110	40.25
19	1524	55.26
20	1525	55.29
22	831	30.13
23	1312	47.57
25	1391	50.44
26	819	29.7
27	943	34.19
28	668	24.22
29	733	26.58
30	773	28.03
Atlas (NLV)	135	4.89

Frequency of Worker Reported Work in NTS Areas (n=2039)		
Tunnel	Number Workers Reporting Work in Tunnel	Proportion Workers Reporting Work in Tunnel
Tunnel A	107	3.88
Tunnel B	319	11.57
Tunnel E	707	25.63
Tunnel G	820	29.73
Tunnel I-J-K	295	10.7
Tunnel N	1406	50.98
Tunnel P	813	29.48
Tunnel T	1133	41.08
Tunnel U	92	3.34
Tunnel X	157	5.69
Tunnel Y	81	2.94
Tunnel 16	527	19.11

Worker Responses to Radiation Monitoring & Incident Questions					
Radiation Question	Responses	Number of Workers	Proportion of Workers (%)	Mean	Std Dev
Did you ever have to be decontaminated because of radiation exposure?		n=2743			
	Yes	872	31.79		
	No	1871	68.21		
	If yes, how many times?	n=773			
	1	276	35.71	11.75	41.35
	2	140	18.11		
	3	112	14.49		
	4	32	4.14		
	5	37	4.79		
	6	19	2.46		
	7	3	0.39		
	8	7	0.91		
	9	3	0.39		
	10	31	4.01		
	11	2	0.26		
	12	10	1.29		
	15	14	1.81		
	16	1	0.13		
	18	2	0.26		
	20	10	1.29		
	22	1	0.13		
	24	1	0.13		
	25	2	0.26		
	30	9	1.16		
	36	1	0.13		
	40	6	0.78		
	50	12	1.55		
	60	1	0.13		
	75	1	0.13		
	99	34	4.4		
	100	2	0.26		
	150	1	0.13		
	400	1	0.13		
	500	1	0.13		
	750	1	0.13		

Radiation Question	Responses	Number of Workers	Proportion of Workers (%)	Mean	Std Dev
Did you ever have personal items or clothing taken from you because they had become contaminated by radiation?		n=2733			
	Yes	631	23.09		
	No	2102	76.91		
	If yes, how many times?	n=586			
	1	277	47.27	6.13	17.63
	2	119	20.31		
	3	64	10.92		
	4	25	4.27		
	5	20	3.41		
	6	14	2.39		
	7	3	0.51		
	8	2	0.34		
	9	1	0.17		
	10	21	3.58		
	12	2	0.34		
	15	7	1.19		
	16	1	0.17		
	20	4	0.68		
	23	1	0.17		
	25	1	0.17		
	30	2	0.34		
	40	2	0.34		
	50	1	0.17		
	99	19	3.24		
Do you think that you might have been contaminated by radiation during any of the following events?					
Rainier Test (Sept. 19, 1957)		n=2723			
	Yes	107	3.93		
	No	2616	96.07		
Operation Nougat Tests (Sept. 15, 1961 to June 30, 1962)		n=2705			
	Yes	236	8.72		

Radiation Question	Responses	Number of Workers	Proportion of Workers (%)	Mean	Std Dev
	No	2469	91.28		
Baneberry Test (December 18, 1970)		n=2716			
	Yes	483	17.78		
	No	2233	82.22		
Misty Rain Test (N Tunnel, April 6, 1985)		n=2718			
	Yes	380	13.98		
	No	2338	86.02		
Mighty Oak Test (T Tunnel, April 10, 1986)		n=2722			
	Yes	369	13.56		
	No	2353	86.44		
Other tests or accidental releases		n=2592			
	Yes	834	32.18		
	No	1758	67.82		
Did you ever have body counts taken to check for radiation exposure?		n=828			
	Yes	265	32		
	No	344	41.55		
	Don't Know	219	26.45		
Did you ever have urine or fecal tests taken to check for radiation exposure?		n=828			
	Yes	148	17.87		
	No	459	55.43		
	Don't Know	221	26.69		
Were you ever told that you had "burned out" or exceeded the quarterly or yearly limits for radiation?		n=2742			
	Yes	309	11.27		
	No	2433	88.73		

Radiation Question	Responses	Number of Workers	Proportion of Workers (%)	Mean	Std Dev
	If yes, how many times?	n=275			
	1	132	48	5.12	15.82
	2	69	25.09		
	3	24	8.73		
	4	17	6.18		
	5	9	3.27		
	6	2	0.73		
	8	4	1.45		
	9	1	0.36		
	10	3	1.09		
	12	1	0.36		
	20	3	1.09		
	25	1	0.36		
	30	1	0.36		
	50	1	0.36		
	99	7	2.55		
Were you ever sent home because you were near or above the radiation limits?		n=2739			
	Yes	131	4.78		
	No	2608	95.22		
	If yes, how many times?	n=112			
	1	53	47.32	5.08	15.94
	2	29	25.89		
	3	10	8.93		
	4	4	3.57		
	5	6	5.36		
	6	1	0.89		
	8	1	0.89		
	10	2	1.79		
	11	1	0.89		
	20	2	1.79		
	99	3	2.68		
Did you wear a radiation badge / dosimeter when you worked at NTS?		n=396			
	Yes	382	96.46		
	No	14	3.54		

Radiation Question	Responses	Number of Workers	Proportion of Workers (%)	Mean	Std Dev
Were there times you did not wear your badge?		n=385			
	Yes	49	12.73		
	No	336	87.27		
What were the reasons you did not wear your badge?					
Badge/dosimeter not provided		n=50			
	Yes	10	20		
	No	40	80		
You were asked not to wear it		n=50			
	Yes	13	26		
	No	37	74		
Close to exposure limit and did not want to go over		n=50			
	Yes	5	10		
	No	45	90		
Non-exposure area, not needed to wear badge		n=52			
	Yes	21	40.38		
	No	31	59.62		
Lost badge, did not ask to replace		n=49			
	Yes	2	4.08		
	No	47	95.92		
Did you ever work with or around plutonium?		n=739			
	Yes	102	13.8		
	No	136	18.4		
	Don't Know	501	67.79		

Worker Reported Periods of No Radiation Monitoring by Union (Were there times you did not wear your badge?)		
Union	Number of Workers Reporting Non-Monitored Periods	Proportion of Workers Reporting Non-Monitored Periods (%)
Laborers	n=65, missing=565	
	11	16.92
IBEW	n=79, missing=358	
	10	12.66
Operating Engineers	n=76, missing=566	
	10	13.16
Ironworkers	n=6, missing=132	
	1	16.67
Plumbers & Pipefitters	n=32, missing=113	
	5	15.63
Carpenters	n=28, missing=138	
	4	14.29
Sheetmetal Workers	n=4, missing=33	
	1	25.00
Teamsters	n=33, missing=189	
	2	6.06
Painters	n=23, missing=23	
IGAN	n=4, missing=124	
	0	0
Other	n=21, missing=137	
	2	9.52
Non-union	n=100, missing=345	
	13	13.00

Frequency of Worker Reported Contractors (n=399)		
Contractor	**Number of Workers**	**Proportion of Workers**
REECO	368	92.23
EG&G	29	7.27
LLNL	4	1.00
LANL	3	0.75
SNL	1	0.25
H&N	9	2.26
F&S	4	1.00
Wackenhut	6	1.50
DOE	5	1.25
DOD	5	1.25
Other	93	23.21

Frequency of Worker Reported Work at Other Doe Sites		
Site	Number of Workers	Proportion of Workers (%)
Alaska / Pacific Tests	46	1.67
Argonne	4	0.15
Atomics International (CA)	1	0.04
Brookhaven National Laboratory	2	0.07
Fermi National Accelerator Lab (Illinois)	1	0.04
Fernald Materials Production Center (OH)	4	0.15
Hanford Site (WA)	36	1.31
Idaho Mational Engineering & Environmetnal Lab	22	0.8
Iowa Ordnance Plant	1	0.04
Lawrence Livermore National Lab	28	1.02
Los Alamos National Lab	47	1.7
Monticello Site (UT)	1	0.04
Mound Plant (OH)	1	0.04
Nevada Test Site	77	2.79
Oak Ridge	6	0.22
Other	208	7.54
Other Test Sites	19	0.69
Paducah	5	0.18
Pantex Plant	5	0.18
Portsmouth	8	0.29
Rocky Flats	28	1.02
Sandia National Lab	29	1.05
Savannah River	10	0.36

Appendix A -- Case File Results Review

Case 1:

Individual indicated that he worked from 1954-1959 and again from 1989 to 1998. Full case file indicates he was not hired until 8/58 and the summary report indicates he had dosimetry records for the following time periods: 1958, 1960-1962, 1964-1989. External dosimetry database records were consistent with hard copy records

Case 2:

Individual indicated that he worked from 1964-1995. Full case file indicates external dosimetry data for the following periods: no data for 1964, yearly summary data for 1966 and 1969, all other periods through 1995 included regular data. External dosimetry database records indicate no dosimetry records for this individual from 1964-1986 but the database does include regular records between 1987-1992. Hard copy records indicate extensive tritium sampling (135 samples) and database records indicate 130 samples. Hard copy records indicate an assigned dose from tritium exposures for the periods from 1972-1973 and 1976-1984. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 3:

Individual indicate he worked from 1962-1992. Full case file indicates external dosimetry data for the entire period from 1962-1992; 1963-1971 is only yearly summary data. External dosimetry database records are consistent with hard copy records. Hard copy records and database records indicate 13 tritium samples during the 1962-1963 time period. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 4:

Individual indicate he worked from 1951-1952 and again from 1957-1994. Full case file indicates external dosimetry data for the entire period -- 1951-1952 (yearly summary data), 1968-1971 (yearly summary data) and other time periods had regular data. External dosimetry database records are consistent with hard copy records. Hard copy records indicate tritium sampling during 1959-1960, 1963, 1976-1977, 1980-1988 with a dose assigned for the time period from 1981-1984. Database records indicate 53 tritium samples during 1976-1985 and 1-7 samples in 1962-1963 (No ID# for this database so could not determine if had the correct individual). The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 5:

Individual indicated he worked from 1965-1995. Full case file indicates external dosimetry data for the entire time period with 1965-1972 having annual summary data only and 1973-1995 including regular sampling data. External dosimetry database records include no data for the time period from 1963-1986 but the database does include records for the time period from 1987-1992. Hard copy records do not indicate any bioassay data and no bioassay records were found in the databases.

Case 6:

Individual indicated he worked from 1959-1995. Full case file indicates external dosimetry data for the time period from 1960-1995 with 1960-1971 having only annual summary data and 1972-1995 including regular sampling data. Tritium sampling for hard copy records and database are consistent with sampling from 1976 through 1983. Hard copy dose records indicate dose assigned for period from 1976-1983. Hard copy record indicates sampling in 1972, 1974 and 1984 with no dose assigned. The reason for not assigning a dose for 1984 is given in the hard copy records (result would be less than 10 mrem CEDE) however, no reason is given for not assigning a dose for 1972 or 1974 although it is apparent that the dose would have been very small. Hard copy records indicated 1 sample for plutonium-239 in 1974 however, the database did not indicate any plutonium sampling. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 7:

Individual indicated he worked from 1959-1995. Full case file indicates external dosimetry data for the time period 1959-1995 with only annual summary doses for the time period from 1969-1971. External dosimetry database includes monitoring data for the entire period with the data being consistent except for a 1963 annual dose in the database of 1765 mrem and the hard copy record shows a dose of 1825 mrem. Hard copy and database records indicate tritium sampling 1959 through 1963 (both include 18 samples) with a dose assigned for the time period from 1961-1963. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 8:

Individual indicated he worked from 1961-1968 and again from 1975 through 1998. Full case file indicates external dosimetry data for time period from 1963 through 1998 with no data for the year of 1961, 1962, or 1968 and annual summary data for periods from 1963-1967 and 1970-1971. All other time periods indicate regular data. External dosimetry database includes monitoring data for the entire time period and the data is consistent with the hard copy record.

Case 9:

Individual indicated he worked from 1964 through 2000. Full case file indicates external dosimetry data for the time period from 1965 through 2000. The hard copy records indicate a date only for several of the dose entries for the time period from 1967 through 1970 with the dose hand written over the computer printout as zero. The years for which the computer printout had no data the hard copy file included card-punch data and the values were added to the printout based on the card punch data. It does not appear that the computer printout for other years was validated against the card-punch data. Extensive tritium sampling data appears to be consistent when comparing the hard copy records against the database records. Database records indicate one Pu-238 sample in 1970 but the hard copy record indicates an I-131 exposure that year with a thyroid dose assigned (this may simply be an error in the database field code). Hard copy record indicates a whole body dose assigned from a Ruthenium exposure in 1971 but the database does not include any sampling for that time period. Finally, the database and hard copy records indicate alpha smear samples in 1962 with no results and no dose assigned. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 10:

Individual indicated he worked form 1963 through 1996. Full case file indicates external dosimetry data for the time period from 1963 through 1995 with annual summary data only for 1963, 1964, and 1967 and no data for 1966, 1970, and 1971. All other years included regular data. External dosimetry database includes no monitoring data for the time period from 1963-1992. Neither hard copy records or database records indicate any bioassay sampling.

Case 11:

Individual indicated he worked from 1961-1993. Full case file indicated no records for 1961-1962, annual summary record for 1963, regular records for 1964, annual summary record for 1965-1971, and regular records for 1972 through 1993. External dosimetry database indicates no records for 1961-1993. Hard copy records indicate 24 tritium samples for the period from 1981-1991 with no dose assigned (results were very low). Hard copy records indicated Pu-239 samples for 1982-1986 and 1991 with no dose assigned. Database indicated no bioassay data. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 12:

Individual indicated he worked from 1962-1998. Full case file indicated regular records from 1962 through 9/12/95 with the exception of 1994 (no records for that year). Annual summary records only for 1963-1971 and regular records for 1972-1995. External dosimetry database indicates records consistent with hard copy records. Hard copy and database indicated one whole body scan with no dose assigned.

Case 13:

Individual indicated that he worked from 1968 through 1991. Full case file indicated annual summary records for 1968 through 1970 and regular records from 1971 through 1991. External dosimetry database indicates no records for period between 1963-1991. Hard copy indicates two whole body scans and database indicates one whole body scan. Hard copy records show no internal dose assigned.

Case 14:

Individual indicated that he worked from 1981 through 1994. Full case file indicated regular records from 1981 through 1994. External dosimetry database indicates no records from 1981-1994. Hard copy records indicate tritium sampling in 1984 and 1986-1988 and 1990 and 1992 with dose assigned only in 1986 since other calculated doses were less than 10 mrem CEDE. Database indicates only 1 tritium bioassay sample. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 15:

Individual indicated that he worked from 1961-1993. Full case file indicated regular records from 1961-1994. External dosimetry database indicates annual summary records for 1961-1971 and regular records from 1972-1992. Hard copy records indicate 17 tritium samples from 1962-1963, 17 samples from 1966-1971, and 35 samples from 1972-1984. Database indicates 17 samples from 1962-1963 and 18 samples from 1972-1984. No samples from 1966 through 1971. Whole body dose from tritium exposures was assigned for 1962, 1963, 1967, 1971, and 1972. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 16:

Individual indicated that he worked from 1951-1991. Full case file indicated regular records for 1951, no records for 1952-1958, annual summary record for 1959, no records for 1960-1963, regular records for 1964, annual summary record for 1965-1971, and regular records for 1972-1991. External dosimetry database indicates regular records for 1951, annual summary records for 1959, annual summary records for 1963-1971 (except 1964), and regular records for 1972-1991. Database recorded doses are consistent with hard copy records. Hard copy records and database indicate no bioassay data.

Case 17:

Individual indicated that he worked from 1958 – 1993. Full case file indicated regular records from 1958 through 1993 except for 1965, 1969 and 1971 which included annual summary data only. External dosimetry database indicates regular records for 1958, annual summary data for 1959-1971, and regular records from 1986 through 1992. Database recorded doses were consistent with hard copy records. Hard copy records indicate tritium sampling in 1961-1962. Database records indicate 14 tritium samples from 1961-1962. Hard copy records also indicate a thyroid dose of 34 rad assigned in 1963. There were records in the hard copy records for the iodine exposure but there were no related data in the database. Finally, the database and hard copy records both indicate 1 alpha nasal smear taken in 1962 with no dose assigned. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 18:

Individual indicated that he worked from 1964 – 1995. Full case file indicated regular records from 1964 through 1995 except for 1964, 1968-1971 which included only annual summary data. External dosimetry database indicates no records for 1964-1983 and regular records for 1986-1992. Hard copy records indicate tritium sampling during 1965-1967, 1972, 1974, 1976-1978, and 1980-1987. Tritium doses were assigned in 1967, 1974 and 1981. Database records indicate 33 tritium samples from 1976-1985. The calculated tritium doses were reviewed using the same assumptions as the NTS staff used and using CINDY version 1.4 with ICRP 30 tritium model and doses consistent with the reported doses were obtained..

Case 19:

Individual indicated that he worked from 1961-1989. Full case file indicated annual summary record for 1960, regular records for 1961-1963, annual summary record for 1964-1971, and regular records from 1972 – 1992. Case file includes one result for 1992 but no data for 1990-1991 (these years appear to be outside the self-reported work end date). External dosimetry database indicates annual summary records for 1960-1971 and regular records from 1972-1989 and 1 record in 1992. Hard copy records indicate 3 tritium samples for 1961-1962. Database records indicate 2 tritium samples from 1962-1963; none in 1961 (which was the only hard copy record greater than detectable). Dose was assigned in 1961. Hard copy records and database records indicate 3 tritium samples in 1981 with no dose assigned.

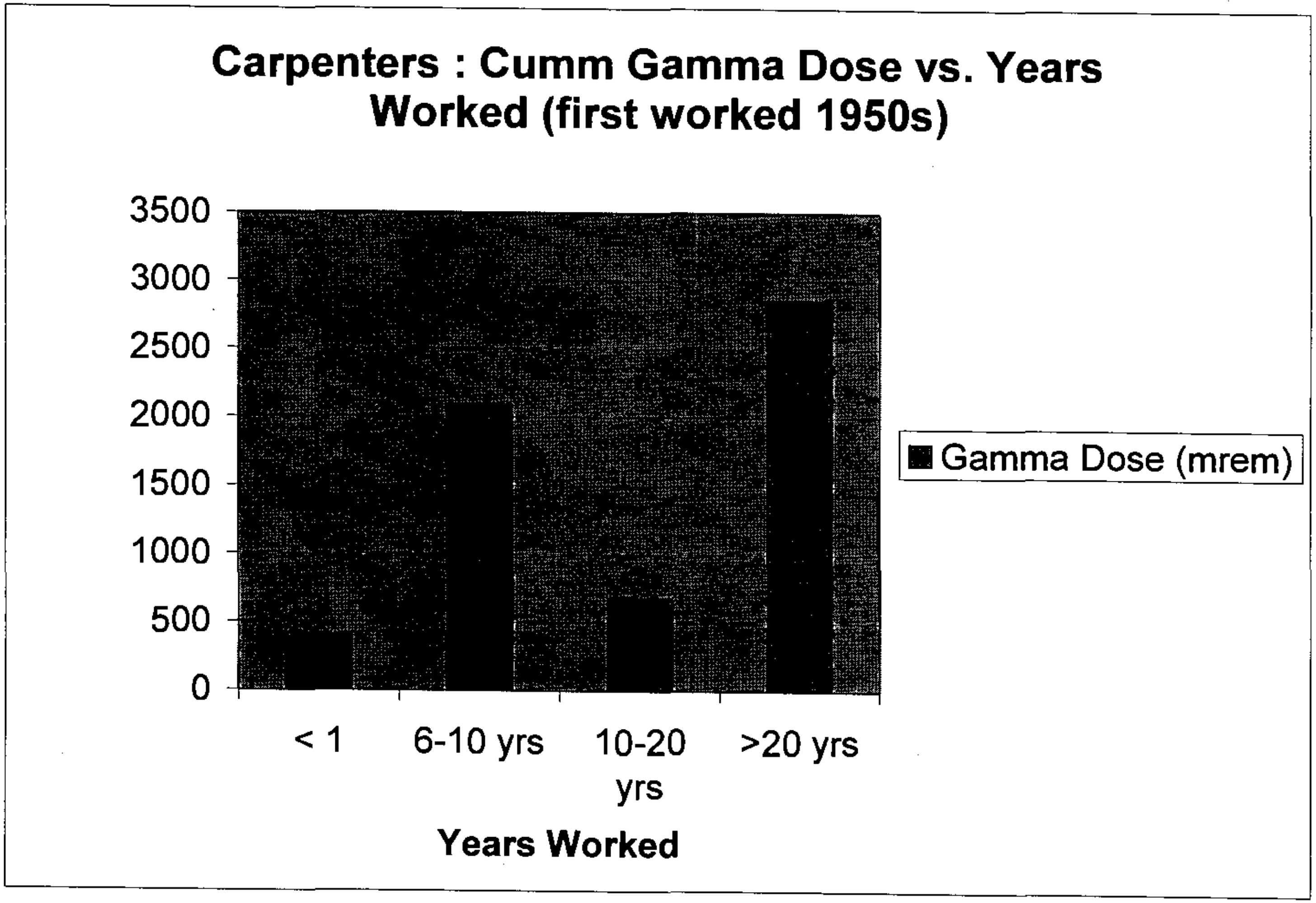
Case 20:

Individual indicated that he worked from 1955-1957 and again from 1967 through 1994. Full case file records indicate regular records for 1957-1959, no records 1960-1964, annual summary record for 1965, no records for 1966-1967, regular records for 1968, annual summary records for 1969-1971, regular records for 1972-1979, no records for 1980-1987, and regular records for 1988-1994. External dosimetry database indicates regular records from 1957-1958, annual summary for 1959, annual summary records from 1965-1971 and regular records from 1972-1979, and regular records from 1988-1992. Hard copy records and database records indicate 2 alpha nasal smears in 1957 with no dose assigned.

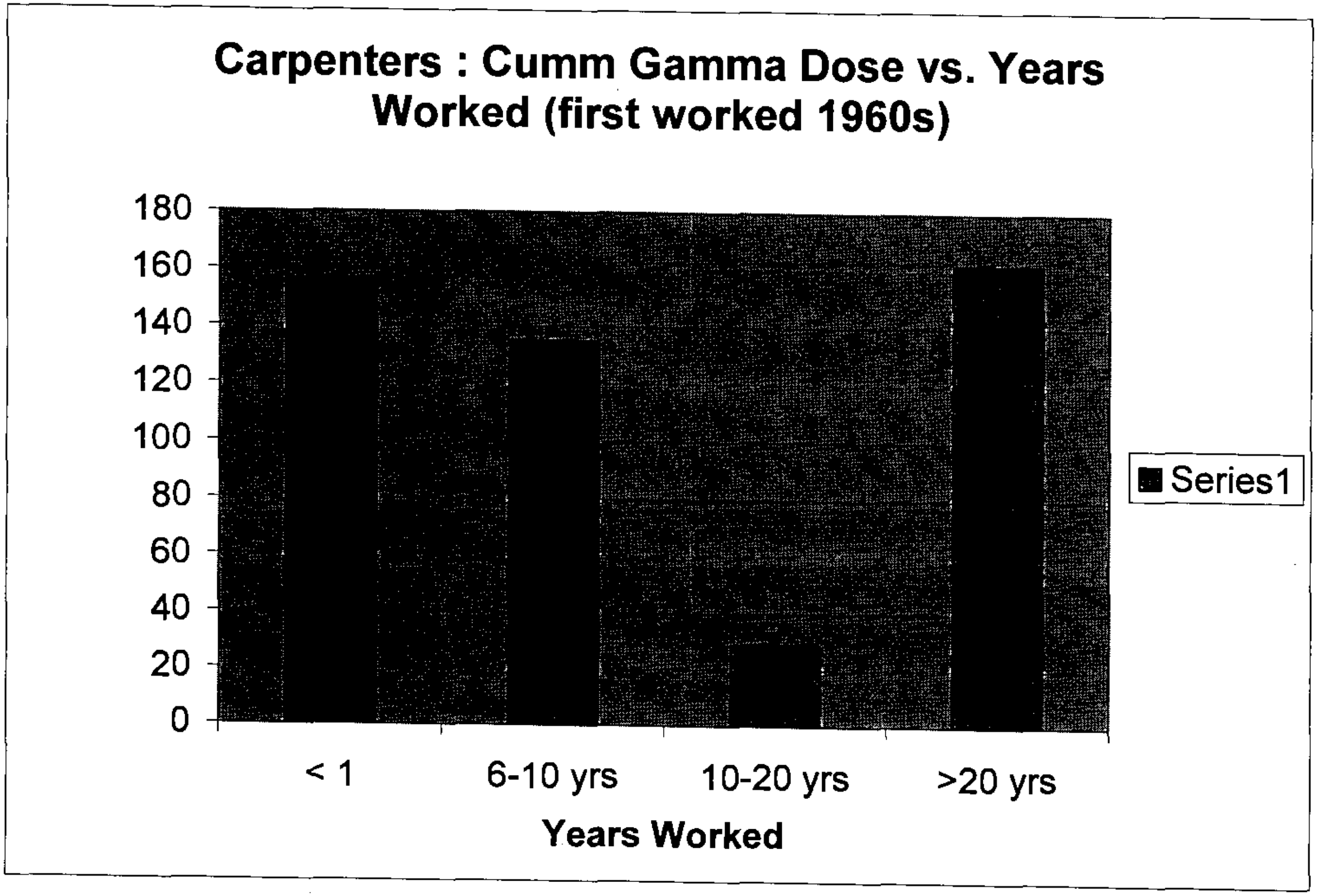
Table 1

Job Classification	Count in Work History Questionnaire	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)	Count with Beta Dose record in Dosimetry Database	Average Beta Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)
Operating Engineer	642	545	780	1822	14791	515	51	284	4200
Other Union	158	81	991	3192	17752	75	141	635	4134
Plumber / Pipefitter	145	129	125	528	4405	126	5	25	224
Sheet Metal	37	35	42	118	565	33	1	5	30
Teamsters	222	176	213	728	7635	172	10	43	355
Painters	23	10	1405	2559	7635	10	100	118	355
Carpenters	166	135	427	1375	8800	119	13	95	1000
Laborers	630	513	1226	2705	17752	481	203	752	6195
IBEW	437	341	483	1956	24580	323	59	345	4134
Ironworkers	138	110	816	3560	36210	104	18	75	585
Non-Union	445	208	916	2328	15810	198	164	712	6135

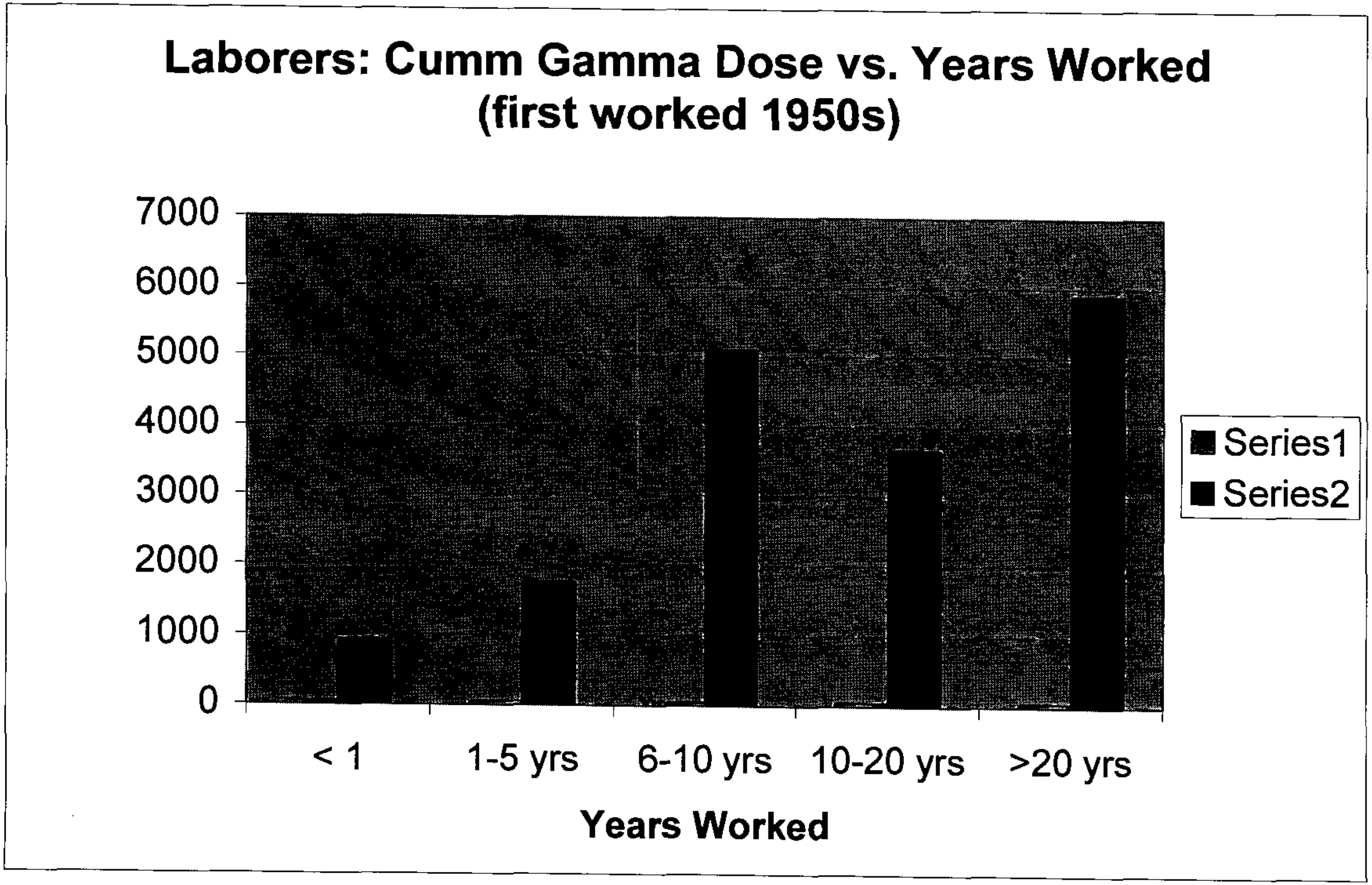
Year	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)	Count with Beta Dose record in Dosimetry Database	Average Beta Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)
1951	5	1124	1177	2660				
1952	15	1542	1772	5734				
1953	27	1929	1348	5370				
1954	12	414	728	2670				
1955	27	848	899	3310				
1956	13	2639	7734	28020				
1957	154	957	1144	5310				
1958	192	496	677	3805				
1959	149	326	606	2635				
1960	208	57	340	4600				
1961	368	472	974	4675				
1962	616	520	899	4690				
1963	490	142	409	2905				
1964	468	48	245	3530	1	50		50
1965	468	92	441	4380	0	0		0
1966	479	137	481	4510	479	60	318	3440
1967	428	107	386	3540	428	53	244	2745
1968	437	48	155	1325	437	33	220	2560
1969	404	19	138	2210	404	6	50	690
1970	381	27	100	845	381	18	112	1560
1971	356	26	117	1045	356	19	132	1940
1972	321	28	195	2780	321	40	239	2545
1973	282	5	31	325	282	1	9	145
1974	297	4	25	345	297	0.5	8	135
1975	293	3	20	175	293	2	12	125
1976	274	3	29	460	274	0	0	0
1977	261	2	20	295	261	1	14	215
1978	262	4	26	360	262	0.2	4	65
1979	236	0.5	6	70	236	0	0	0
1980	238	1	7	70	238	0.4	7	105
1981	241	1	7	90	241	0.4	7	105
1982	237	1	10	140	237	1	14	210
1983	252	0.3	3	40	252	0.2	3	50
1984	1148	3	31	620	1148	1	9	185
1985	1216	4	37	675	1216	3	34	840
1986	1186	31	205	3040	1186	14	110	1890
1987	1179	6	44	903	1179	14	136	3206
1988	1141	2	19	355	1141	3	34	747
1989	1048	0.6	7	195	1048	1	12	259

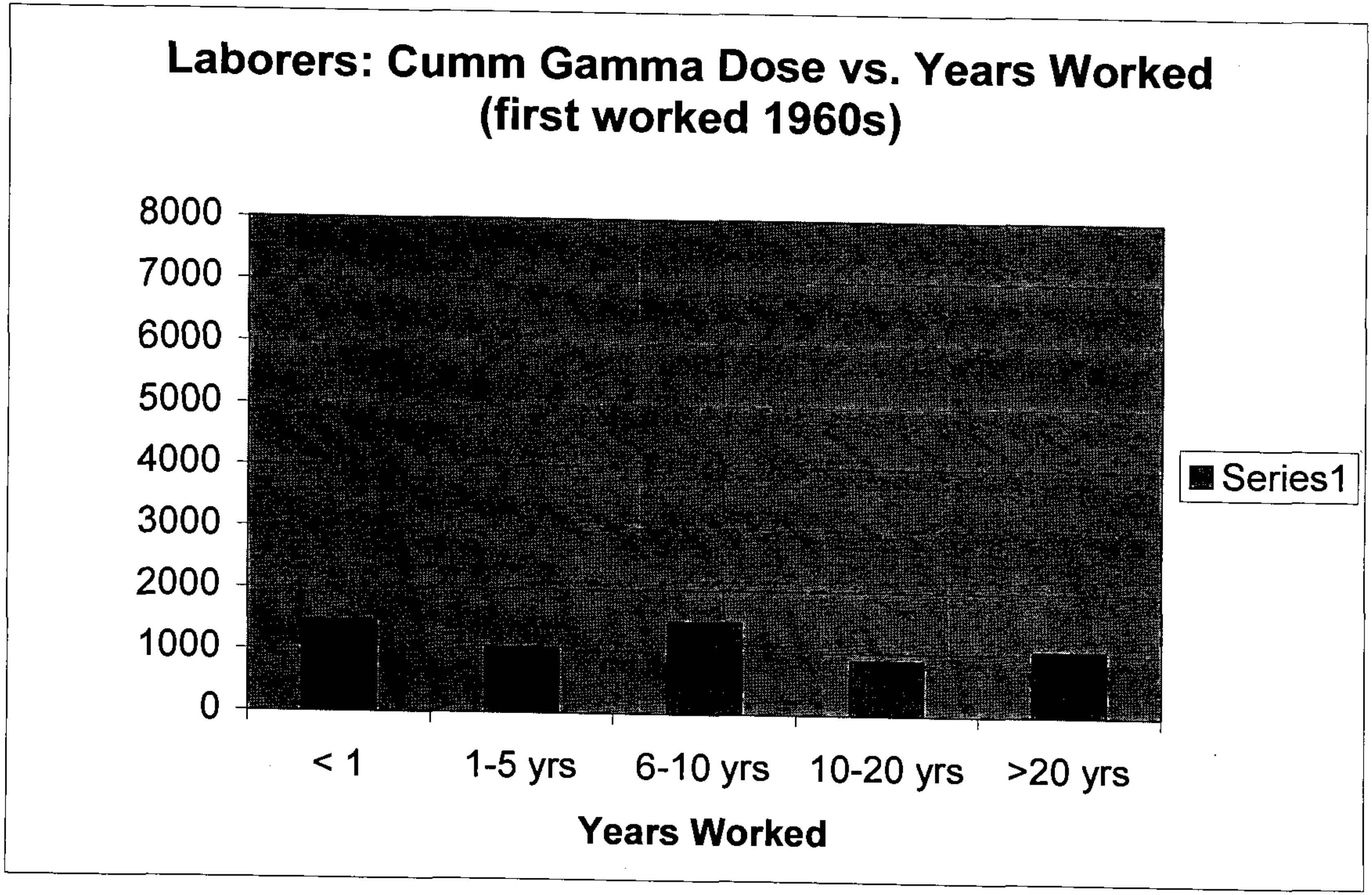


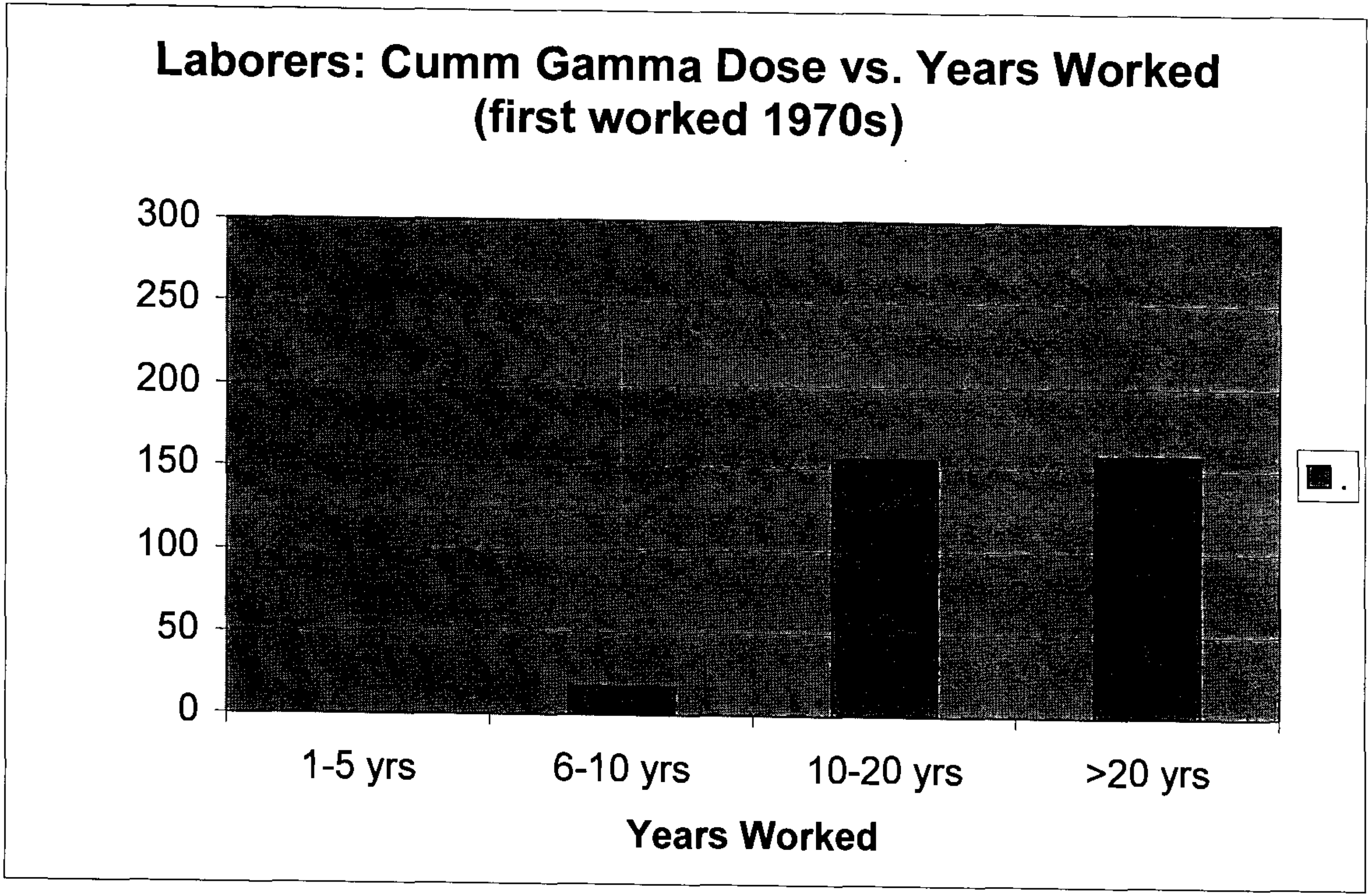
Carpenters : Cumm Gamma Dose vs. Years Worked (first worked 1950s)
3500
3000
2500
2000
1500
1000
500
0
< 1
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Gamma Dose (mrem)

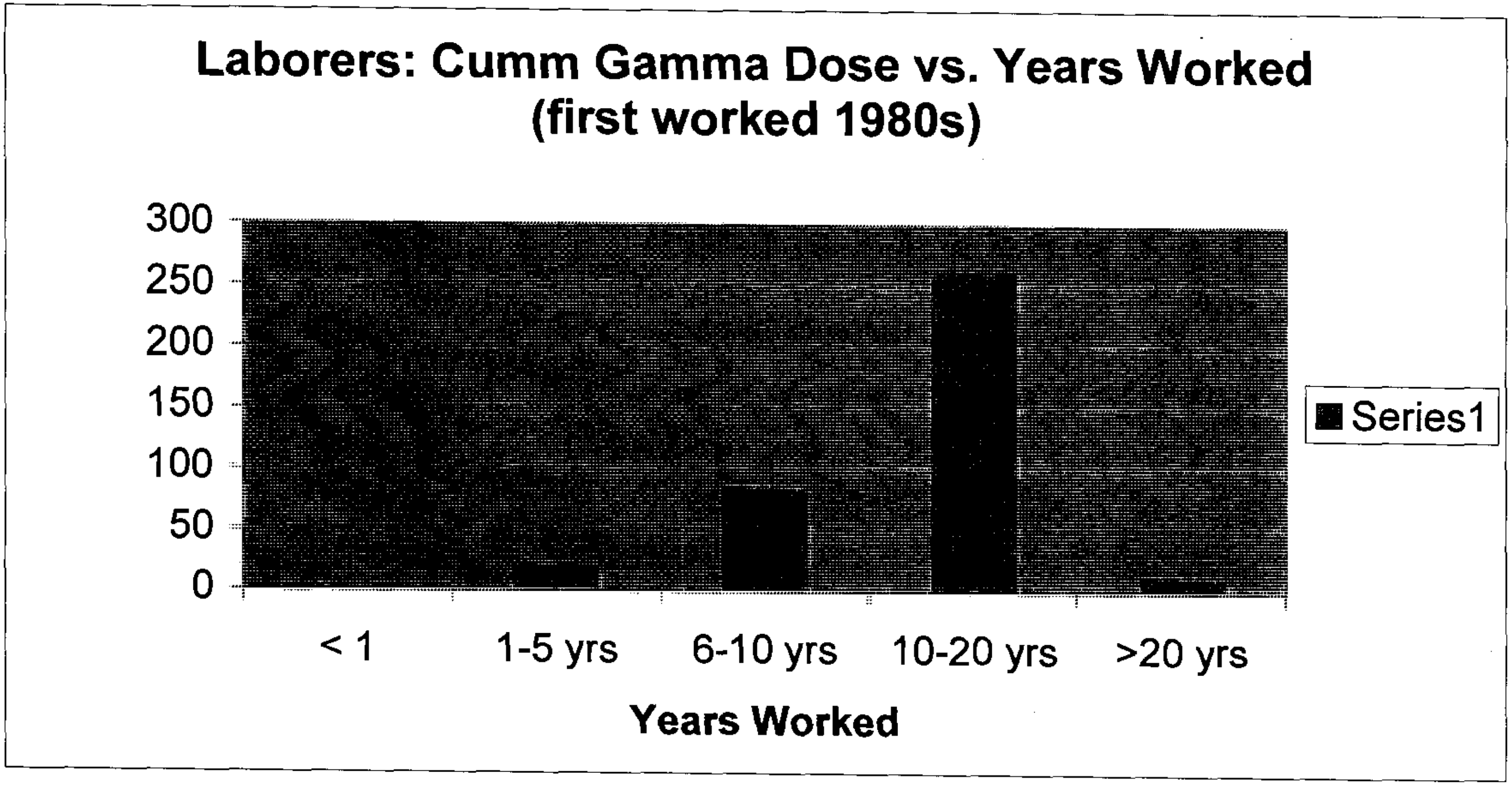


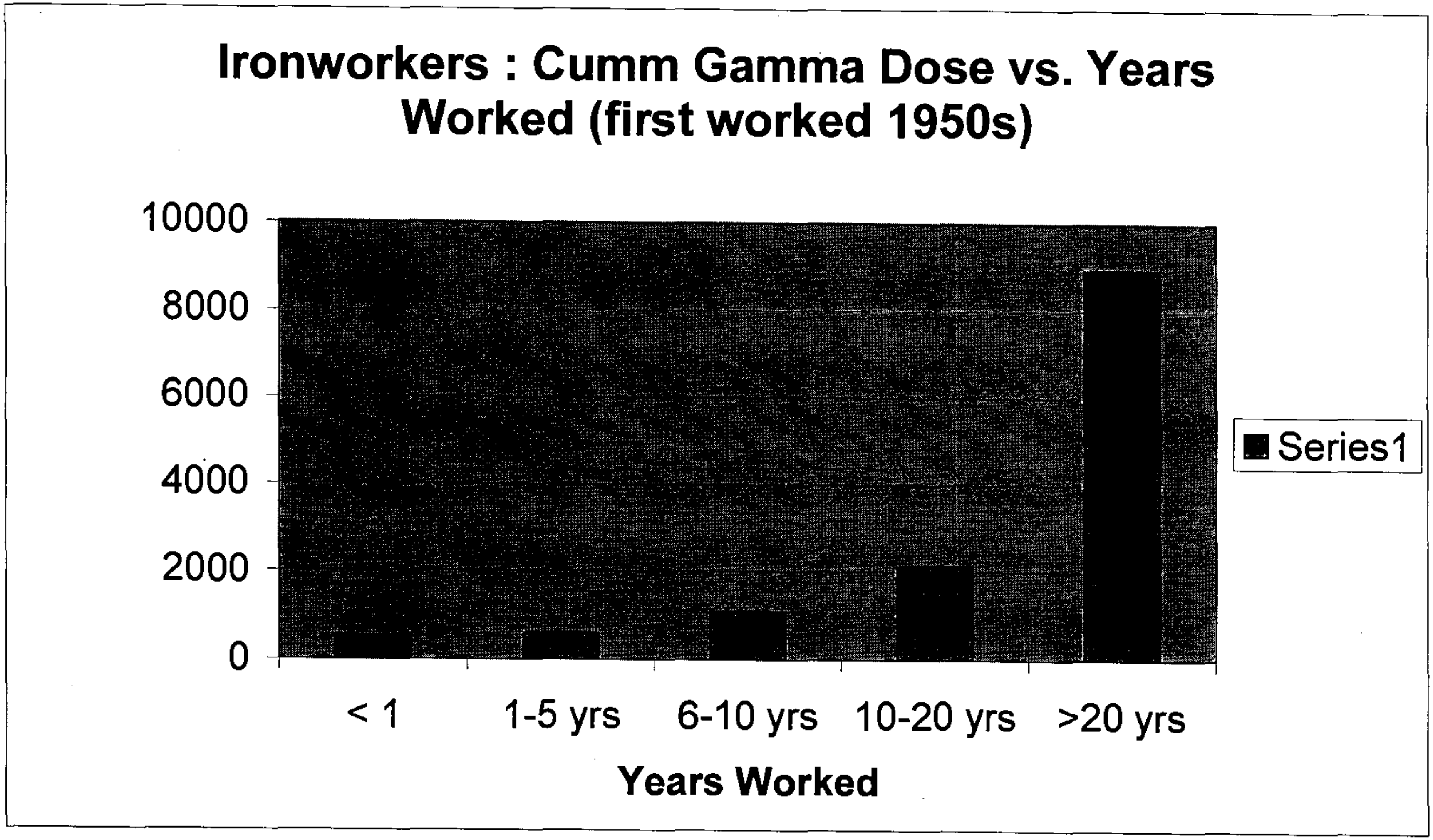
Carpenters : Cumm Gamma Dose vs. Years Worked (first worked 1960s)
180
160
140
120
100
80
60
40
20
0
< 1
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1


Laborers: Cumm Gamma Dose vs. Years Worked
(first worked 1950s)
7000
6000
5000
4000
3000
2000
1000
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1
Series2

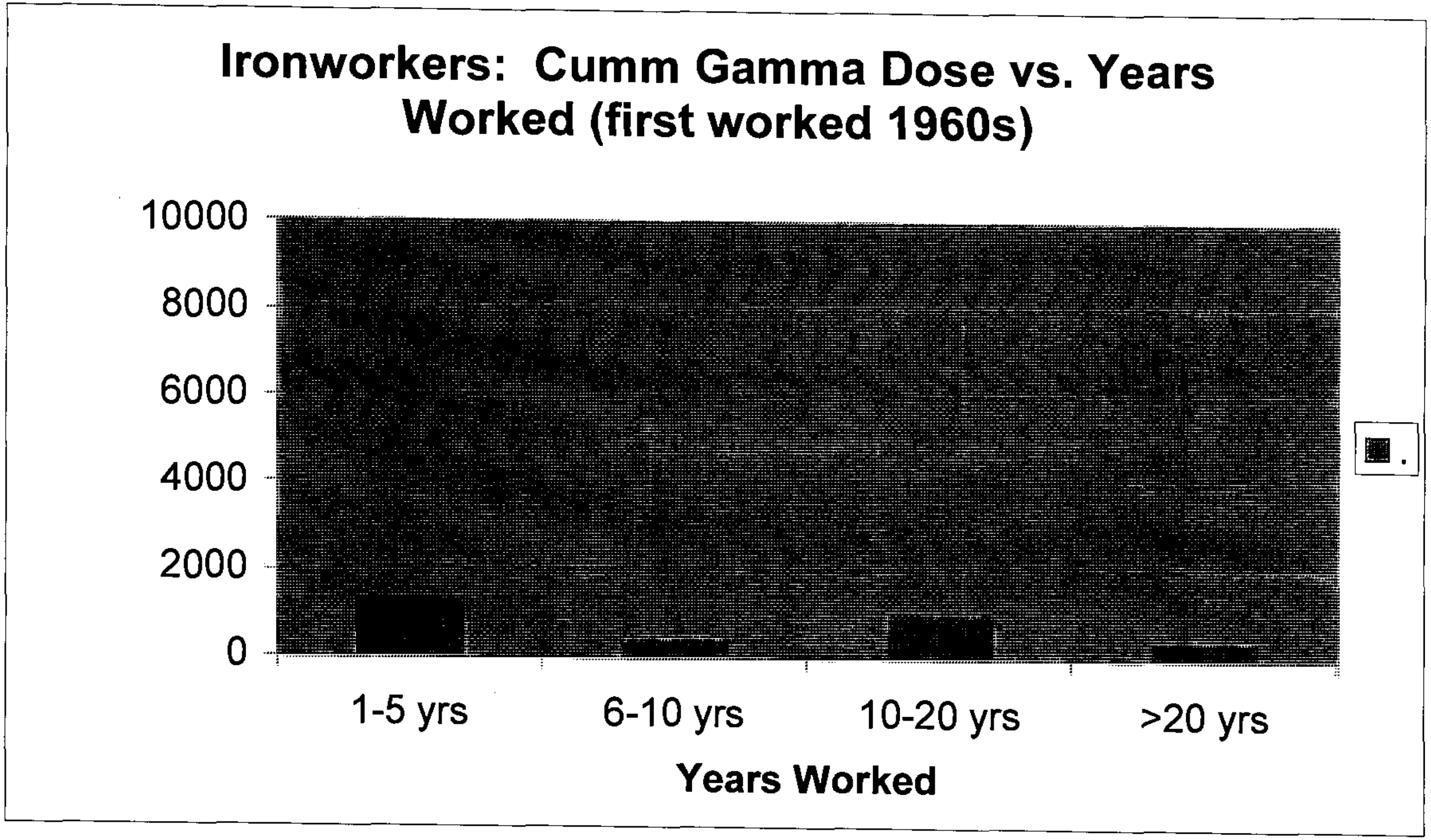

Laborers: Cumm Gamma Dose vs. Years Worked
(first worked 1960s)
8000
7000
6000
5000
4000
3000
2000
1000
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

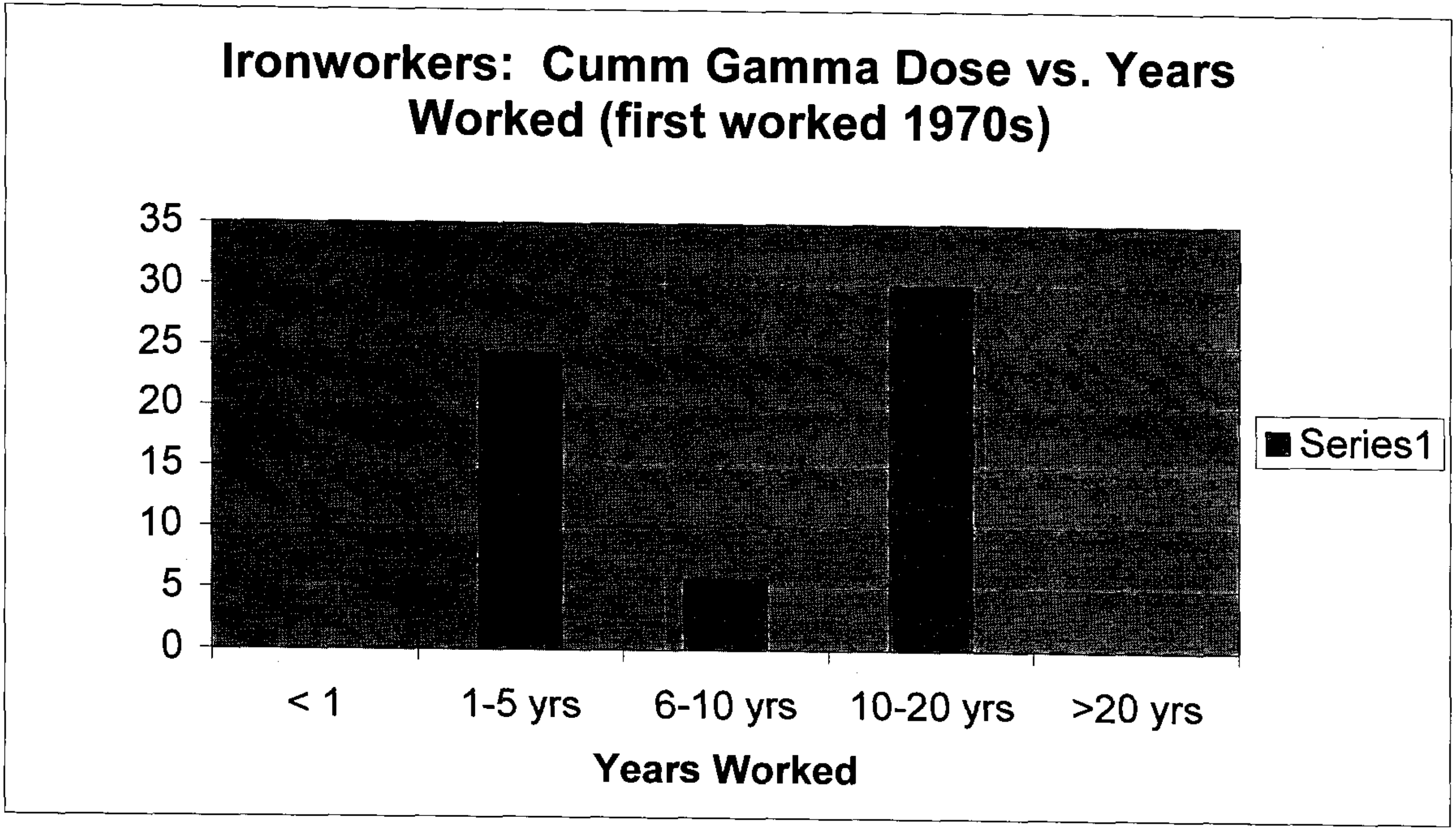

Laborers: Cumm Gamma Dose vs. Years Worked
(first worked 1970s)
300
250
200
150
100
50
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked


Laborers: Cumm Gamma Dose vs. Years Worked
(first worked 1980s)
300
250
200
150
100
50
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

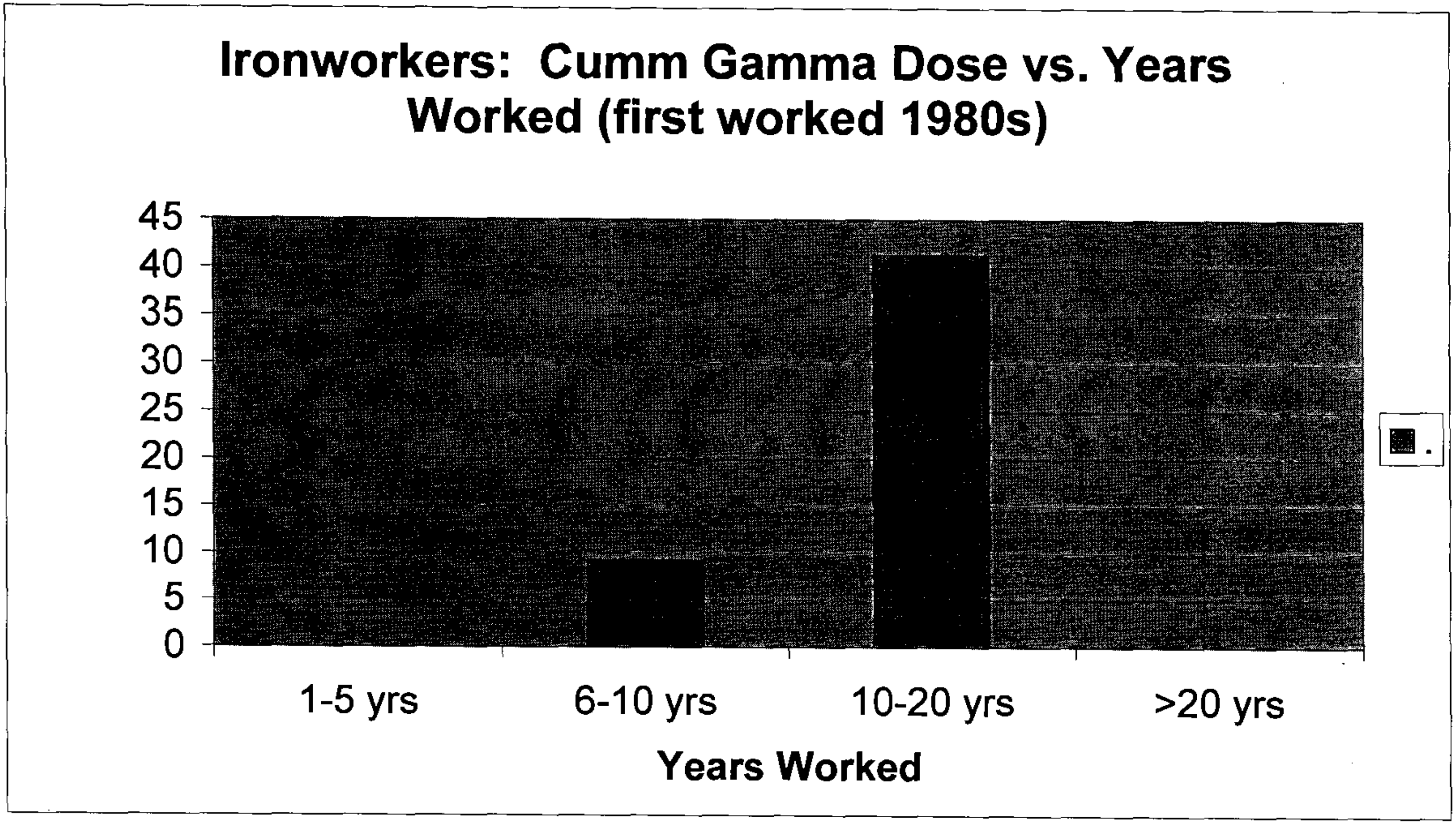


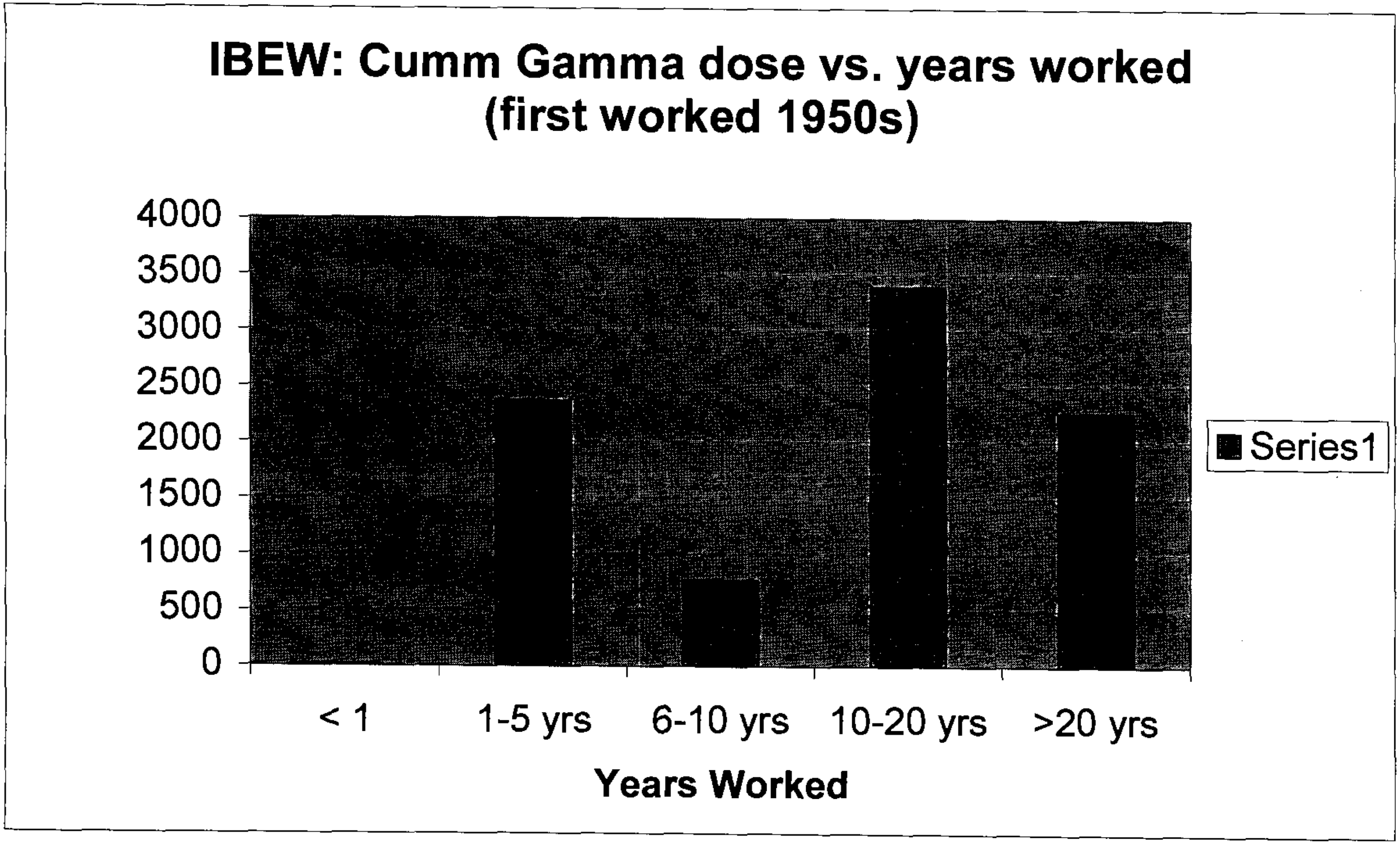
Ironworkers : Cumm Gamma Dose vs. Years Worked (first worked 1950s)
10000
8000
6000
4000
2000
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

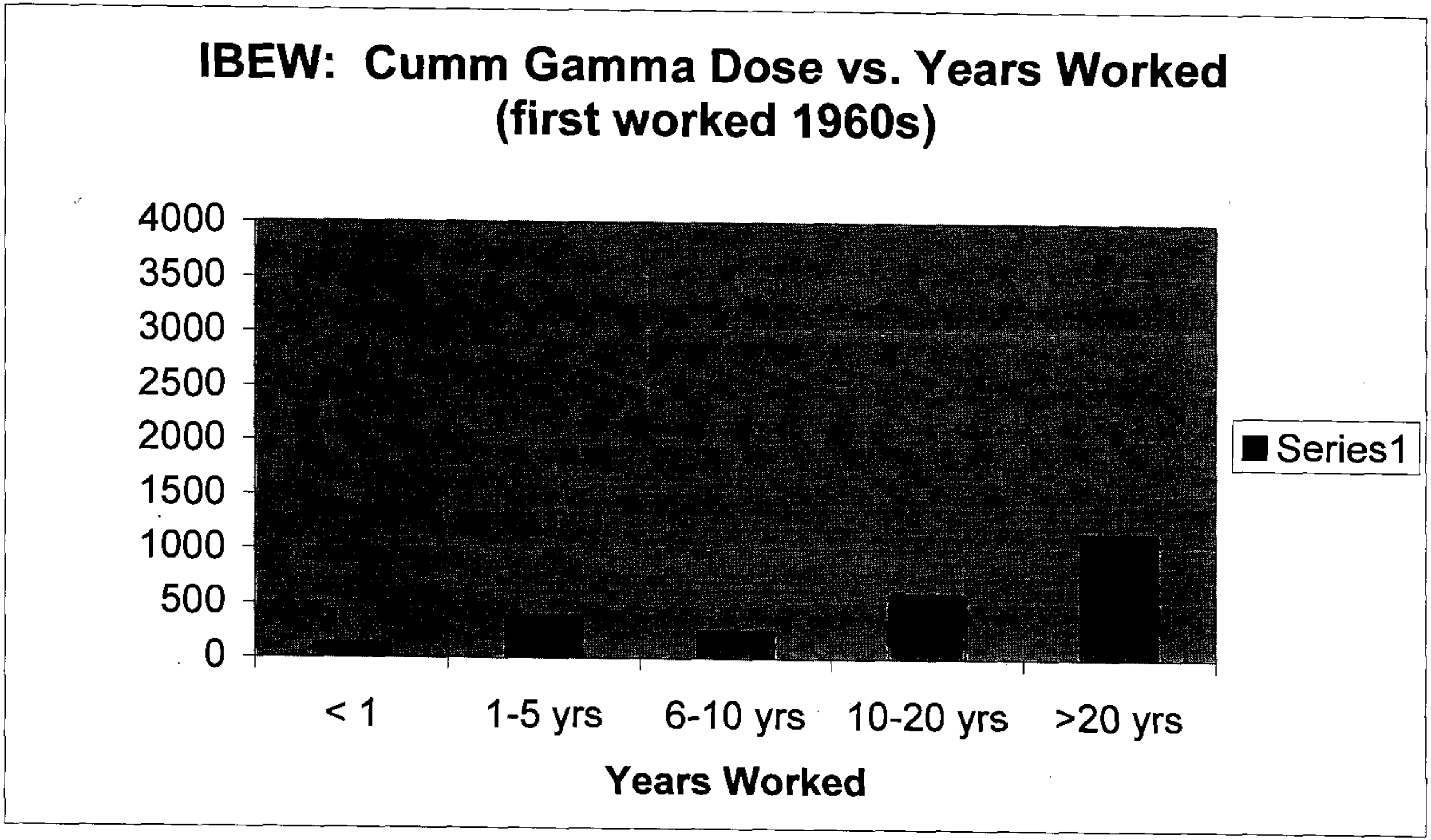

Ironworkers: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
10000
8000
6000
4000
2000
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked



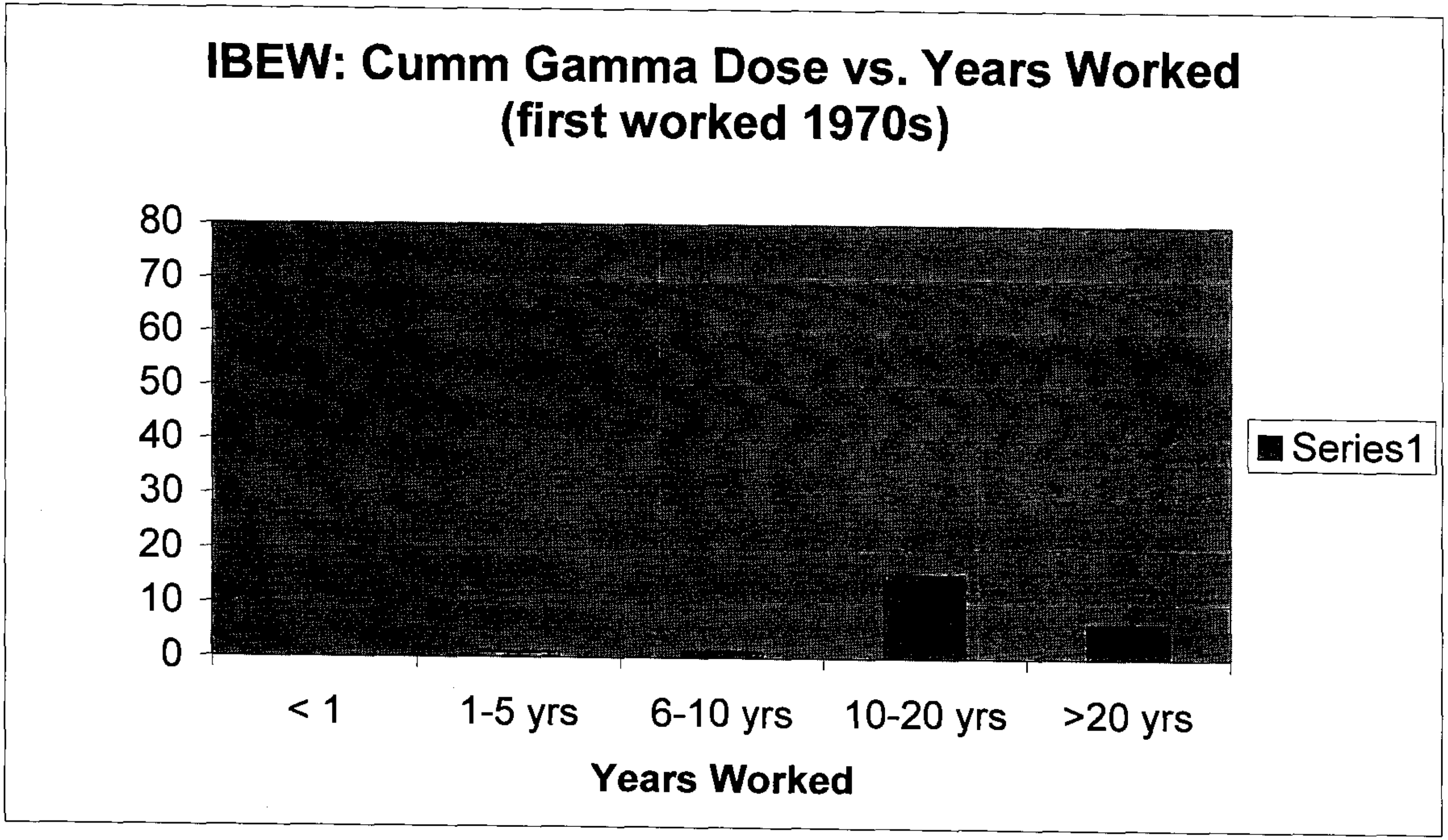
Ironworkers: Cumm Gamma Dose vs. Years Worked (first worked 1970s)
35
30
25
20
15
10
5
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1


Ironworkers: Cumm Gamma Dose vs. Years Worked (first worked 1980s)
45
40
35
30
25
20
15
10
5
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

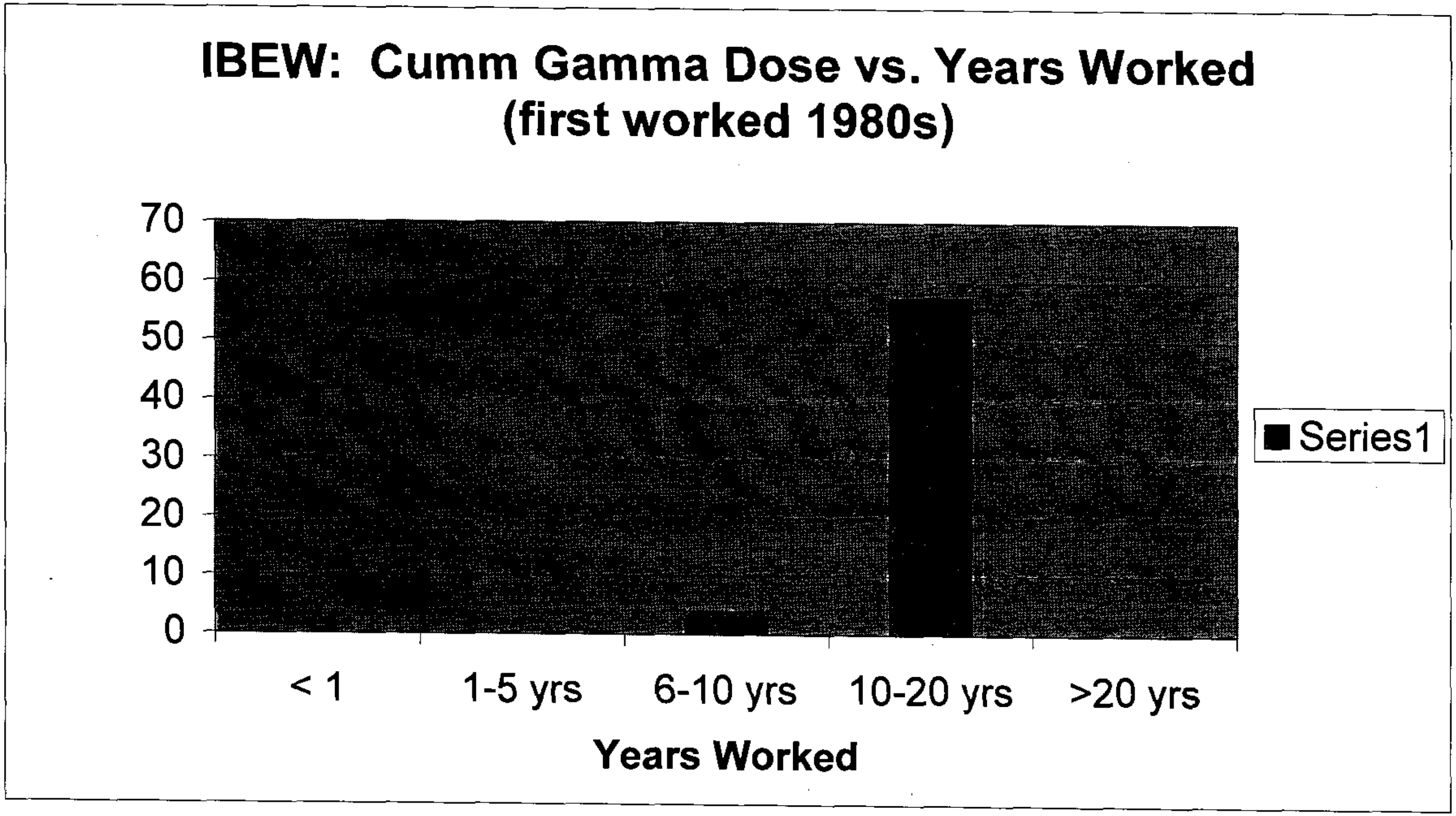

IBEW: Cumm Gamma dose vs. years worked
(first worked 1950s)
4000
3500
3000
2500
2000
1500
1000
500
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

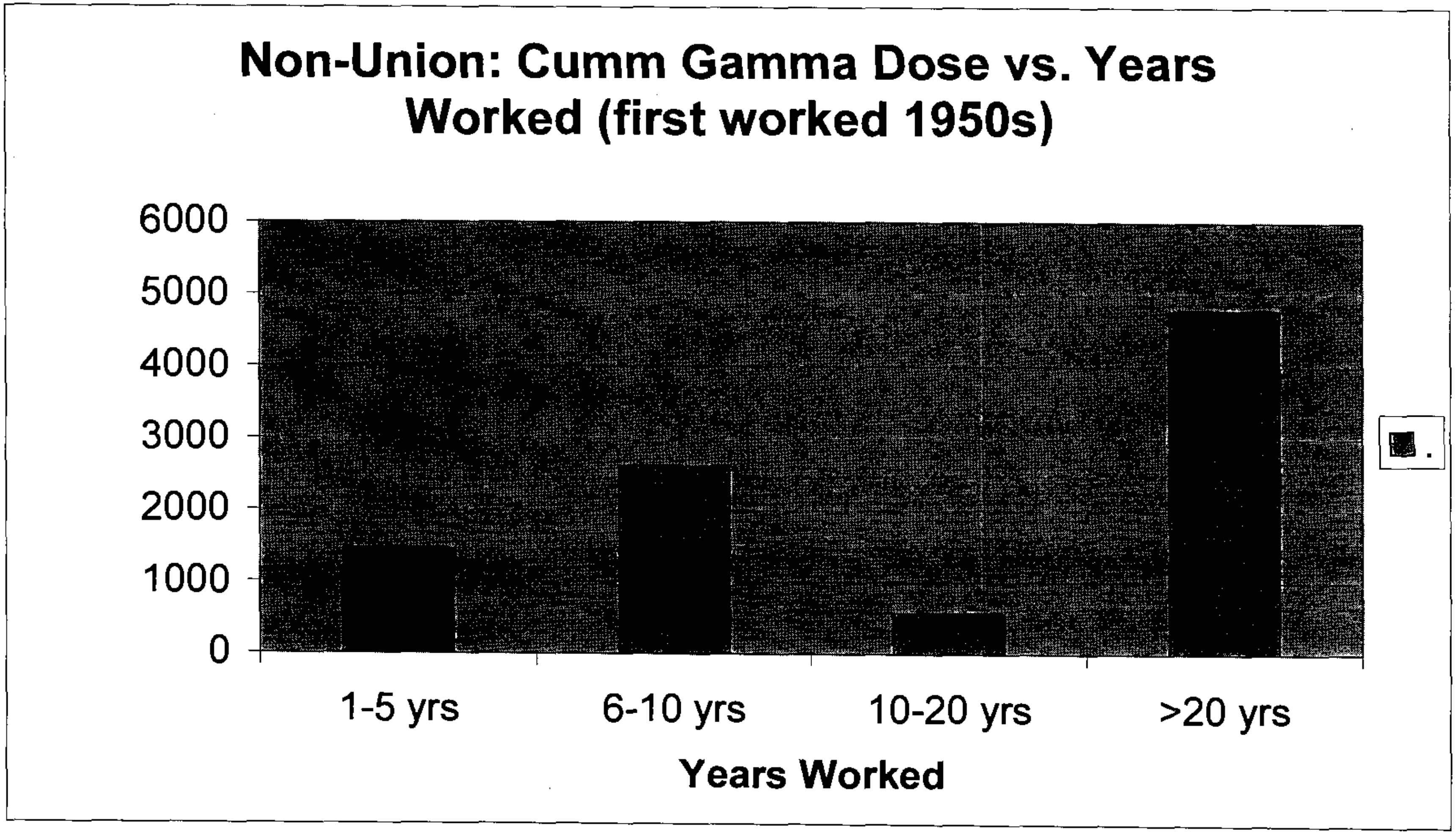


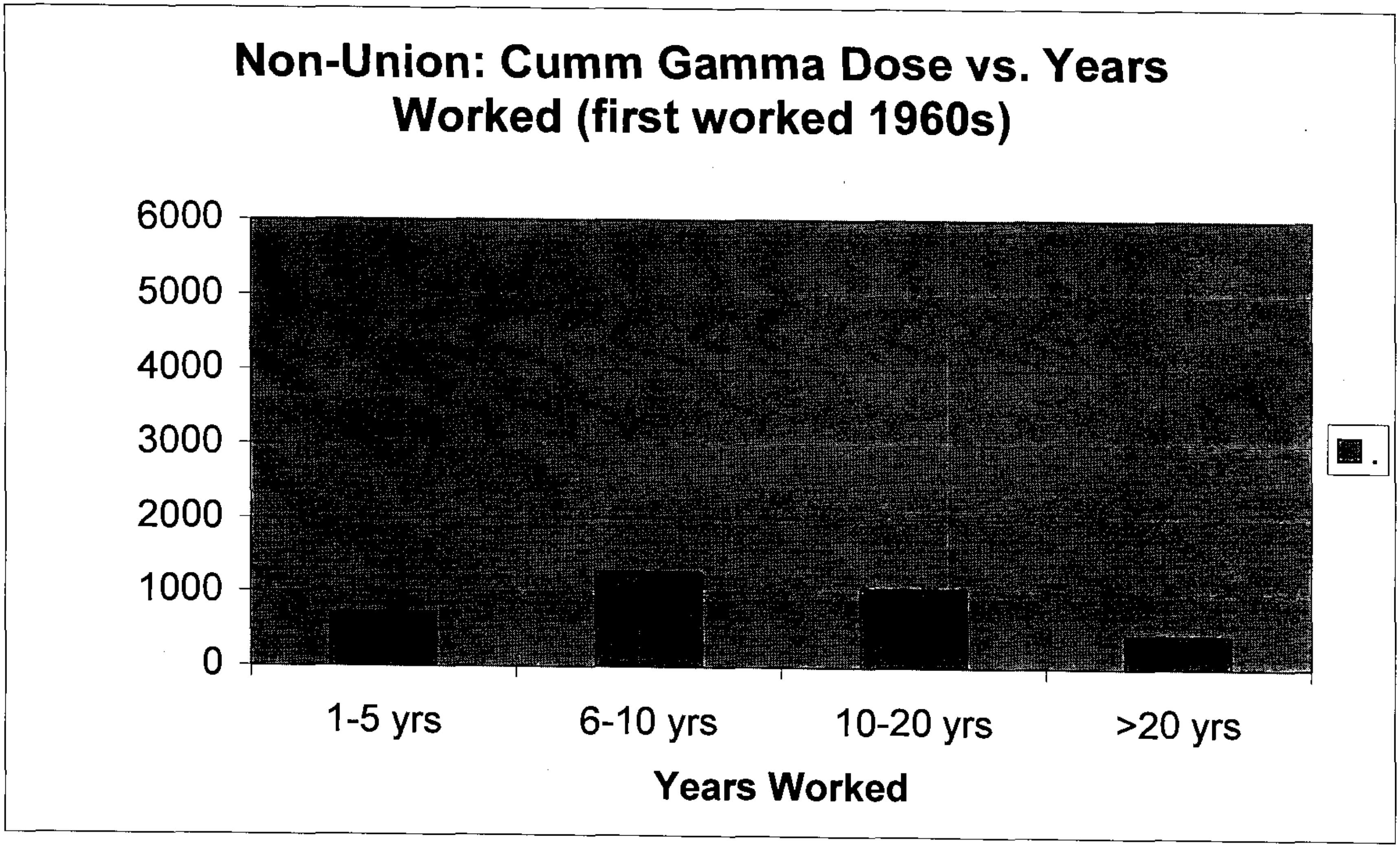
IBEW: Cumm Gamma Dose vs. Years Worked
(first worked 1960s)
4000
3500
3000
2500
2000
1500
1000
500
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

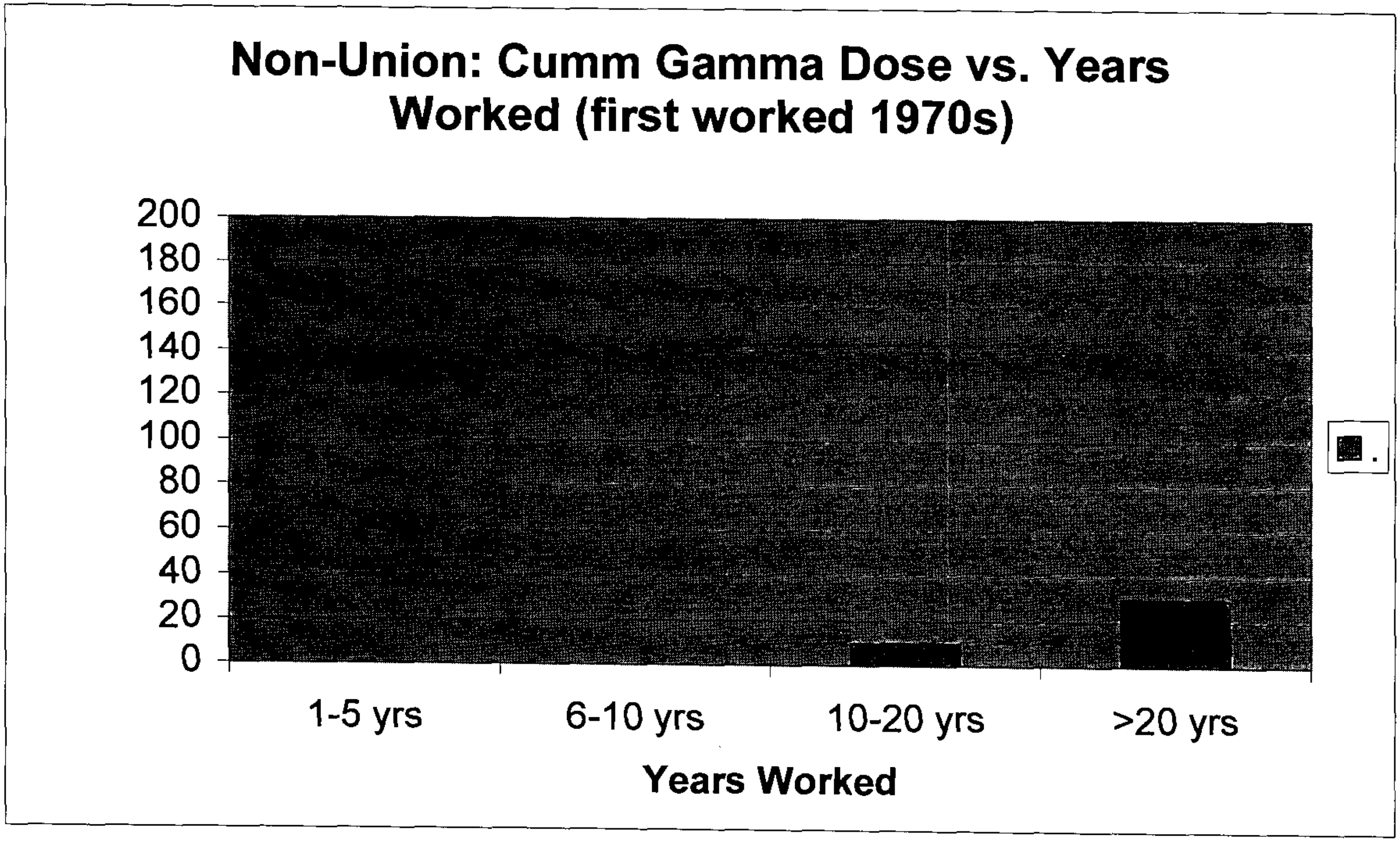


IBEW: Cumm Gamma Dose vs. Years Worked
(first worked 1970s)
80
70
60
50
40
30
20
10
0
Series1
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

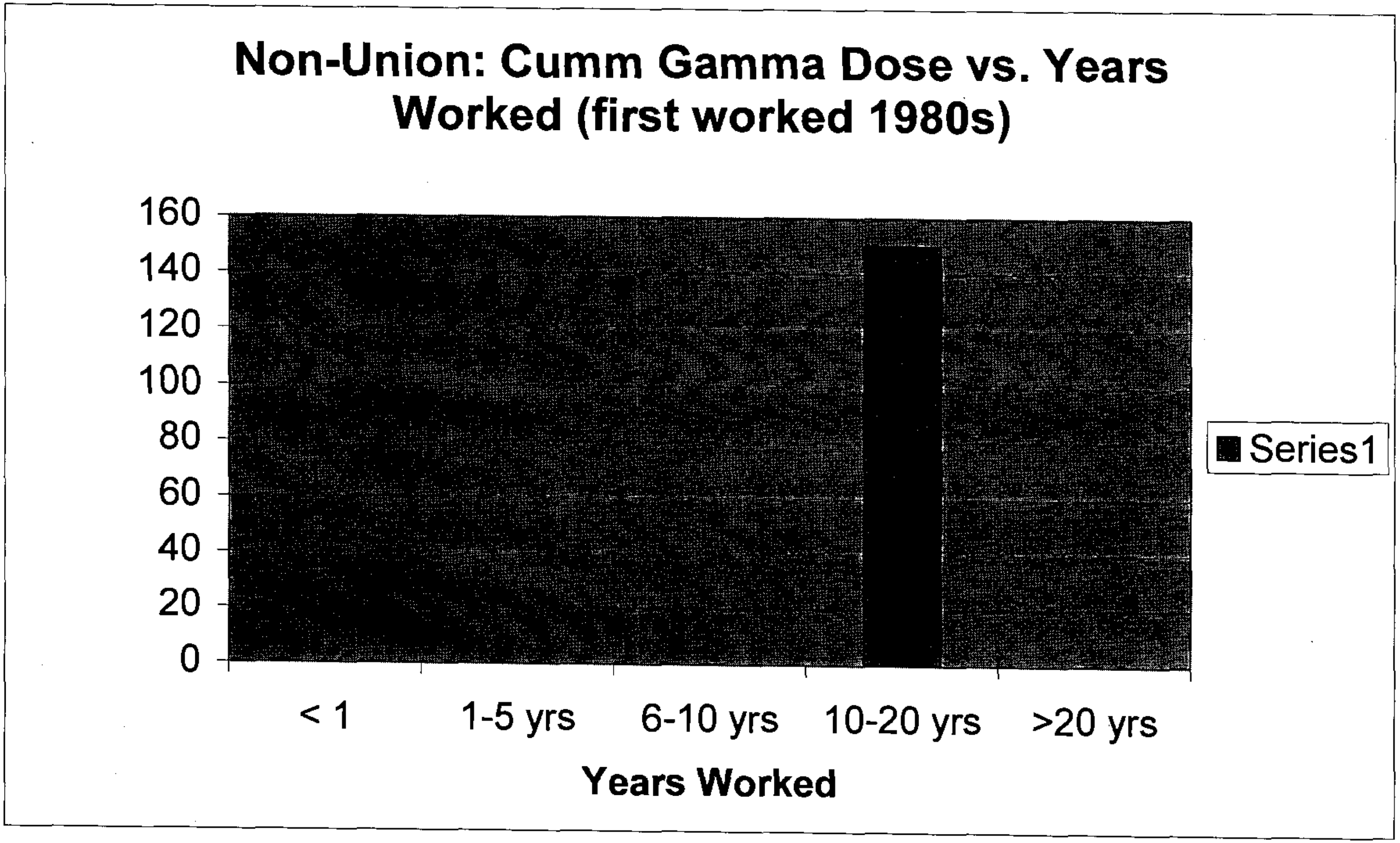

IBEW: Cumm Gamma Dose vs. Years Worked
(first worked 1980s)
70
60
50
40
30
20
10
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

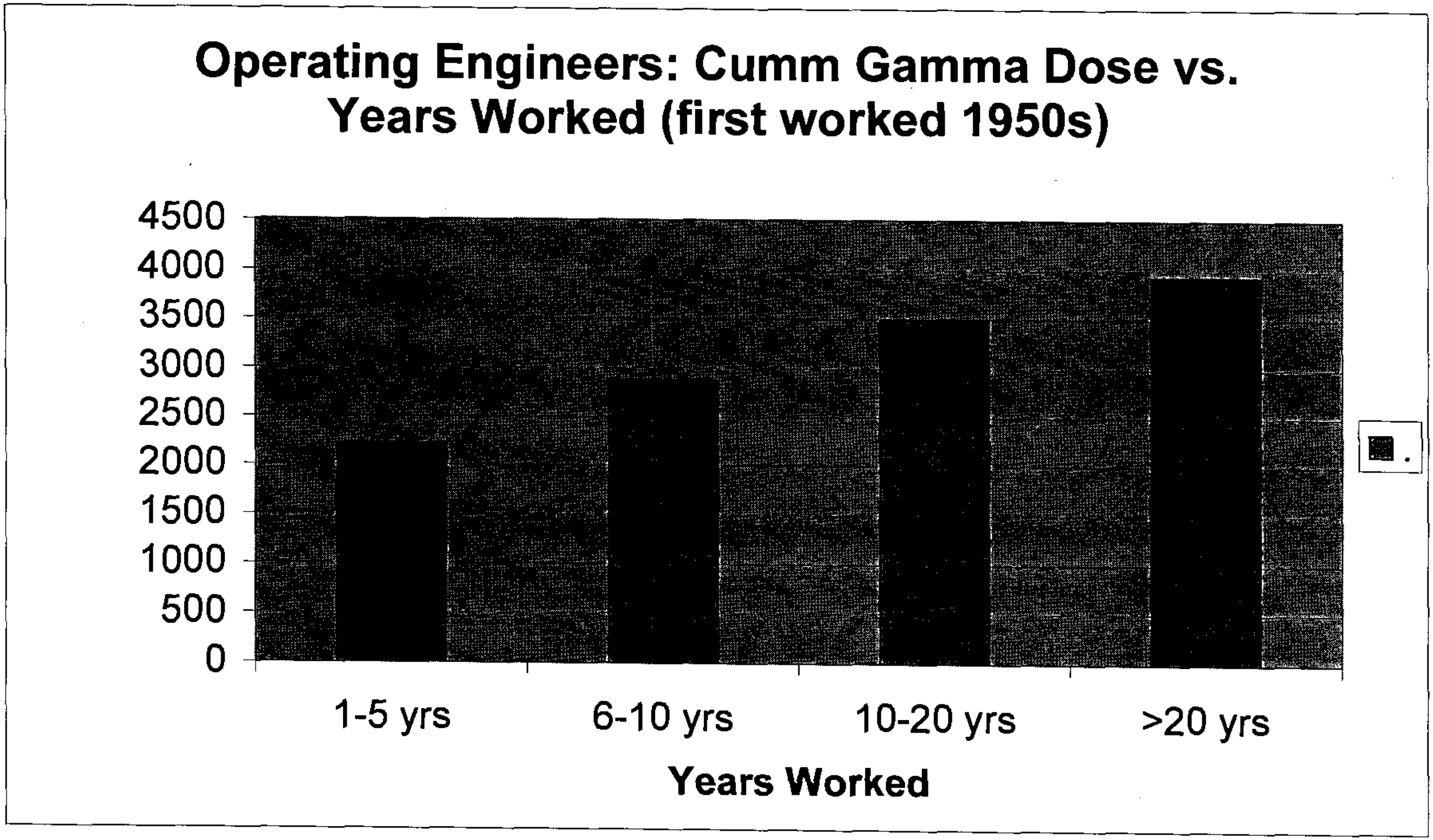

Non-Union: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
6000
5000
4000
3000
2000
1000
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

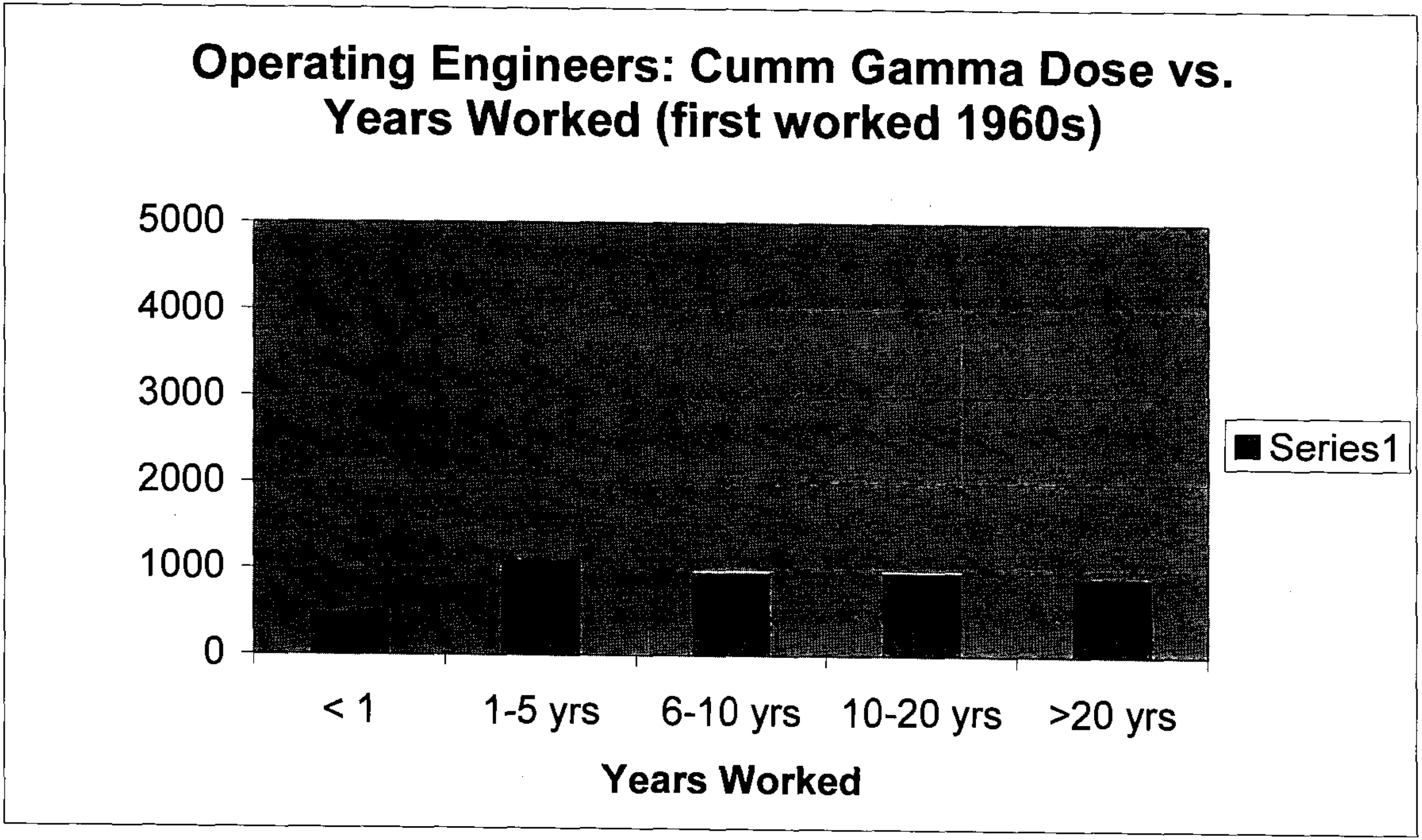

Non-Union: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
6000
5000
4000
3000
2000
1000
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

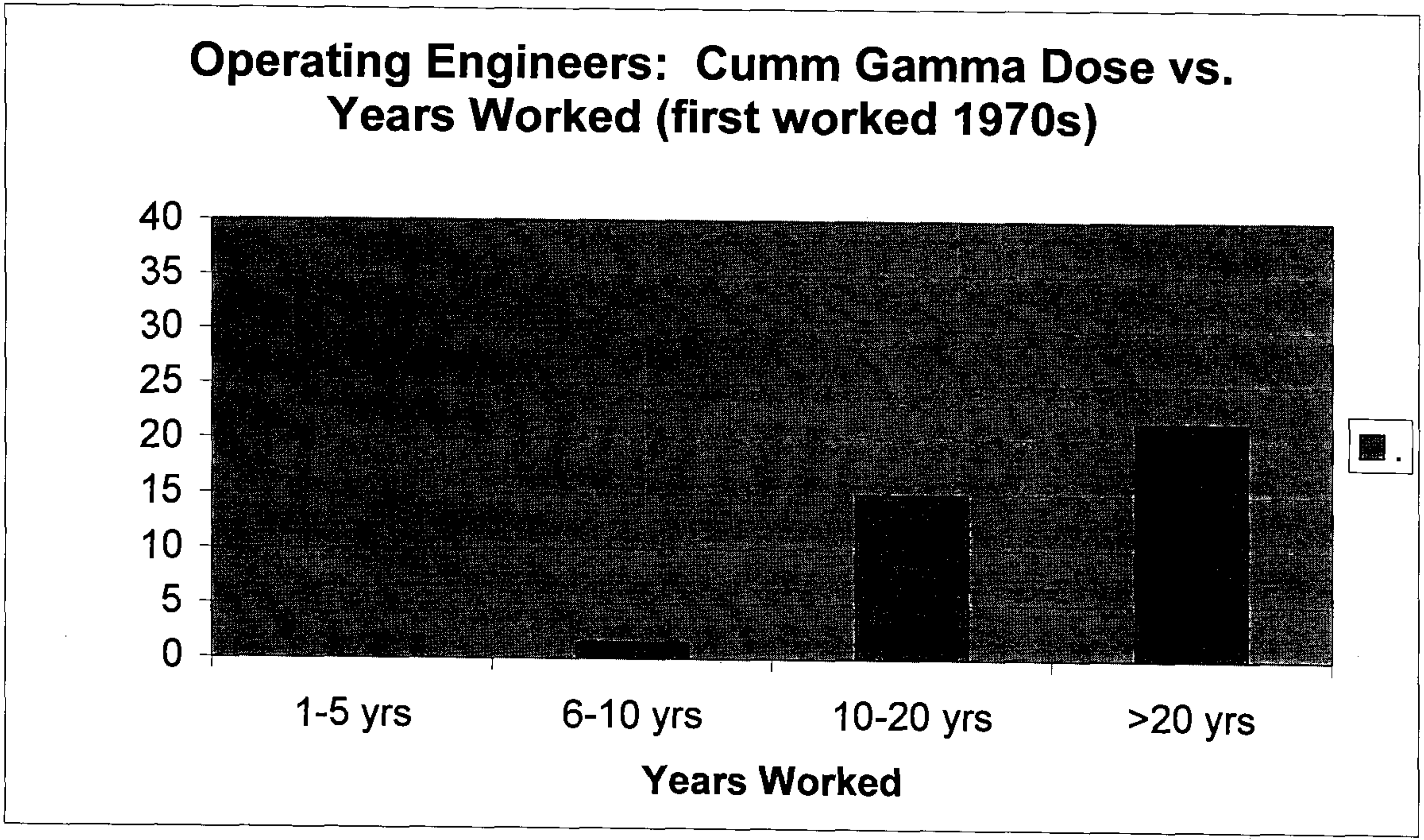


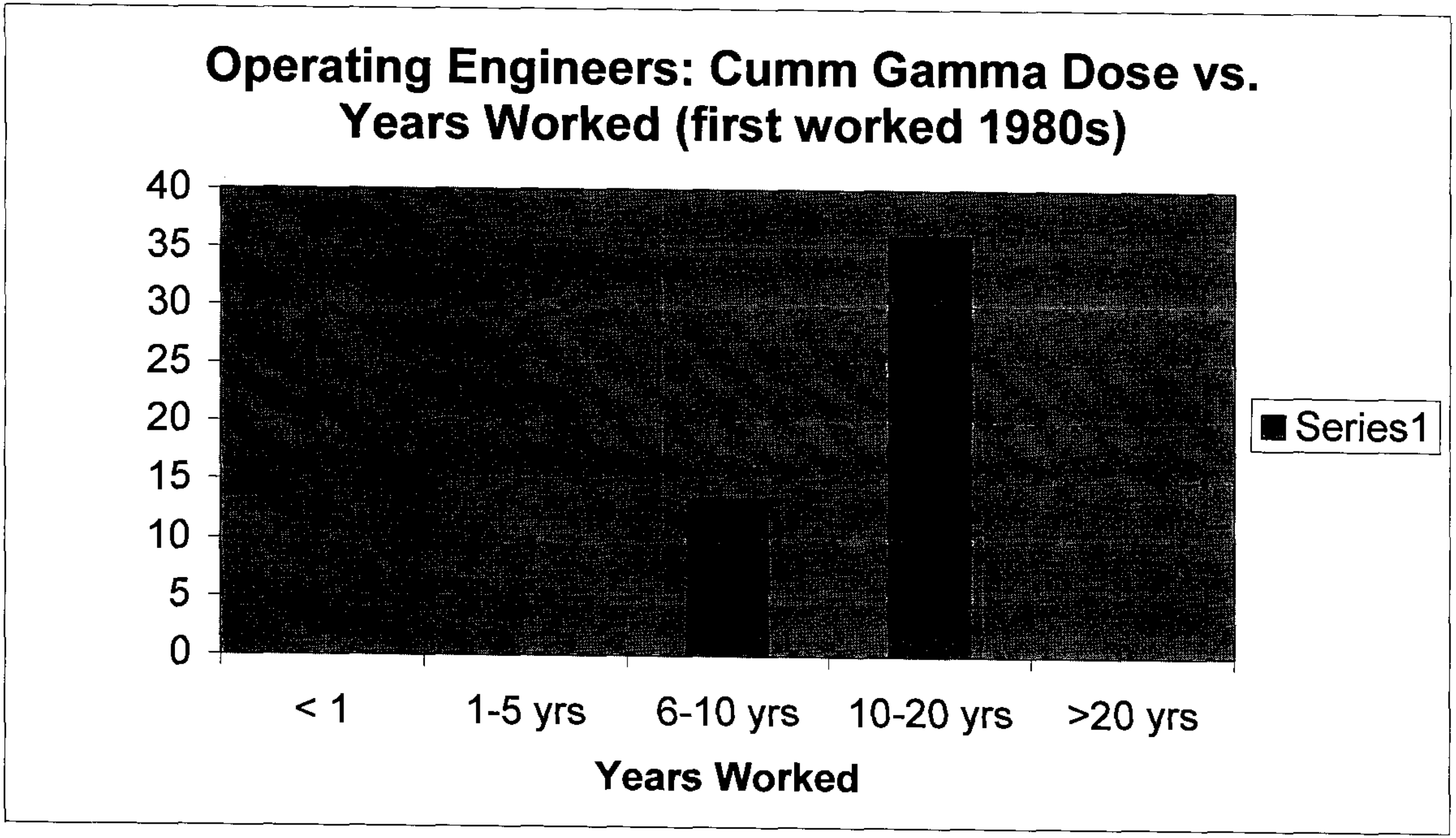
Non-Union: Cumm Gamma Dose vs. Years Worked (first worked 1970s)
200
180
160
140
120
100
80
60
40
20
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

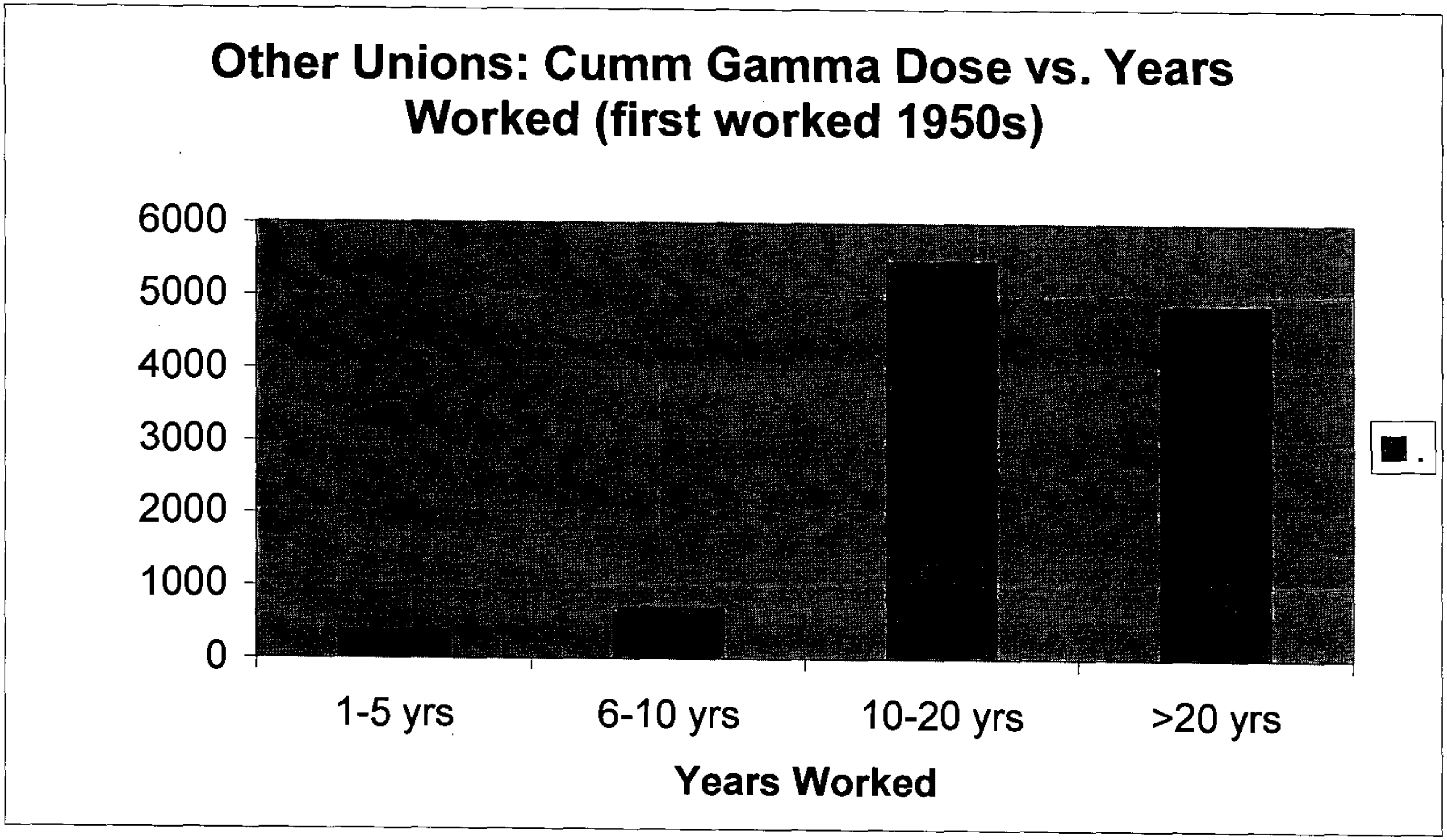

Non-Union: Cumm Gamma Dose vs. Years Worked (first worked 1980s)
160
140
120
100
80
60
40
20
0
Series1
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

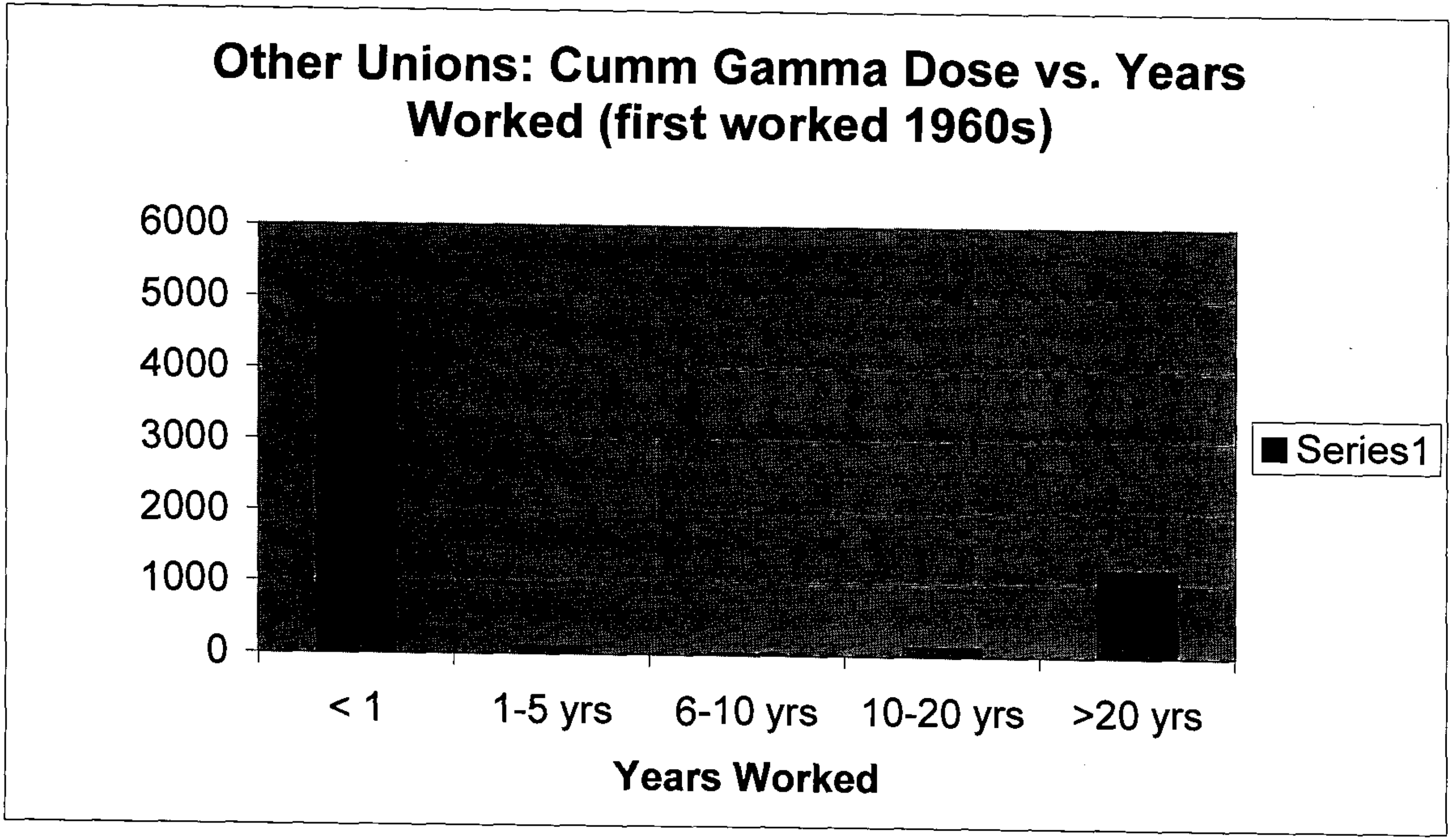

Operating Engineers: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked


Operating Engineers: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
5000
4000
3000
2000
1000
0
Series1
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

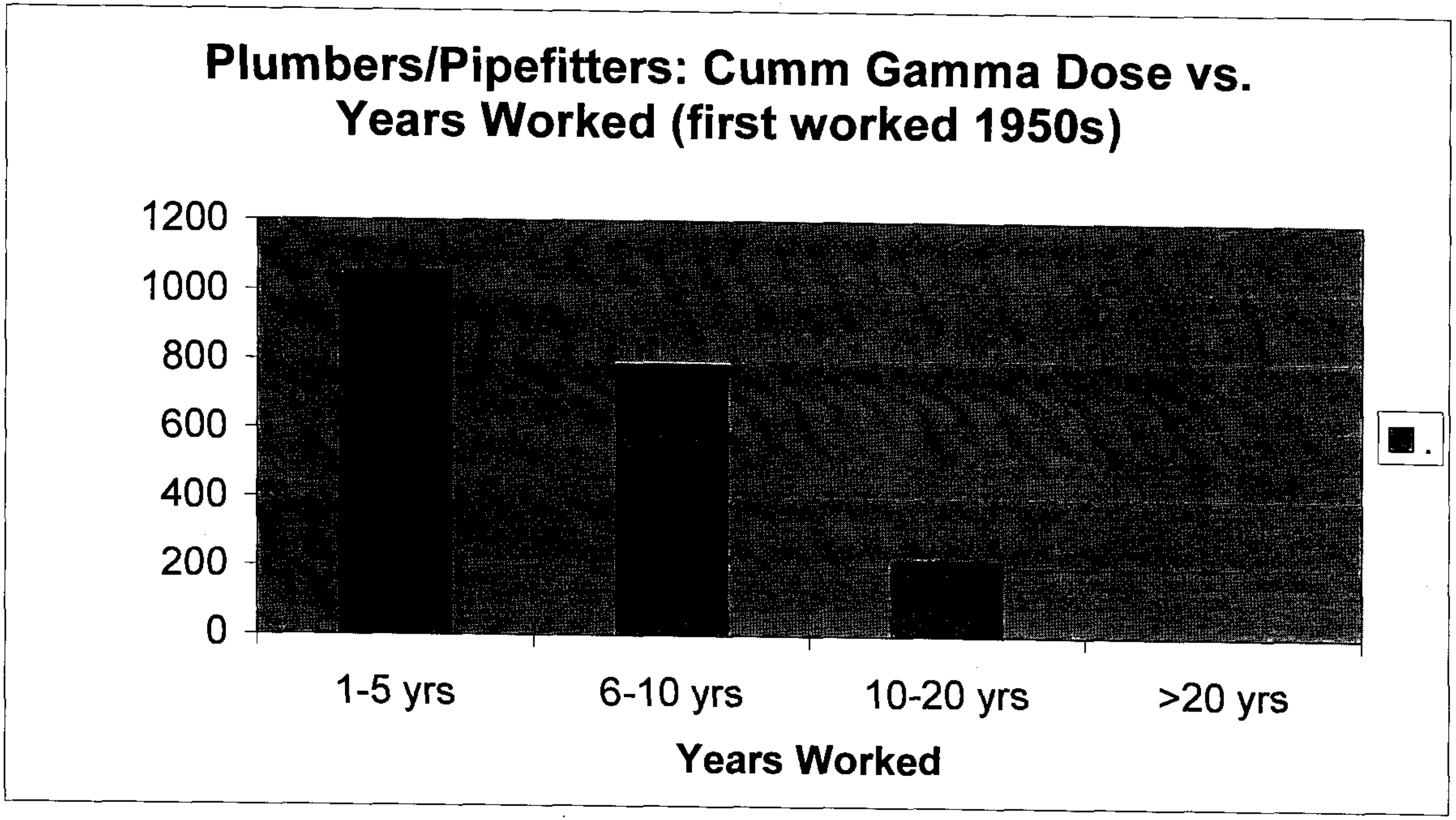

Operating Engineers: Cumm Gamma Dose vs. Years Worked (first worked 1970s)
40
35
30
25
20
15
10
5
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked


Operating Engineers: Cumm Gamma Dose vs. Years Worked (first worked 1980s)
40
35
30
25
20
15
10
5
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

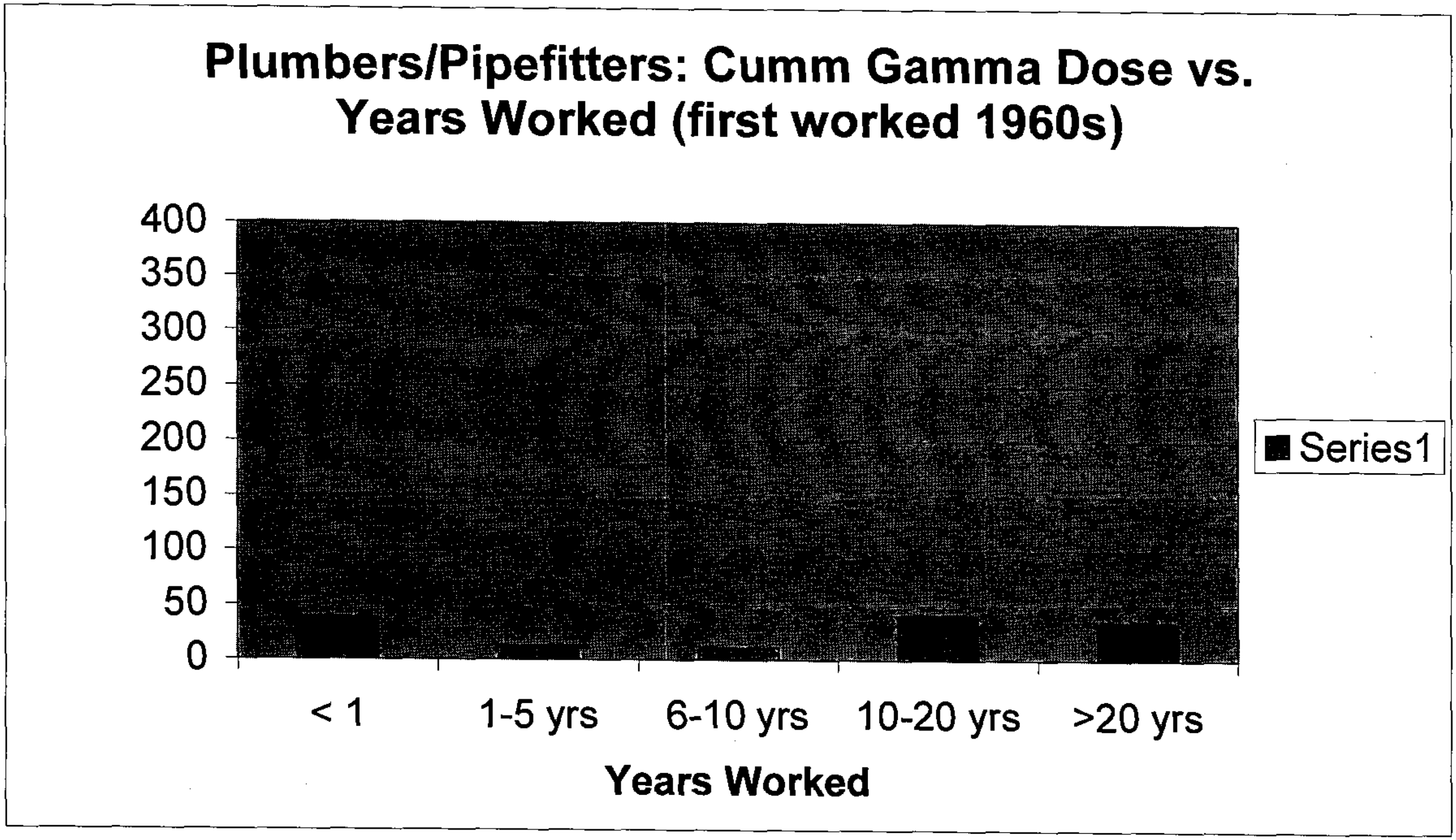

Other Unions: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
6000
5000
4000
3000
2000
1000
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

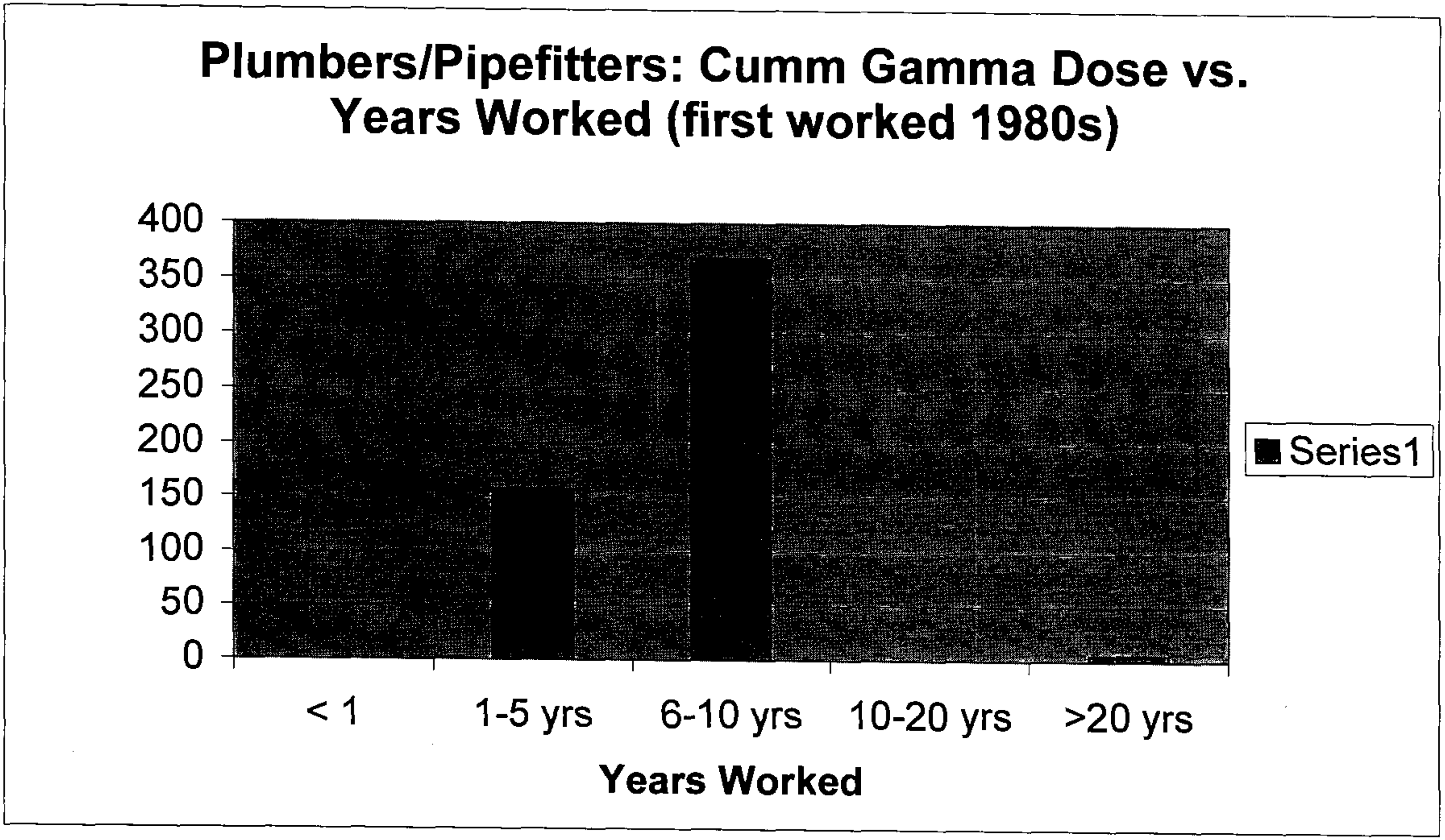


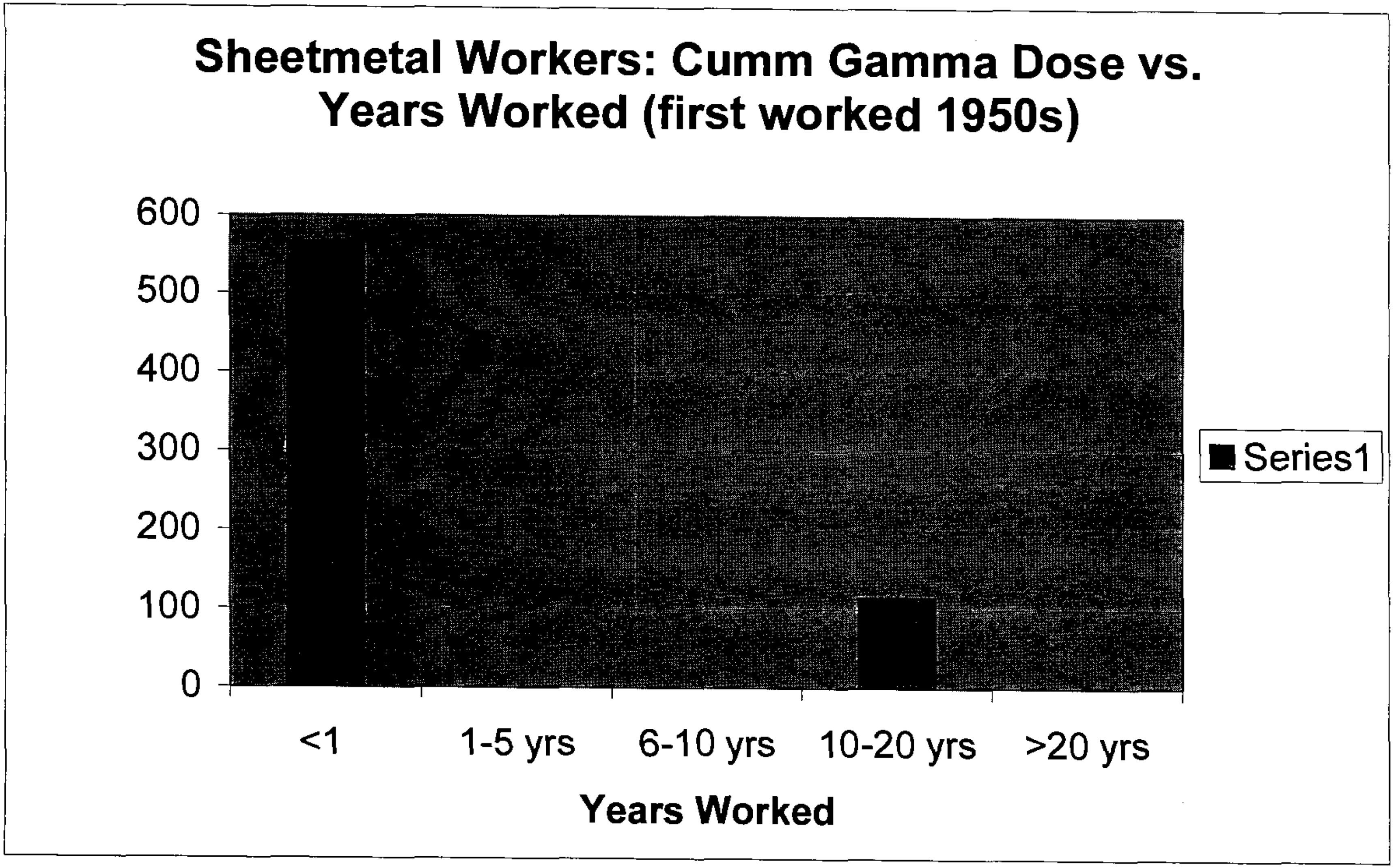
Other Unions: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
6000
5000
4000
3000
2000
1000
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1



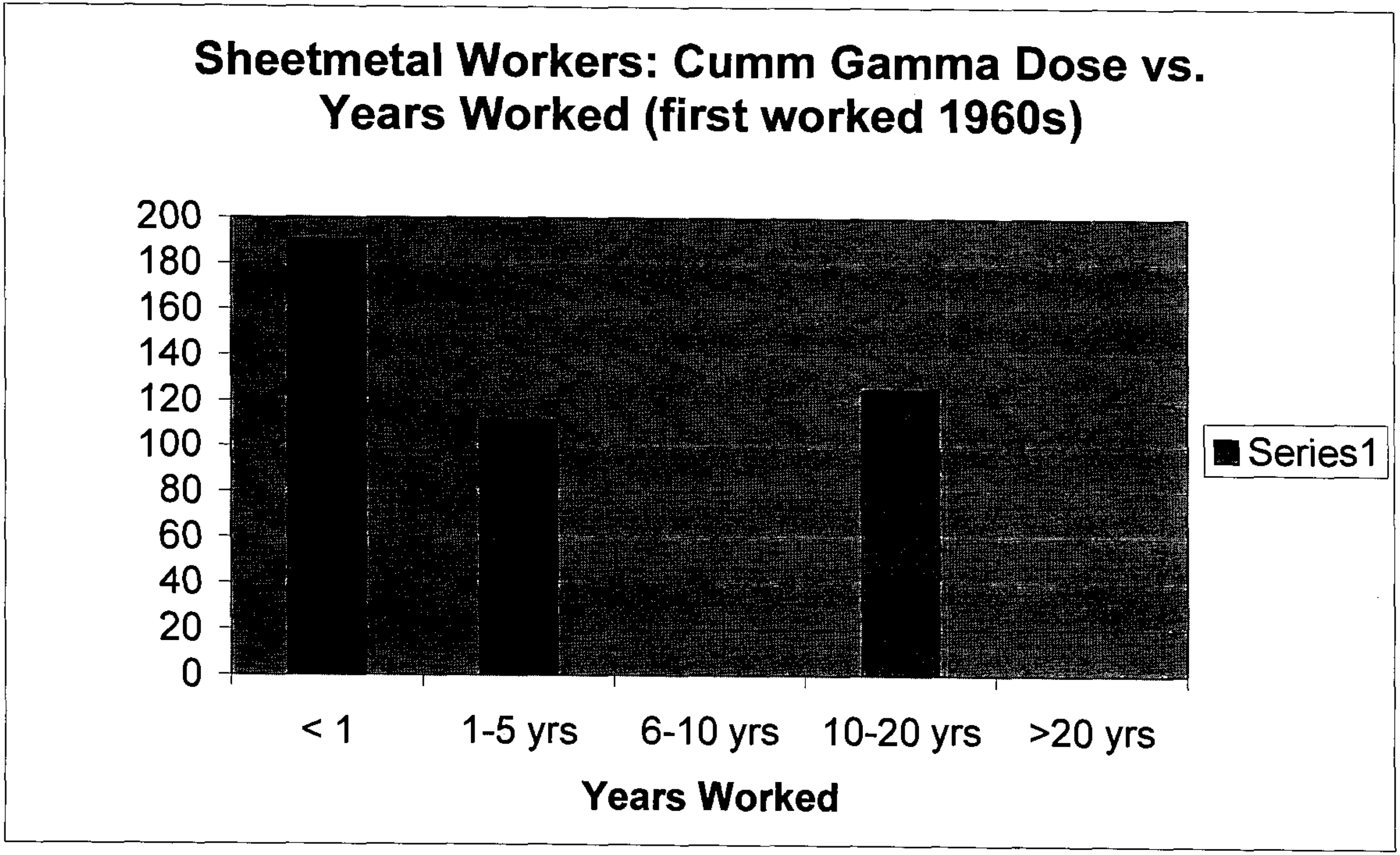
Plumbers/Pipefitters: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
1200
1000
800
600
400
200
0
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked

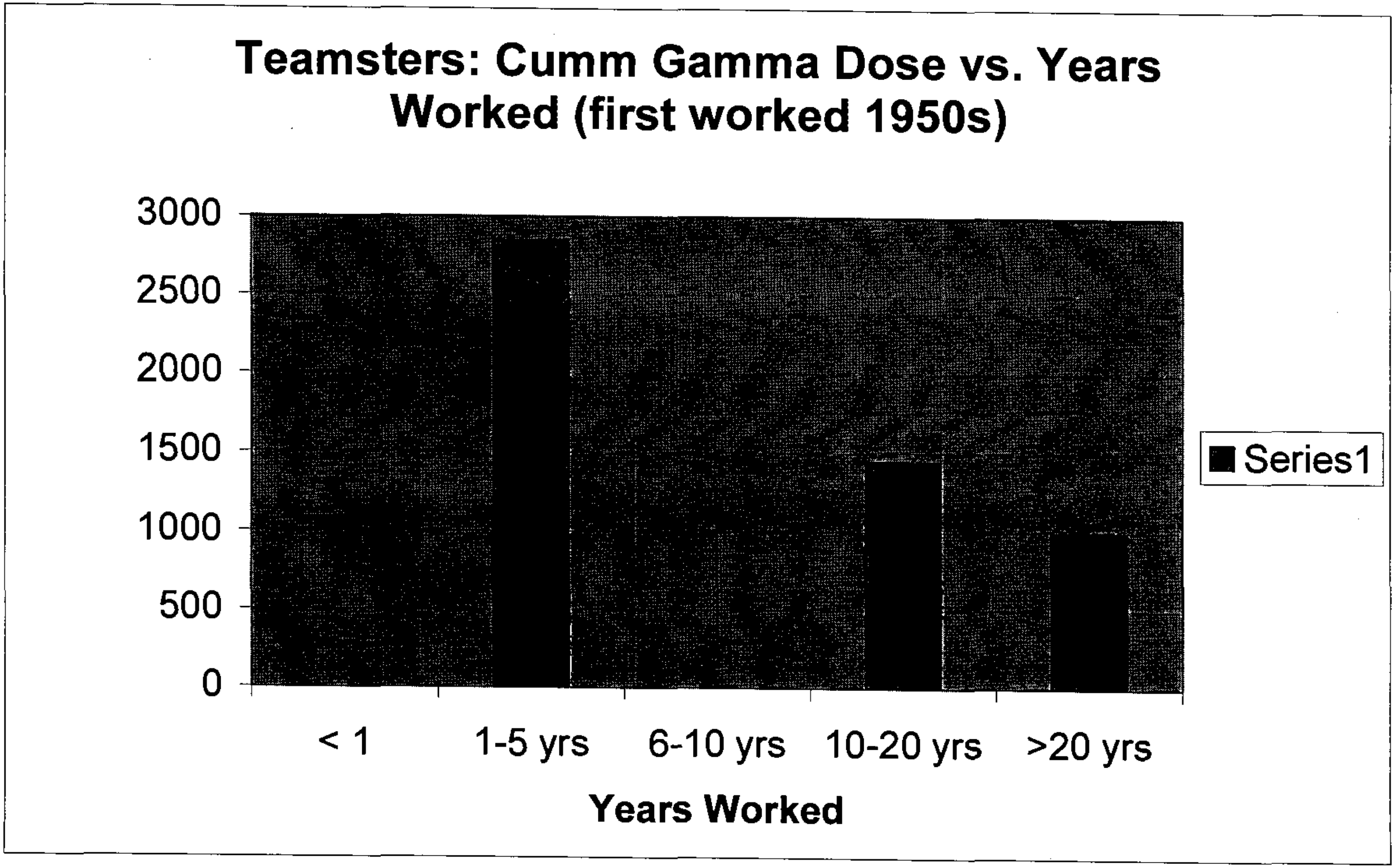

Plumbers/Pipefitters: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
400
350
300
250
200
150
100
50
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

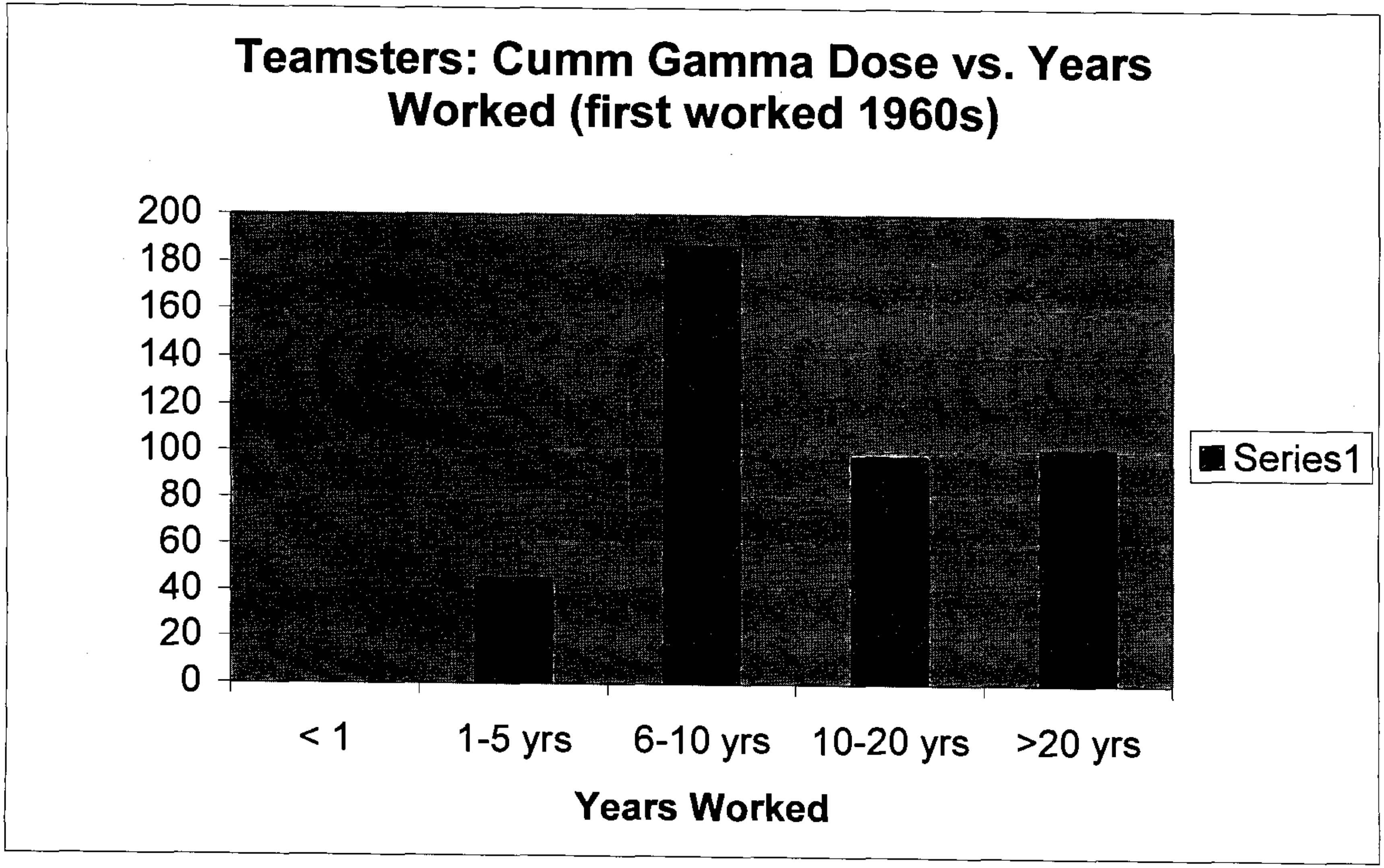

Plumbers/Pipefitters: Cumm Gamma Dose vs. Years Worked (first worked 1980s)
400
350
300
250
200
150
100
50
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1



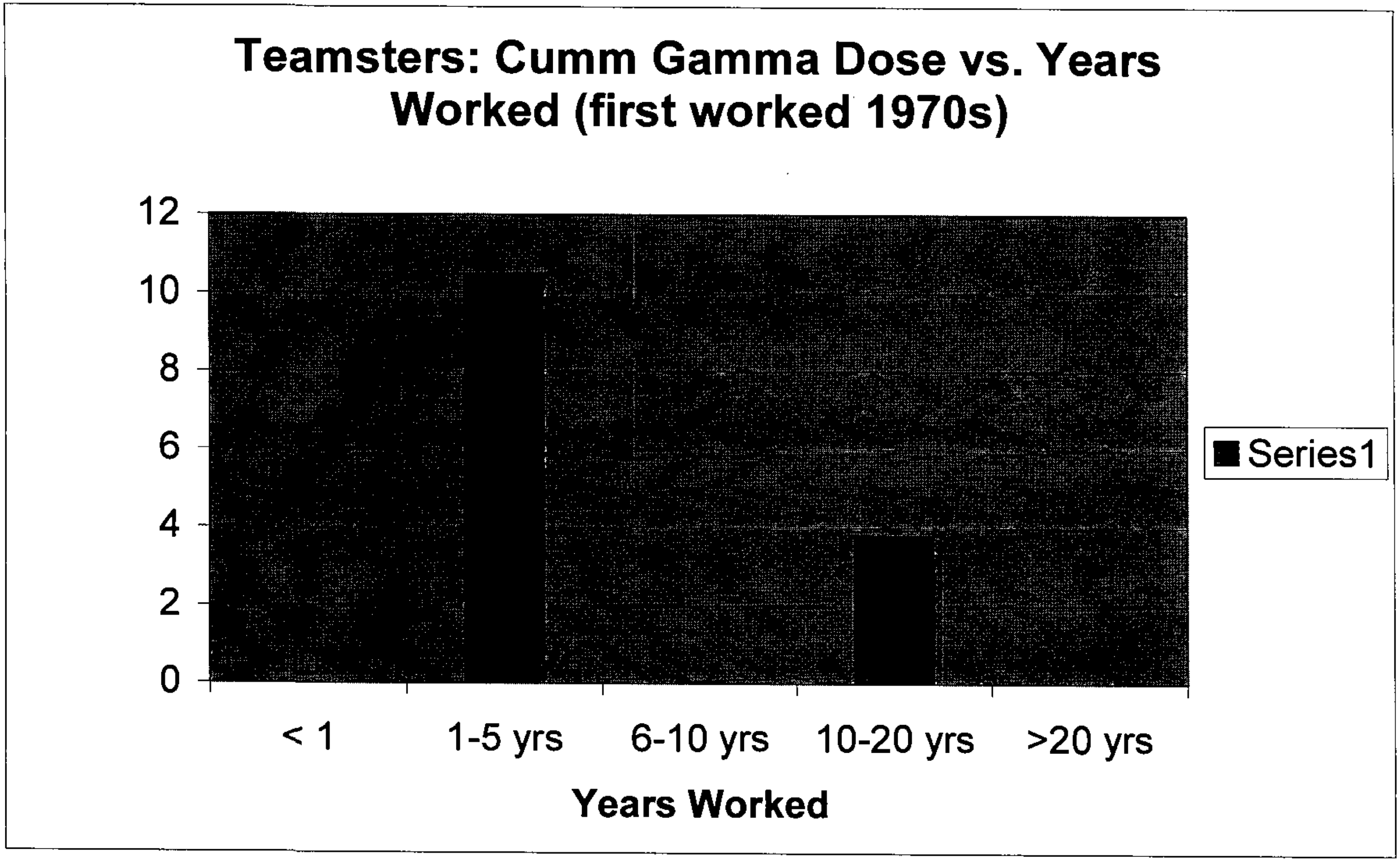
Sheetmetal Workers: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
600
500
400
300
200
100
0
<1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1


Sheetmetal Workers: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
200
180
160
140
120
100
80
60
40
20
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

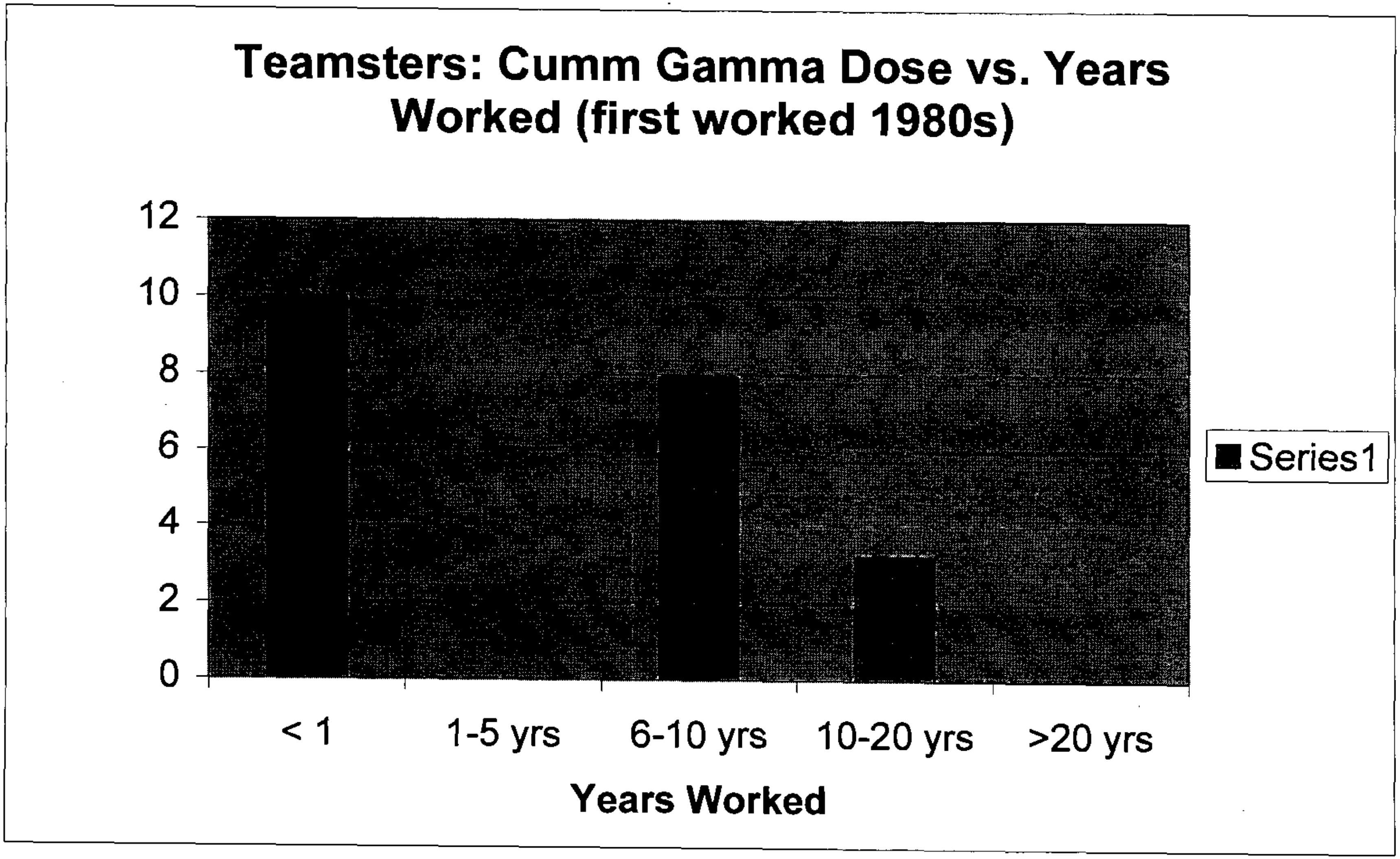

Teamsters: Cumm Gamma Dose vs. Years Worked (first worked 1950s)
3000
2500
2000
1500
1000
500
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1



Teamsters: Cumm Gamma Dose vs. Years Worked (first worked 1960s)
200
180
160
140
120
100
80
60
40
20
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1



Teamsters: Cumm Gamma Dose vs. Years Worked (first worked 1970s)
12
10
8
6
4
2
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1


Teamsters: Cumm Gamma Dose vs. Years Worked (first worked 1980s)
12
10
8
6
4
2
0
< 1
1-5 yrs
6-10 yrs
10-20 yrs
>20 yrs
Years Worked
Series1

Decon	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose *(mrem)*	Standard Deviation *(mrem)*	Maximum Dose *(mrem)*	Count with Beta Dose record in Dosimetry Database	Average Beta Dose *(mrem)*	Standard Deviation *(mrem)*	Maximum Dose *(mrem)*
Decon-yes	872	1396	3088	36210	872	165	637	6135
Decon-no	1871	296	1108	12815	1871	33	272	195

Tunnel	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)	Count with Beta Dose record in Dosimetry Database	Average Beta Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)
Yes		789	2294	36210		96	488	6195
No		226	754	7416		10	58	850
Number								
0		203	666	4150		21	152	1415
1		639	2081	36210		58	357	6135
1 to 10		970	2361	12480		154	627	5745
11 to 20		1378	2710	14791		205	573	2936
21 to 30		1635	2968	1240		290	1179	6195
31 to 40		2778	4856	24580		392	1082	4356
>40								
Reentry								
Yes		1309	3113	36210		199	707	6195
No		374	1290	17752		10	58	1020
Present		700	1889	10060		126	598	4460
Number								
0		217	704	5510		8	51	1020
1		928	2547	36210		103	480	6135
1 to 10		1372	2856	12865		220	750	5745
11 to 20		1808	3365	14791		378	776	2935
21 to 30		2409	2559	7081		1055	2266	6195
31 to 40		3230	5367	24580		345	978	4134
>40								

Above Ground Tests	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)	Count with Beta Dose record in Dosimetry Database	Average Beta Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)
Yes		1880	3236	36210		173	703	6195
No		119	726	15985		39	254	4460
Number								
0		505	1074	4850		138	614	4134
1		1513	2418	12865		123	514	4200
1 to 10		2219	3685	24580		116	489	3115
11 to 20		2295	3664	14791		106	249	1025
21 to 30		2427	2048	5890		39	93	325
31 to 40		3536	5832	36210		300	1000	5745
>40								
Number of Test Clean ups								
0		1123	2170	12815		138	612	6135
1		1960	2783	13567		199	845	6195
1 to 10		3231	4469	24580		176	560	3115
11 to 20		2681	3617	14791		224	712	2935
21 to 30		2429	2323	7635		57	118	325
31 to 40		3897	6764	36210		75	347	2090

Shaft	Count with Gamma Dose record in Dosimetry Database	Average Gamma Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)	Count with Beta Dose record in Dosimetry Database	Average Beta Dose (mrem)	Standard Deviation (mrem)	Maximum Dose (mrem)
Shaft-yes		1073	2581	24580		148	629	6195
Shaft-no		352	1486	36210		22	147	2905
Shaft reentry-yes		1590	3442	24580		176	597	3485
Shaft reentry-no		415	1244	12375		47	399	6135
Shaft reentry-present		960	2625	15985		207	748	4460