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DESCRIPTION OF THE PROCESS USED TO CREATE 1992 HANFORD MORTALITY STUDY DATABASE

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SUMMARY

An updated and expanded database for the Hanford Mortality Study has been developed by PNL's Epidemiology and Biometry Department. The purpose of this report is to document this process.

The primary sources of data were the Occupational Health History (OHH) files maintained by the Hanford Environmental Health Foundation (HEHF) and including demographic data and job histories; the Hanford Mortality (HMO) files also maintained by HEHF and including information of deaths of Hanford workers; the Occupational Radiation Exposure (ORE) files maintained by PNL's Health Physics Department and containing data on external dosimetry; and a file of workers with confirmed internal depositions of radionuclides also maintained by PNL's Health Physics Department. This report describes each of these files in detail, and also describes the many edits that were performed to address the consistency and accuracy of data within and between these files.

The study population is defined to include all workers who were initially employed as operations workers 1978 or earlier, and currently includes 44,284 workers. This report describes efforts to determine which workers are appropriately a part of the study population, and to link and consolidate the information for each worker from the various source files. This was often difficult because of discrepancies in data from the various files described above, and because some workers have been known under more than one Social Security number.

The Hanford Mortality Study database currently includes several files, which were prepared from the source files described above after resolution of various errors and discrepancies discovered through numerous checks for consistency of information. The KEY file provides the Social Security number, name, birthdate and sex currently judged most likely to be correct for each Hanford worker considered for inclusion in the database. The KEY file also indicates all other files on which the worker appears, and gives alternative Social Security numbers, names, birthdates and sex that may have been found on various source files. The JOB89 file is an abbreviated form of the Occupational Health History (OHH) file, and provides job titles and codes that

allow the assignment of socioeconomic status. The DOS89 file consolidates information on external dosimetry taken from the several files in the Occupational Radiation Exposure (ORE) system, and external dosimetry for workers who were not on the ORE files but had dosimetry on an earlier file used for mortality analyses. The INT89 file provides information on workers with internal depositions. Finally, the IARC89 files link selected information from JOB89, DOS89, INT89, and the mortality data (HMO) to provide a file that can be used for statistical analysis of the Hanford Mortality data. This report provides a detailed description of the procedures used to prepare these files and also gives their format.

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1.0 INTRODUCTION

1.1 BACKGROUND

In 1979, a master data analysis file was prepared, and is referred to in this document as MST79. Data for this file were extracted from three sources: Occupational Health Histories (OHH), Hanford Radiation Occupational Exposure (HRO) files, and files containing mortality data. The OHH and mortality data files are maintained by the Hanford Environmental Health Foundation (HEHF); the OHH file as it existed in 1979 will be referred to as OHH79. The HRO files were maintained by Pacific Northwest Laboratory (PNL), and have subsequently been replaced by Occupational Radiation Exposure (ORE) files, described later. Only workers employed as operations workers, and doses received as operations workers were included. Construction workers, and certain other groups such as employees of the Department of Energy (DOE) and its predecessors were not included. Mortality data have been updated several times.

A description of the process used to prepare the MST79 file is attached as Appendix A, and includes a description of each of the variables extracted from OHH79 and HRO. A description of variables giving mortality information is also given, and includes designation of the time the information was received and its source. Analyses published in 1989 (Gilbert et al. 1989a; Gilbert et al. 1989b) were based on data on MST79.

The Department of Energy is developing a public use database known as the Comprehensive Epidemiologic Data Resource (CEDR). The initial Hanford worker data file provided to CEDR was a file containing the most important variables on MST79. This file, which will be referred to as CEDR78, includes dosimetry data through 1978, and contains the data needed to reproduce analyses presented in Gilbert et al. (1989a).

In 1988, plans were initiated to conduct international combined analyses. These analyses are being conducted at the International Agency for Research on Cancer (IARC). Contributing investigators are responsible for planning and interpreting analyses. A protocol for these analyses has been completed (Cardis and Kaldor 1989) and specifies a list of variables to be

supplied for each included study population. This list is included as Appendix B. Some of the required variables were not included on MST79.

In 1988, we began the process of developing a more complete and up-to-date Hanford worker database. New research interests, participation in the international combined analyses, and CEDR, have generated a need for data on variables that had not been included on MST79. Also, there was a need to update the file to include more recent data on dosimetry, occupational histories, and mortality.

1.2 FILES PROVIDING SOURCE DATA FOR THE PNL HANFORD MORTALITY STUDY DATABASE

In 1988, an updated version of OHH79 was received from HEHF, and several files providing dosimetry data were received from PNL's Health Physics Department. These files, which are described below, contained similar but more up-to-date data than those used previously. Also, some corrections and changes had been made to older data. A detailed description of the these files is found in Appendix C.

OHH88: Two files of Occupational Health Histories were received from HEHF in 1988, one containing construction workers and the other containing operations workers. Both files included workers initially employed in the years 1979-1983 (who were not included on OHH79). Only the file of operations workers was used in creating the Hanford Mortality Study database.

OHH_OP: This designation is used to denote the subset of OHH88 consisting of operations workers with initial hire date prior to 1979.

HEHF_AKA: This is a file, maintained by HEHF, that includes alternative Social Security numbers and names under which workers have been known. AKA stands for "also known as."

HMO91: This is a file providing mortality information for both operations and construction workers, and was based on data received from HEHF in 1991. The file includes information on both date and cause of death.

ORE files: ORE stands for Occupational Radiation Exposure. These are files of annual external radiation exposure received from PNL's Health Physics Department in 1990, and include information from 1944 through 1989. The file includes doses for construction workers, who are not a part of the study population, but each annual record had a code that allows one to determine if the dose was received in operations or construction work. Some operations workers also performed construction work and these construction doses are included in the files.

INDEP: This is a file containing information on workers with confirmed internal depositions of plutonium and other radionuclides, and includes information from 1944 through 1989. It was provided by PNL's Health Physics Department in 1991.

MST79: This is the master data file created in 1979, referred to above, and described in detail in Appendix A. The file was created from the Occupational Health History file received from HEHF in 1979 (OHH79) and a file of external dosimetry (HRO) received from PNL's Health Physics Department in 1979. It is noted that in creating MST79, some workers were found only on OHH79, and thus have no dosimetry data on MST79, while other workers were found only on HRO, and thus have no OHH79 data on MST79. MST79 includes dosimetry data from 1944-1978, and mortality data from 1944-1981. Mortality data for deaths occurring in the State of Washington in the years 1982-1985 is also included.

CEDR78: This file, which is noted above, contains the required data to reproduce analyses presented in Gilbert et al. (1989a), and was created by extracting the most important variables from MST79.

1.3 FILES CREATED FOR THE PNL HANFORD MORTALITY STUDY DATABASE

A brief description of the files that are being created is given below. A complete description of the variables on each file is given in Appendix D.

KEY file: This file contains information on all workers found either on OHH_OP or on MST79. The file gives Social Security numbers, name, date of birth, sex and a sequential identification number. It also includes information regarding alternative names, Social Security numbers, and birth dates that may have been used for a worker with the source of both correct and alternative information indicated. The KEY file indicates all other files on which the worker appears.

JOB89: This is an edited and abbreviated form of OHH_OP, which can be used to generate job category and social class data.

DOS89: This file includes detailed information on dosimetry for each calendar year 1944-1989. The dosimetry data was obtained from the ORE files and from MST79. DOS89 includes a designation indicating whether each annual dose was received as an operations worker or in other work such as construction.

INT89: This file gives data on those workers with confirmed depositions of plutonium and other radionuclides.

IARC89: This file includes all variables specified in the IARC protocol. The population included on this file consists of workers initially employed as operation workers prior to 1979 and for whom there was no reason to suspect inadequate mortality ascertainment. The population differs slightly from the study population included on MST79 and CEDR78 as

described in Chapter 2. The differences occur because additional edits that were performed among the various files revealed some workers who appeared more than once on MST79 (under different Social Security numbers), some workers who should not have been a part of the original study population, and some workers for whom mortality ascertainment may not have been adequate because of incorrect Social Security numbers. In addition, the updated occupational histories (OHH_OP) identified some additional workers initially employed prior to 1979 who had not been included on MST79. The file includes dosimetry data from 1944-1989, and, unlike MST79 and CEDR78, includes doses received in construction work (although all workers must have been employed at some time in operations work). The file includes mortality data from 1944-1986, and, in addition, deaths occurring in the state of Washington 1987-1989.

ADD89: This file identifies workers who were not included on IARC89 because of questions regarding adequacy of mortality ascertainment (see Chapter 2), but who were part of the cohort of subjects initially employed as Hanford operations workers prior to 1979.

The subsequent chapters of this report provide a detailed description of the steps in building the PNL database. Chapter 2 describes several edits that were conducted to define the study population, and to resolve problems involving workers known under more than one Social Security number. Chapters 3, 4, and 5 describe the respective processes of creating the condensed occupational history file (JOB89), the external dosimetry file (DOS89), and the internal deposition file (INT89). Chapter 6 describes the process used to update the mortality data.

In several places in the document, groups of workers that were identified in various edits are described. This document indicates only the number of workers in such groups. An unpublished supplementary document provides the identification numbers for these workers.

2.0 DEFINITION OF THE STUDY POPULATION

The study population is defined to include all workers who were initially employed as operations workers 1978 or earlier, and this group will be referred to as "the study population", or sometimes as "the complete study population." Whether a worker is a part of the study population is determined through examination of data on the MST79 (which was derived from OHH79 and dosimetry files), OHH_OP, and ORE files. Problems in defining the study population arise because of discrepancies in data on these files, and because some workers have been known under more than one Social Security number.

Initial efforts were directed at resolving discrepancies among the various files, and included efforts to identify, link, and consolidate workers who were known under more than one Social Security number. These efforts are summarized in Section 2.1, and described in detail in Sections 2.2, 2.3, and 2.4. The objective of these efforts was to identify, based on currently available records, those workers initially employed as operations workers 1978 or earlier. All workers were assigned an identification number (ID), with known duplicates under a single ID number.

This process identified some workers who were judged to be members of the study population, but for whom there is some question regarding ascertainment of mortality data, usually because of multiple Social Security numbers, or because workers were not found on the latest occupational history files, which serve as the basis for mortality follow-up. These workers are placed on a separate file called ADD89. Until it can be assured that mortality ascertainment for these workers is adequate, they will not be included in mortality analyses. The population of workers employed as operations workers prior to 1979, but excluding workers on ADD89, will be referred to as "the current study population." The IARC89 file includes data only on members of the current study population.

2.1 OVERVIEW

In order to be considered a part of the complete study population, workers were first required to satisfy at least one of the following criteria.

1. Data on OHH_OP (This meant that according to HEHF records in 1988, the worker had been employed in operations work prior to 1979.) A total of 44,407 workers qualified by meeting this criterion.

2. OHH79 data on MST79 (This meant that according to HEHF records in 1979 the worker had been employed in operations work prior to 1979.) An additional 104 workers, who had not qualified under criterion 1, met criterion 2. It is noted that there were 3 workers with OHH79 data on MST79 where data on more recent OHH88 files indicated that initial employment was after 1978; these 3 workers were not considered to be eligible for the study population.

3. Current records (other than OHH_OP) at HEHF indicating the worker was a part of the operations worker cohort. To ascertain this, staff at HEHF searched for records of workers who were on MST79, but not on OHH_OP. Many of these workers had only dosimetry data, and had not previously had data on the OHH79 file. These searches were primarily conducted in 1989.

   An additional 36 workers, who had not qualified under criteria 1 or 2, qualified under criterion 3. Thus, a total of 44,547 workers met at least one of the three criteria.

Because it is known that the OHH files sometimes erroneously included workers who reported for initial physical examinations, but never actually started work, it was also required that <u>in addition</u> workers meet <u>at least one</u> of the three criteria listed below. The first two criteria involve use of dosimetry records from both ORE and MST79. The use of MST79 was necessary, because the ORE system no longer includes the records of over 10,000 early workers, for whom external dosimetry data were available in 1979 when MST79 was created.[1]

A. Workers had to have at least one year of onsite operations dosimetry on the ORE file prior to 1979. 26,375 workers qualified by meeting this criterion. Dosimetry data for these workers were taken from ORE.

B. Workers had to have dosimetry data on MST79. An additional 10,305 workers, who did not meet criterion A, qualified under criterion B. For these workers, dosimetry data were taken from MST79. In some cases, workers had dosimetry on MST79, had a Social Security number match with ORE but no onsite operations dosimetry on ORE (offsite or construction

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[1]These records belonged to employees who left Hanford with DuPont when General Electric replaced DuPont as the major contractor. Because DuPont had taken exposure records of these persons with them, a decision was made that these dose records were the responsibility if DuPont rather than the Hanford Radiological Records program.

dosimetry only); these workers were not considered as qualifying under criterion A or B.

C. Workers without dosimetry (as established under criteria A and B) had to have current records at HEHF, either by being included on OHH_OP or by having other records indicating they were a part of the operations cohort. To establish this, HEHF staff searched for records of workers who were included on MST79, but without data on OHH_OP. In addition, workers without dosimetry were required to have more than just a hire date on OHH_OP (or on MST79 if they were not on OHH_OP). Workers with only hire dates could have reported to HEHF for physical examinations (and thus were entered in the OHH file), but may not have initiated employment. These workers should not have been retained on the OHH files, but errors may have been made. An additional 7,604 workers qualified under criterion C, who did not qualify under criteria A or B. These workers do not have dosimetry data.

It may be useful to indicate the numbers of workers excluded for various reasons. Of the 44,547 workers who were eligible for the complete study population (under criteria 1-3), 7,867 workers did not have dosimetry data as defined under criteria A and B. Of these 7,867 workers, 80 workers were excluded from the study population because they had no current records at HEHF (64 of the 80 workers had only hire dates on MST79), and 183 workers who had current records at HEHF were excluded because they had only hire dates. Thus, the total number of workers in the complete study population is 44,284.

Certain workers qualifying for the study population according to the above criteria were temporarily excluded from the current study population to be included on IARC89. This was done because of uncertainty regarding the adequacy of mortality ascertainment either because there was some question about the correctness of the Social Security number on OHH_OP, or because workers were not found on OHH_OP. HEHF's OHH files have been used as the basis for mortality follow-up. These excluded workers were placed on a special file called ADD89.

Specifically, the ADD89 includes four groups of workers as follows:

1. 27 workers for whom the Social Security number found on OHH_OP is thought to be incorrect. This group included 17 workers who were known under more than one Social Security number, and are referred to as "duplicates." These workers are described in detail in Section 2.3.

2. 40 workers identified as having potential Social Security number errors in probability linkages of OHH_OP and ORE files. These workers are described in detail in Section 2.4.

3. 59 workers who were not included on OHH_OP. Of these 59 workers, 50 had other records at HEHF, while 9 did not, but were found on MST79 with both OHH79 and dosimetry data.

4. 2 workers with no data on birth date.

Table 2.1 summarizes the status of workers who appeared either on MST79 or on OHH_OP. Categories not considered to be a part of the complete study population are indicated with an asterisk. Table 2.2 shows the same information for workers determined to be a part of the current study population (on IARC89) and for workers placed on the addendum (ADD89).

TABLE 2.1. Total number of workers by status on MST79 and according to HEHF records

Status at HEHF	Status on MST79			
	OHH79 data	Dosimetry data only	Not on MST79	Total
On OHH_OP	43,986	314	107	44,407
Not on OHH_OP but other records found	15	36		51
No records at HEHF	89	25[a]		114
On OHH88 file, but hire date after 1978[b]	3[a]	2[a]		5[a]
Total	44,093	377	107	44,577

(a) Not eligible for complete study population.
(b) These workers are included in this table only because they appeared on MST79.

TABLE 2.2. Total number of workers on IARC89 and on ADD89 (in parentheses) by status on MST79 and according to HEHF records

Status at HEHF	Status on MST79			
	OHH79 data	Dosimetry data only	Not on MST79	Total
On OHH_OP	43,739 (66)	313 (1)	104 (2)	44,156 (69)
Not on OHH_OP but other records found	0 (14)	0 (36)		0 (50)
No records at HEHF	0 (9)	0 (0)		0 (9)
On OHH88 file, but hire date after 1978	0 (0)	0 (0)		0 (0)
Total	43,739 (89)	313 (37)	104 (2)	44,156 (128)

Table 2.3 shows the status of worker records on MST79, and also additional workers found on OHH_OP but not on MST79. The column labelled "Duplicates" describes the records of forty (40) workers with multiple Social Security numbers. These duplicates produced 72 records on MST79, and an additional 9 records on OHH_OP (with Social Security numbers that did not match those on MST79.) See Section 2.3 for additional detail on these duplicates. Note that, because of the duplicates, the total of 44,502 records on MST79 results from 44,470 workers, while the overall total of 44,623 records results from 44,582 workers.

TABLE 2.3. Number of entries on MST79 and number of entries from OHH_OP that were not on MST79

	Duplicates	Remainder	Total
Both OHH79 data and dosimetry data	28	35,864	35,892
OHH data only	19	8,190	8,209
Dosimetry data only	25	376	401
Total entries on MST79	72	44,430	44,502
Entries from OHH_OP, not on MST79	9	112	121
Total	81	44,542	44,623

Table 2.4 shows the status of various workers with respect to IARC89 and ADD89. The 40 duplicates are again shown separately. The designation "with dosimetry link" indicates that the worker either had operations dosimetry on the ORE file prior to 1979, or that the worker had dosimetry data on MST79. It is noted that of the 128 workers on ADD89, nearly half (60) were hired 1975 or later. Only nine workers on ADD89 had cumulative doses exceeding 10 mSv, and none had cumulative doses exceeding 50 mSv.

TABLE 2.4. Number of workers on IARC89 and ADD89

	IARC89	ADD89	Total
Duplicates - With dosimetry link	21	14	35
Remainder - With dosimetry link	36,552	93	36,645
Total - With dosimetry link	36,573	107	36,680
Duplicates - Without dosimetry link	2	3	5
Remainder - Without dosimetry link	7,581	18	7,599
Total - Without dosimetry link	7,583	21	7,604
TOTAL	44,156	128	44,284

Workers in the study population were later linked with dosimetry for the years 1979-1985. In addition, some workers in the study population had also been monitored while performing construction work either prior to or after their period of operations employment. These doses were also added to the file, and thus increased the number of workers with dosimetry data. To summarize, of the 44,156 workers on the IARC89 file, 7183 had no onsite dosimetry data, 35,309 had only operations dosimetry, 1,564 had both operations and construction dosimetry, and 100 had construction dosimetry only. Of the total of 36,973 with dosimetry data (operations, construction, or both), 36,603 had dosimetry data prior to 1979.

2.2 COMPARISON OF DATA ON MST79 AND OHH_OP

An important step in identifying the study population was comparing the information on MST79 with information on the more recent OHH files, specifically OHH_OP. The OHH_OP file included both Social Security number and name, and, in addition, could be linked to the HEHF_AKA file for other Social Security numbers and names under which workers had been known. MST79 was made from occupational health histories (OHH79) and dosimetry data received in 1979, and included only a single Social Security number, and no names.

Table 2.5 shows the results of linking the files based on exact matches of the single Social Security numbers on OHH_OP and MST79. Some workers (401) on MST79 had dosimetry data, but no data from the earlier OHH79 file. Some entries in Table 2.5 were later found to represent duplicates (i.e. different Social Security numbers for the same worker).

Workers in groups A, C1, C2, and C3 in Table 2.5 were checked against the HEHF_AKA file, and were also checked by clerical staff at HEHF. This process and other edits resulted in determining that some workers in C were the same as workers in A (but under different Social Security numbers), and in determining some workers who had been on MST79 twice under different Social Security numbers, usually one number with only dosimetry data and one number with only OHH79 data. Details are given Section 2.3.

TABLE 2.5. Results of linking the files OHH_OP and MST79

	OHH_OP	MST79
Total on file	44,296	44,502
A. On OHH_OP, but not on MST79	121	
B. On both OHH_OP and MST79		44,296
1. Dosimetry data only on MST79 (no OHH79 data)		318
2. OHH79 data on MST79		43,978
C. On MST79, but not on OHH_OP		206
1. Dosimetry data only		83
2. Both OHH79 and dosimetry data		29
3. OHH79 data only		94

For some workers in group C, records of workers were found at HEHF even though these workers had not appeared on OHH_OP. It is also noted that of the 123 workers with previous OHH79 data in group C, 71 had only hire dates.

For those workers who linked (B in Table 2.5), edits for agreement of birth year, sex, and hire year between OHH_OP and MST79 were performed. In addition, the age at hire was checked to determine if it fell within the range of 15-70 years on one or both files. In cases failing to pass these edits, discrepancies were resolved at HEHF. The correct information, in addition to the incorrect (with flag) is carried on the KEY file. (See list of variables on KEY file in Appendix D).

These edits identified 64 cases where sex did not match, 94 cases where birth year did not match, one instance where both mismatched, 17 instances where hire year did not match, and 8 instances where the age at hire was not in the range 15-70. The information on the more recent OHH_OP was usually judged correct, although there were exceptions.

2.3 DUPLICATES AND INCORRECT SOCIAL SECURITY NUMBERS

Examination of workers in groups A, C1, C2, and C3 in Table 2.5 and other work performed in building the worker database, led to the identification of forty workers with multiple Social Security numbers, and nine workers with incorrect Social Security numbers. Whether or not a given Social Security number was correct was determined by staff at HEHF and/or

PNL's Health Physics Department, who examined available source records. Although the words "correct" and "wrong" are used in discussing the status of Social Security numbers, in fact, these are judgments based on available data. Both the HEHF_AKA file (file of alternative Social Security numbers maintained by HEHF) and forms provided to us by the Health Physics Department indicating modification of Social Security numbers were used in this process. This process identified 50 workers as indicated in Table 2.6.

TABLE 2.6. Status of workers with more than one Social Security number or with incorrect Social Security number on MST79 and OHH_OP

Group	Number of workers	Description
A.	6	Correct Social Security number on MST79, but wrong Social Security number on OHH_OP.
B.	4	Wrong Social Security number on MST79, but correct Social Security number on OHH_OP.
C.	7	On MST79 under two Social Security numbers, both with old OHH79 data.
D.	6	Wrong Social Security number for the MST79 entry that included OHH79 data, but correct number for the MST79 entry with dosimetry data only. Two workers had the correct Social Security number on OHH_OP; four workers did not (that is, the Social Security number on OHH_OP agreed with the incorrect Social Security number on MST79).
E.	16	Wrong Social Security number for the MST79 entry with dosimetry only, but correct number for the MST79 entry that included OHH79 data.
F.	1	Two Social Security numbers on MST79, both with dosimetry only. One of the numbers linked with the OHH_OP.
G.	10	Social Security number incorrect on both MST79 and OHH_OP (same number).

The 27 workers in groups A, B, D, F, and G were placed on the ADD89 file, and will not be included as a part of the study population until it can be assured that mortality ascertainment is adequate. The 23 workers in groups C and E were included on IARC89; these workers had correct Social Security

numbers on both MST79 and on OHH_OP, the files that have served as the basis for mortality ascertainment.

2.4 PROBABILITY LINKAGES OF OHH_OP AND ORE DOSIMETRY FILES

Files created from the OHH_OP files and from the ORE files were sent to Advanced Linkage Technologies of America (ALTA). The purpose of this linkage was to resolve instances in which workers may have been known under different Social Security numbers on the two files. It is known that in some cases HEHF or PNL's Health Physics Department have modified Social Security numbers. Changes at HEHF should lead to an entry on the HEHF_AKA file, but some changes could have been missed. PNL has provided us with change records only recently.

The information obtained from these linkages has been used only to identify certain workers who may have incorrect Social Security numbers (and thus inadequate mortality ascertainment). These are excluded from IARC89, but appear on ADD89. They will not be included in analyses until resources permit further investigation of these linkages.

The extract sent to ALTA from the OHH_OP file included Social Security number, name, date of birth, sex, and alternative Social Security numbers, names, etc. that had been used for the worker. The extract from the ORE file included similar data for workers with at least one year of dosimetry designated as operations or as "X". (The "X" designation was used for workers employed by more than one contractor in the designated year, including workers employed in both operations and construction work). This allowed the identification of possible linkages between the two files in cases where the Social Security numbers disagreed. Available data on Social Security number, name, sex, and birth date were used to assign a probability linkage weight for all matches, including those where Social Security numbers matched exactly. Linkages assigned weights of 9 or more are considered to be "high likelihood linkages", while those assigned weights between 4-8 are considered to be "low likelihood linkages."

The ALTA linkages did not consider dates of employment from OHH_OP and dates of dosimetry from ORE. This information can be used to provide

additional information on which to judge whether a particular linkage is correct. Because it is known that some Social Security numbers in the ORE system had been modified after MST79 was created, it is also useful to compare doses on MST79 with doses from ORE in evaluating whether or not a linkage is correct.

We first evaluated low likelihood linkages (weights 4-8) that involved exact Social Security matches. Linkages that were based on exact Social Security number matches would have been linked previously, but might have been incorrectly linked. With one possible exception, these were judged to be correct. High likelihood linkages with weights 9+ involving exact Social Security number matches were accepted without further examination; these would have been identified in our own linkages.

We then evaluated all linkages with weights of 4 or higher that did not involve exact Social Security number matches. These are potential candidates for new linkages. Results are shown in Table 2.7.

In order to fully use this information, it is necessary to conduct detailed checks of information with HEHF and PNL's Health Physics Department to determine which Social Security number is correct, and in some cases, which dosimetry is correct. Because we did not wish to delay progress on these files, this task has been postponed. For the time being, the only way these results are used is to assign a flag equal to the group number given above, and to exclude all workers in groups 2, 4, and 6 from the current study population on IARC89. These workers are included on ADD89 (see Section 2.1). Note that for workers in these groups, Social Security numbers from OHH_OP and ORE disagreed, and thus there is a possibility that the OHH_OP number is wrong, and we cannot be certain that mortality data was sought under the correct Social Security number. Workers on ADD89 will not be included in analyses planned for the near future.

Workers in Group 1 are duplicates which have been dealt with separately in Section 2.2. Workers in Groups 3 and 5 did not seem likely to be correct matches, and thus the original data is likely to be correct. These workers were retained on IARC89, with the dosimetry from MST79.

TABLE 2.7. Status of probability linkages that did not involve exact Social Security number matches

High likelihood linkages (weights of 9+).

Group and number of workers		Description
1H.	2	Already identified as duplicates or incorrect Social Security numbers (Section 2.3)
2H.	4	New linkages judged to be correct based on a comparison of OHH_OP and ORE dates. No dosimetry data on MST79.
3H.	1	New linkage judged not to be correct based on a comparison of OHH_OP and ORE dates. No dosimetry on MST79 or on ORE under OHH_OP Social Security number.
4H.	3	New linkage judged not to be correct based on a comparison of OHH_OP and ORE dates. Workers had dosimetry on MST79 (which did not agree with the new linkages), but did not have an exact match between OHH_OP and ORE.
5H.	1	Same as Group 4H except that this worker also had an exact match between OHH_OP and ORE.
6H.	7	New linkage judged correct based on a comparison of OHH_OP and ORE dates. Workers also had dosimetry on MST79, which agreed with the new linkages.

Low likelihood linkages (weights of 4-8).

Group and number of workers		Description
1L.	2	Already identified as duplicates or incorrect Social Security numbers (Section 2.3)
2L.	1	New linkage judged to be correct based on a comparison of OHH_OP and ORE dates. No dosimetry data on MST79.
3L.	3	New linkages judged not to be correct based on a comparison of OHH_OP and ORE dates. No dosimetry on MST79 but one of the workers had dosimetry on ORE under the OHH_OP Social Security number.
4L.	1	New linkage judged not to be correct based on a comparison of OHH_OP and ORE dates. Worker had dosimetry on MST79 (which did not agree with the new linkages), but did not have an exact match between OHH_OP and ORE.
5L.	9	Same as Group 4L except that these workers also had an exact match between OHH_OP and ORE.
6L.	10	New linkages judged correct based on a comparison of OHH_OP and ORE dates. Workers also had dosimetry on MST79, which agreed with the new linkages.

In addition, the OHH_OPP file was linked with workers on the ORE file who had no dosimetry designated as operations or "X" prior to 1979. This yielded 14 linkages which appeared to be correct, but where the Social Security numbers differed. These workers were also excluded from IARC89, but included on ADD89.

3.0 PREPARATION OF A CONDENSED OHH_OP FILE AND THE ASSIGNMENT OF SOCIAL CLASS

OHH_OP is an extremely large file containing a sequence of entries for each worker, presumably an entry for each time that certain changes in job category and organizational code occurred. In practice, many of these changes are not of interest to us so that the file can be condensed without losing useful information. In addition, we were aware of many problems in the manner that job category codes were assigned. To some extent, these problems could be reduced through computer editing.

Each entry on OHH_OP includes an alphanumeric description of the job, beginning and ending dates, a three digit Bureau of Census (1971) job code, and possibly a job status code (hire, termination, etc.). Additional information on work locations and organizational codes is also included, but was not used in preparing JOB89. The format for the OHH_OP file is given in Appendix C.

An objective in creating JOB89 was to use the occupational history data to assign job category and/or socioeconomic status on a time specific basis. We were particularly interested in using the job category data to develop a socioeconomic index comparable to the social class index used in some United Kingdom nuclear worker studies, and, thus, had a special concern for correcting errors that would assign workers incorrect socioeconomic indices. We were also interested in identifying workers in certain job categories that are specific to the nuclear industry. Some of these categories do not have Bureau of Census Codes, and thus needed to be assigned special codes.

Section 3.1 describes the process used to edit and condense the OHH_OP file to form JOB89. Section 3.2 describes the summary information on job category and socioeconomic index that was extracted for the IARC89 file.

3.1 DEVELOPMENT OF THE CONDENSED OHH_OP FILE, JOB89

3.1.1 Modifications of Bureau of Census Codes

The first step in creating JOB89 was to modify certain Bureau of Census codes based on the alphanumeric descriptions. These changes, with explanations, are as follows. The Bureau of Census codes are summarized in

Appendix E. The changes below do not correct all inconsistencies between alphanumeric data and Bureau of Census codes, but do correct the inconsistencies that occurred frequently or that were important for use in assigning social class, and for designating special categories of nuclear workers.

Code 085: If the designation RAD MON was used, the code 085 was changed to 691, a new code for radiation monitors. (The code 085 was intended to be used for health technologists and technicians, but at Hanford was used for radiation monitors. The special code 691 was created for these workers, who can be considered as semi-skilled manual workers, not professional technical workers as is implied by the code 085.)

Code 151: If the designations CHEM HELPER, CHEM TRNE, NUC CHEM LDR, or NUC CHEM LDR OPER were used, the coded 151 was changed to 692, a special code for chemical process workers. (The code 151 was intended to be used for chemical technicians, but at Hanford was sometimes used for chemical process workers. The special code 692 was created for these workers, who can be considered as semi-skilled manual workers, not professional technical workers as is implied by the code 151.)

Code 162: If the designation TECH INSTRUMENT was used, the code 162 was changed to 492, the code for mechanics and repairmen. (The code 162 was intended to be used for engineering and science technicians, but at Hanford was sometimes mistakenly used for workers who should have been assigned 492 for mechanics and repairmen.)

Code 226: If the designation CONDUCTOR was used, the code 226 was changed to 550. (These workers were really probably switchmen, and were arbitrarily reassigned a code that would place them as skilled manual workers. There were only five instances of the use of "CONDUCTOR".)

Code 245: If any of the designations MAINT, SHIFT, RAD MON, CREW, PROC, CRAFT, SUPP, OPER, ELEC, MT, JANITOR, SHOPS, SUBSTATION were used, the code 245 was changed to 590, a new code defined for supervisory manual workers. (The code 245 was intended to be used for managers and administrators, but at Hanford was sometimes used for supervisors of those performing manual work. The special code 590 was created for these workers, who can most appropriately be considered as skilled manual workers, not white collar managers as implied by the code 245.)

Code 525: This code was changed to 695, a new code for power operators. (These workers are most appropriately considered as semi-skilled manual workers, rather than skilled manual workers. The new code reflects this.)

Code 545: If either of the designations PILE or REAC occurred, the code 545 was changed to 693, a new code for reactor operators. (Reactor operators were sometimes assigned the non-specific 545 code for stationary engineers. 693 is a special code for reactor operators.)

Codes 690-699: The following steps were conducted in the order listed. Only one code was assigned with priorities as indicated.

1. If any of the designations CHEM, PROC, or SEP occurred, the worker was coded 692.
2. If either of the designations PILE or REAC occurred, the worker was coded 693.
3. If the designation UTIL occurred, the worker was coded 694.
4. If the designation POWER occurred, the worker was coded 695.
5. If none of the above designations occurred, the worker was coded 696.

The resulting new codes are as follows:

691: Radiation monitors
692: Process operators
693: Reactor operators
694: Utility operators
695: Power operators
696: Other operators

(The codes 690, 692, 694, and 695 were all general Bureau of Census codes for operatives. At Hanford, process operators and reactor operators were often assigned these codes. The scheme above provides specific codes for these two major nuclear worker groups. If only the term "UTIL" occurred, it was impossible to determine if a worker was in process or reactor operations.)

3.1.2 Assignment of Social Class

Using the job category codes, as modified above, each code was assigned a more general code as indicated in Table 3.1. The first digit of these codes indicates "Social Class" in a manner that is reasonably comparable the classification system used in the United Kingdom. The second digit keeps track of certain subdivisions within Social Class.

3.1.3 Condensation of the OHH_OP file

The abbreviated file JOB89 combines sequential entries for which the social class codes described in 3.1.2 did not change, and for which the worker did not terminate employment. Sequential entries were also combined if the time interval between the termination code and the next code on the file was less than one month. Each of the entries on JOB89 includes the beginning date for the entry, the ending date for the entry, and the length of time in the social class code indicated for the category (the difference in the two

TABLE 3.1. The assignment of general occupational codes and Social Class from Bureau of Census codes

Code	Description	Bureau of Census codes to be included
10	Social Class 1	001-073 except 032, 056
21	Social Class 2 Technical	032, 056, 074-195
22	Social Class 2 Managerial	201-245, 265
31	Social Class 3 Clerical, non-industrial	301-395, 280
32	Social Class 3 Industrial	401-575, 961, 964-995
33	Supervisors	590
40	Social Class 4	600-689, 694-726, 755, 912-916
41	Radiation Monitor	691
42	Process Operator	692
43	Reactor Operator	693
44	Security	962
50	Social Class 5	740-954 except 912-916

dates.) Using the length of time variable, it is easy to determine the total length of time spent in each social class or job category.

3.2 VARIABLES DEFINED FROM JOB89

The condensed file JOB89 was used to define the summary social class/job category information that was extracted for IARC89. For this purpose, only information through 1985 and before the worker reached age 60 was used. The date 1985 was chosen because the next mortality analyses will include deaths through 1986. The reason for considering only information before workers reached age 60 was that some workers may have changed to physically less demanding jobs as they approached retirement age, or may have returned to work part-time in less demanding jobs after retirement. For workers initiating employment after age 60, the variables below were based on the first job category code.

The following variables were defined for each worker.

LASTSC: the last social class/job category held by the worker.

SCXX: the number of years spent with SC = XX;
XX = 10, 21, 22, 31, 32, 33, 40, 41, 42, 43, 44, 50

LONGSC: the social class/job category held the longest, defined as the social class associated with the largest of SC10, SC21, ..., SC50

In addition, four "general" social classes were defined as follows. General social class 1 consists of the combined categories 10, 21, and 22; general social class 2 consists of 31; general social class 3 consists of the combined categories 32, 33, 40, 41, 42, 43, 44; and general social class 4 consists of 50. Within these general categories, distinctions concerning socioeconomic status were not clear-cut, and it was thus thought desirable to combine them for some purposes. Variables indicating the length of time spent within each general category were defined as follows. IARC89 includes the variables LASTSC, LONGSC, LONGGEN, and TLENG.

LENG1: SC10 + SC21 + SC22
LENG2: SC31
LENG3: SC32 + SC33 + SC40 + SC41 + SC42 + SC43 + SC44
LENG4: SC50
TLENG: LENG1 + LENG2 + LENG3 + LENG4
MAXSC: maximum of LENG1, LENG2, LENG3, LENG4.
LONGGEN: the general social class held the longest.

It should be noted that there are many instances of long gaps in workers' histories without OHH_OP entries. It is not known whether these gaps represent periods for which there was no change in status, or whether certain changes simply were not entered on the OHH_OP file. To the extent that the latter occurred, there will be errors in the variables described above. Because there is not a great deal of movement across general social classes, the variable LONGGEN is less subject to error than variables giving more detail on the occupational history.

4.0 EXTERNAL DOSIMETRY DATA

4.1 INTERNAL EDITS OF THE ORE FILES

The ORE files were obtained from the PNL's Health Physics Department. These files include an entry for each worker for each year of monitoring for external exposure. Each entry includes the recorded dose from photons (PENE), from X-rays (XRAY, recorded separately only in the years 1957-1971), neutrons (NEUTRON), and tritium (TRITIUM). For earlier years, dose from slow neutrons is separated from dose from fast neutrons. Dose from non-penetrating radiation and doses to extremities are also included, but are not considered for the discussion here. The file also includes separate entries indicating dose received offsite, which is described below. The current ORE files are described in detail in Appendix C. Additional information on dosimetry records is given by Gilbert (1990).

Several edits were performed with potential problems resolved by PNL's Health Physics Department staff. Edits were initially based on data through 1982, with later edits conducted on the 1983-1989 data. An initial edit checked for out-of-range dates and exact duplicates. Discrepancies were resolved, and exact duplicates were deleted.

4.1.1 Annual Whole Body Doses Exceeding 50 mSv

For each year, the whole body dose (WB) was calculated as WB = PENE + 35% XRAY + NEUTRON (fast & slow) + TRITIUM. Only dose received onsite was included. There were 44 instances in the period 1944-1982, where WB exceeded 50 mSv. These cases were printed out for examination. For 28 of these cases, the doses were only slightly over 50 mSv (less than 70 mSv), and doses received by the worker in nearby years indicated that the worker was in a job involving higher radiation exposures. In these cases, it did not appear that an error had been made in recording the dose, and further checking was judged unnecessary. In addition, three high doses from an incident in 1962 had been previously verified, so that no further checking was considered necessary.

The remaining 13 cases were checked by the PNL's Health Physics Department. In seven cases the recorded doses were verified. In six cases,

the recorded doses were found to be incorrect and were modified as indicated in Table 4.1. The indicated changes were made both in our files and the source ORE files maintained by PNL's Health Physics Department.

4.1.2 Offsite Doses Exceeding 250 mSv

Offsite doses are occupational doses received at locations other than Hanford. These doses are usually entered as a lump sum in the year that a worker initiates employment, or returns to Hanford after visiting or being employed at another location. It is not known how completely these exposures are ascertained, and doses received after final termination of employment at Hanford cannot be obtained by this system. Past analyses of the Hanford data (Gilbert et al. 1989a) have included these doses as having been received in the year they were recorded. Other options for handling these doses will be considered in future analyses.

There were 24 workers for whom the total offsite dose for the years 1944-1982 was greater than 250 mSv. Because such doses could potentially have strong effects on statistical analyses, these were checked by the PNL's Health Physics Department. For 18 of the 24 workers, the offsite doses were confirmed with results for the remaining 6 workers indicated in Table 4.2. The year listed is the year the information was received and represents cumulative dose received prior to that time. The codes IF, OL, etc. indicate where the dose was received. (See codes in Appendix C.) Some workers had more than one entry representing multiple years and/or locations.

TABLE 4.1. Modifications in recorded annual doses exceeding 50 mSv

Worker	Year	WB (mSv)	Resolution
1.	1963	96.6	Changed to 0.6
2.	1954	105.5	Changed to 10.6
3.	1971	65.0	Changed to 6.5
4.	1962	70.6	Onsite dose deleted (An offsite dose of 70.6 mSv was also given for 1962, and was retained.)
5.	1987	201.2	Changed to 0.0
6.	1987	201.1	Changed to 1.1

TABLE 4.2. Modifications in recorded offsite doses exceeding 250 mSv

Worker	Year Location-Dose (mSv)	Resolution
1.	1964 IF-700.0	700.0 changed to 192.9
2.	1978 OL-77.0 1978 NT-63.5 1979 OL-77.0 1979 NT-63.5	1979 readings removed
3.	1969 BA-134.9 1969 OL-134.9	One reading of 134.9 removed.
4.	1978 OL-280.0 1979 OL-280.0	1978 reading removed
5.	1968 IF-404.6	404.6 changed to 134.6
6.	1979 OL-355.0	355.0 changed to 35.5

A later edit was conducted for the 1983-1989 data. All cases in which the total offsite dose for the years 1983-1989 was greater than 50 mSv were checked. Ten cases were identified. All were checked and were correct. However, in one case, the recorded offsite dose was the total for 1966 through 1983 (instead of 1983-1989), and an earlier offsite dose needed to be deleted.

4.2 COMPARISON OF DOSES TAKEN FROM ORE WITH THOSE ON MST79

Analyses of Hanford mortality data (Gilbert et al. 1989a) have been based on the dosimetry on MST79, which was obtained from the HRO file, a predecessor of the current ORE file. Between 1979 and 1989, corrections were made to the earlier HRO data, and we were thus interested in whether these differences would be likely to affect the results of dose-response analyses. The edits in this section address this issue.

For workers dying of cancer, annual doses based on ORE, and annual doses based on MST79 were compared. Discrepancies of more than 1 mSv in any single year, or discrepancies of more than 10 mSv in the total dose through 1978 were examined.

Only 12 such discrepancies were found, and most were trivial. Only one instance of a substantive change was found, where the dose for 1969 (mostly offsite) was changed from 301.3 mSv to 135.3 mSv. This worker died in 1977 with ICD code 154 (cancer of the rectum).

4.3 ADDITIONAL DOSIMETRY EDITS COMPARING DATA ON ORE WITH THAT ON OHH_OP

Workers on OHH_OP and/or MST79 were linked with ORE files using exact matches on Social Security numbers including consideration of other Social Security numbers under which workers may have been known. In order to qualify as a link, a worker was required to have one or more external dosimetry records before 1979 that was indicated as an operations reading or as an "X" reading (The "X" designation was used for workers employed by more than one contractor in the designated year, including workers employed in both operations and construction work). As discussed in Section 2.1, a group of early workers are no longer included on the ORE files. If a worker had dosimetry on MST79, but failed to link with ORE, dosimetry data were taken from MST79. The status of workers with respect to these linkages has been previously summarized in Section 2.1.

4.3.1 Edits for Dosimetry Outside the Range of Employment Dates

The edits described in this section primarily involve checking the initial and final dates of employment from OHH_OP with dates of monitoring. Although workers may be employed at Hanford without being monitored, dosimetry data outside the range of employment dates may indicate an error.

In preparing the earlier analysis file MST79, there were many instances in which the initial date of dosimetry preceded the initial employment date on the OHH79 file. There were too many such workers to make it feasible to check them all, but a sample of these cases were checked against source records by staff in the PNL's Health Physics Department. These checks indicated that when there was a gap of several years without dosimetry, the date on OHH79 was usually correct and the dosimetry readings outside the range of employment dates were in error. However, when a worker had dosimetry for most years during the interval in question, the dosimetry records were usually correct,

although in some cases the worker might have been employed in construction work during the period in question.

Discrepancies were too numerous for it to be feasible to check all cases individually so it was necessary to develop rules, based on the findings noted above, to handle these cases. Similar rules were developed to handle cases where the date of last dosimetry exceeded the final date on the OHH79, and were also based on checking a sample of cases.

In building our new database, we used the same rules developed previously for handling those cases where the initial date from ORE preceded the initial date on OHH_OP, or when the final date from ORE was later than the final date on OHH_OP. These rules provided the basis for excluding some dosimetry data outside the range of the OHH_OP employment dates. The rules also provided a basis for defining initial and final monitoring dates. Although annual doses incurred in construction work were included in our database as discussed at the end of Section 2.1, these doses were not considered in the edits described below.

The dates referred to below as "initial OHH date", "initial OHH year", "last OHH date" or "last OHH year" are defined as follows. If no OHH_OP data were available, the first and last dates were taken from MST79; these had been previously extracted from the OHH79 file in 1979. In all other cases, the first and last dates were taken from the OHH_OP file, with the last date defined as the latest date on the file prior to 1986. The initial and final dosimetry years were based on ORE data from 1944-1985. For those workers without ORE data, but with dosimetry on MST79, the dates were taken from MST79.

The following procedure was applied when the initial dosimetry date preceded the initial OHH date:

Let NY = Initial OHH year - Initial dosimetry year
Let ND = Number of dosimetry entries with year less than initial OHH year
If ND/NY is greater than or equal to 0.5, the dosimetry data (doses and initial dosimetry year) are not altered)
If ND/NY is less than 0.5, the initial dosimetry year is set equal to the initial OHH year, and earlier doses removed from the file.

An edit was performed to determine if substantial doses might be deleted by this practice. There were no instances in which the excluded dose exceeded 10 mSv.

The following procedure was applied when the final dosimetry year was later than final OHH year:

Let NY = Final dosimetry year - Final OHH year
Let ND = Number of dosimetry entries with year greater than final OHH year
If ND/NY is greater than or equal to 0.5, the dosimetry data (doses and final dosimetry year) are not altered
If ND/NY is less than 0.5, the final dosimetry year is set equal to the final OHH year, and later doses removed from the file.

Again, an edit was performed to determine if substantial dose might be deleted by this practice. There was only one instance in which the excluded dose exceeded 10 mSv. The exception had an OHH_OP termination date of 1945, and dosimetry in 1945, 1954, 1955, 1956, and 1957. This worker was not on ORE, and dosimetry was thus taken from MST79. Doses for this worker were verified by the PNL's Health Physics Department, and the termination date was changed.

A further edit examined instances where the final OHH_OP year or the final dosimetry year was after the date of death. Two cases were found where one of the dates had been incorrect; these were corrected. In an additional 91 cases, the death had occurred in the year preceding the latest dosimetry date, and it appeared that dosimetry data had simply been recorded late. In these cases, the final dosimetry date was changed to the date of death and any dose recorded in this final year added to the year that death occurred.

Using the various available dates, a variable, "last known employment date" (referred to below as LED) was defined as follows.

If the last OHH date prior to 1986 was in 1985 and designated as a termination (T), retirement (R), or inactive (I) date, then LED was set equal to the last OHH date prior to 1986.

If the last OHH date prior to 1986 was in 1985 and <u>not</u> designated as T, R, or I, then the LED was set equal to December 31, 1985.

If the year of the last OHH date was earlier than 1985, and greater than or equal to the year of last <u>operations</u> dosimetry, the LED was set equal to the last OHH date.

If the year of last OHH date was earlier than 1985, and less than the year of last operations dosimetry, the LED was set equal to June 30 of the year of last operations dosimetry. However, if the last date of operations dosimetry was 1986 or later, the LED was set equal to December 31, 1985.

It should be noted that the subtraction of the initial employment date from the LED will not always yield the same value as TLENG, defined in Chapter 3. TLENG excludes periods when workers may have terminated employment and returned at a later date. Also, TLENG is based exclusively on the OHH_OP file, and thus does not include periods when workers were monitored for radiation, but with no indication of employment at Hanford on the OHH_OP files. In particular, there are some workers with only hire dates on the OHH_OP file, and for whom TLENG=0 even though they may have a few years of dosimetry.

4.3.2 Neutron and Offsite Doses for Workers with Dosimetry on MST79 but not on ORE

As indicated above, some workers did not link with ORE, and dosimetry data was taken from MST79. MST79 did not include dosimetry data that were as detailed as that on ORE, and, in particular, did not include the annual neutron doses or the annual offsite doses that are required by the IARC protocol (see Appendix B). MST79 includes annual whole body doses (the sum of contributions from photons and neutrons and of onsite and offsite components), and also includes the total neutron dose (added up over all years of employment), and the first and last years that neutron dose was received. MST79 also includes the total offsite dose, the year and amount of the first offsite dose, and the number of offsite exposure records.

There were 8 workers with positive neutron doses, and without ORE data. Four of these workers had only a single reading, and thus their annual neutron doses could be constructed exactly. The other four had two readings each as follows: 64,65 - 3.6 mSv; 67,70 - 0.8 mSv; 68,69 - 0.4 mSv; 71,72 - 19.3 mSv. For the IARC89 file, the neutron dose was allocated in proportion to the recorded whole body dose. The photon dose (from gamma and x-rays), also required by the IARC protocol, could then be obtained by subtracting the neutron dose from the recorded whole body dose.

There were 13 workers with positive offsite doses, and without ORE data. In only one case was there more than one offsite dose; for this worker the total offsite dose was only 0.2 mSv, and the year was indicated as 1978.

5.0 INTERNAL DEPOSITION DATA

The INDEP file, which contains data on each worker with one or more confirmed internal depositions of plutonium or other radionuclides, was provided by the PNL's Health Physics Department in September of 1991. Review of this file for missing data and for workers with multiple entries resulted in the additions and corrections listed in Table 5.1. These were determined by the PNL's Health Physics Department.

TABLE 5.1. Additions and corrections to the INDEP file

Worker	Change
1.	1971 added as the year of deposition.
2.	Two plutonium entries combined. The year of deposition is 1972. The total amount is 6.0%.
3.	1972 added as the year of deposition.
4.	Duplicate record removed. Also, amount of Americium deposition modified from 5.0% to 5.8%.

The INDEP file was linked with the KEY file using exact Social Security number matches. There were 63 workers on INDEP who did not link with the KEY file. Of these, 47 workers were not operations workers, or the dates given were such that it was possible workers had been initially employed after 1978, and thus not a part of the study population. The remaining 16 workers appeared to be operations workers, and had depositions 1978 or earlier, and thus should have been included on the KEY file. As is described below, it was determined that one of the 47 workers and 9 of the 16 workers had incorrect Social Security numbers on INDEP, and did in fact link with the KEY file under their correct numbers. It is not known why the remaining 7 workers (from the group of 16) were not found on the KEY file. All but one of these workers were found on the source list used in 1979 to provide deposition information; these workers did not link at that time either. None of the workers had depositions exceeding 5% of a maximum permissible body burden.

An additional edit identified workers who had internal deposition data on MST79, but who did not have exact Social Security number matches with INDEP. Twelve (12) workers were found. Of these, 10 had Social Security

numbers and deposition data that were very similar to the workers noted in the previous paragraph, who were on the INDEP file, but did not link with MST79. Checks with staff in PNL's Health Physics Department verified that the Social Security numbers on INDEP for these 10 workers were incorrect. The checks also found that two workers with depositions on MST79 but not on INDEP had been reevaluated, and were no longer considered to have depositions.

6.0 MORTALITY DATA

6.1 OVERVIEW

Mortality data is obtained by HEHF through periodic submissions of terminated workers to the Social Security Administration and, more recently, to the National Death Index. Death certificates are obtained by the Death Certificate Retrieval Office at Oak Ridge Associated Universities. In addition, direct probability linkages are made with computerized death files in the states of Washington and California.

Death certificates are sent to certified nosologists at the National Center for Health Statistics (NCHS), and all medical conditions recorded on the certificate are coded according to the Ninth Revision of the International Classification of Diseases (ICD9, WHO 1977). The death certificates and codes are then returned to HEHF, where the information is computerized and again sent to NCHS. NCHS software is then used to verify the consistency of the codes, and to assign the underlying cause of death. Submissions are made periodically to NCHS, and in one of the submissions made since the latest analyses were conducted (Gilbert et al. 1989a), all Hanford deaths were resubmitted. This allows for consistency in assignment of the underlying cause of death in the event of changes in NCHS's system.

NCHS assigns ICD9 codes (WHO, 1977), which are then translated back to ICD8 codes (WHO, 1965) at PNL. For cancers and for broad categories of other diseases, this translation is straightforward. The translation may not be adequate for detailed non-cancer causes, but we have not been interested in analyzing data at this level. The translation code as it involves cancer is included as Appendix F.

For 15 deaths, the NCHS was not able to assign a code because of problems with the information sent to them. These 15 deaths were resubmitted to NCHS and resolved.

6.2 EDITS INVOLVING HM091 DATA

6.2.1 Linkages of HM091 with Data from Other Files

All workers on HM091 who were designated as operations workers, or as both operations and construction workers, should have been included on the KEY file described in Section 1.3. Linkage with the KEY file was addressed at determining possible differences in Social Security numbers that needed resolution. The results of linking HM091 and the KEY file are shown in Table 6.1.

TABLE 6.1. Number of Operations Workers on HM091 by Status on Other Files

I. Workers with exact Social Security number matches between HM091 and the correct Social Security number on the KEY file	10,917
a. Workers included in the current study population (on IARC89)	10,767
b. Workers on ADD89	18
c. Workers on the KEY file, but excluded from the current study population	132
II. Workers without exact Social Security number matches between HM091 and the correct Social Security number on the KEY file	92
a. Workers found to link with an alternative Social Security number on the KEY file	4
b. Workers found to link with the KEY file but where the Social Security number on HM091 was not on the KEY file	15
c. Workers who do not link, and are not an appropriate part of the study population	73

The 92 workers in group II were checked by staff at HEHF. In most cases, the 73 workers in group IIc were determined to be construction workers. In a few cases, the deaths had been identified through probability linkage, but examination of available records indicated they were probably not appropriate matches. For the 19 workers in IIa and IIb, HEHF staff determined which Social Security number was most likely to be correct, and necessary corrections were made.

6.2.2 Comparison of Mortality Data on HMO91 with Data on MST79

These edits checked for inconsistencies between mortality status on MST79 and that on HMO91. Recall that the mortality data on MST79 included all deaths that had been included in analyses described in Gilbert et al. (1989). Deaths that were on HMO91 but not MST79, or deaths that had causes on HMO91 but not MST79 were simply additions of information, and were not considered as inconsistencies.

We first checked for workers who were dead with causes according to MST79, but were not found on HMO91. One such death was found. The MST79 data on this death was judged to be correct, and this death was included on IARC89.

We next checked for workers who were dead with causes according to MST79, were on HMO91, but who had no cause information on HMO91. Three such deaths were found. The MST79 data on these deaths was judged to be correct, and causes of death were included on IARC89.

We then checked for workers who were dead without causes according to MST79, but were not found on HMO91. For one death, the data on MST79 was judged correct, and the death included on IARC89. For two cases, the data on MST79 was judged incorrect, and the deaths were not included on IARC89.

Finally, we checked for workers who were dead with causes on both MST79 and HMO91, but either the underlying cause of death was different, or the date of death was different.

For 11 deaths, the ICD8 codes for the underlying cause disagreed, and these are listed in Table 6.2. Note that only three deaths involved cancer codes (140-209), and none of these three deaths had doses exceeding 10 mSv. Examination of the death certificates for these workers at HEHF indicated that there was probably an error in the assignment of 199 to worker 1, and in the assignment of 410 to worker 6. These deaths thus appear with their MST79 ICD codes on IARC89. For the remaining deaths, the new ICD codes were used. In most of these cases, HEHF had sent additional information to NCHS (that had been added because of autopsies or other reasons), and this resulted in a new underlying cause of death being assigned.

TABLE 6.2. Workers with different ICD8 codes on MST79 and HM091

Worker	ICD8 on MST79	ICD8 on HM091	Total Dose (mSv)
1.	157	199	0.0
2.	286	572	10.2
3.	189	187	Unmonitored
4.	519	485	Unmonitored
5.	560	531	2.4
6.	150	410	5.3
7.	389	038	16.7
8.	430	442	5.4
9.	515	517	12.8
10.	429	427	16.5
11.	434	436	2.8

For six deaths, the years of death disagreed, and these deaths are listed in Table 6.3. The new dates were used on IARC89.

TABLE 6.3. Workers with different dates of death on MST79 and HM091

Worker	Date on MST79	Date on HM091	Total Dose (mSv)
1.	1973	1972	29.6
2.	1978	1977	Unmonitored
3.	1978	1973	Unmonitored
4.	1980	1981	74.8
5.	1977	1982	Unmonitored
6.	1959	1958	3.8

We also checked for final OHH_OP dates or final dosimetry dates that were after the date of death. Only negligible differences were found; in these cases, the final dosimetry date was changed to be consistent with the death date.

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APPENDIX A

DETAILED DESCRIPTION OF THE DEVELOPMENT OF MST79

APPENDIX A

DETAILED DESCRIPTION OF THE DEVELOPMENT OF MST79

The documentation that follows was prepared in 1979 and 1980, but never formally published. The file that resulted is MST79, which is described in APPENDIX C.

I. Edits and Extractions from the Occupational Health History (OHH) File

The OHH file was provided to PNL early in 1979. This file contains data on 44,095 workers including an identification number, date and place of birth, sex, race and occupational history. The latter consists of a series of entries, each including a date, a code to indicate if the entry is a hire date, termination date, etc., a job title, a job code, and in some instances a job location. We performed a series of edits on this file; with problems checked by the HEHF staff. In some instances this resulted in changes on our file as well as the source OHH file. See Section A below for documentation of the edit procedures.

Our next step was to prepare a file of extracted information eventually to be linked with exposure and mortality data. This extract, which is described in Section B, required the coding and summarizing of occupation, a process which is described in Section C.

SECTION A: Edits

Below is a list of the computer edits performed and the outcome of the edits.

1. The dates of the occupational history for each worker were checked to ensure they were in the proper sequence (earliest through latest). No errors of this type were found.

2. The range of year, day and month of all dates were checked. That is, we checked to see if each year was in the range of 44 through 78 (birthdates were not so restricted), each month from 1-12, and each day from 1-31. No out-of-range years were found. Out-of-range months or days were found for 21 birthdates and 1 hire date. These were checked (at HEHF) and corrected. In three instances the required change

resulted in a change of more than one year in the date of birth (i.e., the year, although not out of range, was also wrong).

An additional three cases were found with no birthdates. Since one of these proved to be a non-start; and the other two had been employed less than 2 years, these workers were removed from our file.

3. We checked to see if each worker was at least 15 years old at the time of hire. That is, we listed those workers for whom the difference in the hire date and the birthdate was less than 15. Fifty-eight (58) such workers were identified and investigated with the following results.

   For 31 workers, the birthdate proved incorrect and was corrected. (For 24 of these workers the birth year was equal to the hire year -- these cases were early in the 1970's.)

   For 7 workers the hire date proved to be incorrect and was corrected.

   For 19 workers, the dates were correct but the worker had been born in the 1800's. (The edit programs assumed that any birth year earlier than '80 had occurred in the 1900's, but these 19 workers had been born in the 1870's and hired at an advanced age in 1944.)

4. We listed workers whose last entry on the OHH occurred before 1972 with no indication that the worker terminated employment. There were 65 such workers. These workers will later be checked against the HRO and those with no dosimetry will be investigated to see if in fact termination has occurred.

5. We looked for workers with a termination code, a subsequent entry but no indication of rehiring. A sampling indicates that there are approximately 700 workers on the file with this problem. We did nothing about this problem but it must be taken as an indication that the occupational history is not always complete.

SECTION B: Extracted File

The following items were included in our OHH extract.

1. ID number
2. Date of birth*
3. Sex (1 = male, 2 = female)
4. Race (1 = white, 2 = nonwhite)
5. Initial employment date*
6. Final date on file*

7. Code for final date (letters refer to codes on the original OHH)

   1 = Hire date (H)
   2 = Termination of employment (T)
   3 = Inactive (I)
   4 = Retirement (R)
   5 = Still employed (No code)
   6 = Died (D)
   7 = Disability Retired (DR)

8. General Occupational Code (See Section C)

   1 = White collar
   2 = Nuclear
   3 = Craftsmen
   4 = Service

9. Specific occupational codes (up to 2) (See Section C)

   1 = Radiation monitor
   2 = Millwright
   3 = Steamfitter
   4 = Power operator
   5 = Reactor operator
   6 = Chemical operator

*Dates are indicated with decimals using the following formula

$$\text{Year} + \frac{\text{Month}-1}{12} + \frac{\text{Days} - 0.5}{365}$$

SECTION C: Occupational Coding

Workers frequently have a large number of entries on the OHH file often including several different occupational codes. We could not reasonably include (or utilize in analysis) the complete occupational history of each worker, but we did wish to include a general indication of occupational type and to signal those workers who had worked in specific occupations of special interest to us. The methods used to determine these codes is described below.

General Codes

These codes were defined as follows with the 3-digit numbers referring to the occupational codes of the Bureau of the Census

1 = white collar = 000-399 (except 085)

2 = nuclear = 085 (radiation monitor) and 690,692 (misc. operators--used for reactor and chemical operators)

3 = craftsmen = 400-599

4 = service workers, etc. = 600-999 (except 690, 692)

These categories were chosen partially because movement across these general categories was limited, i.e., most workers tended to remain in one of these general categories.

Our system of coding was to use the general code of the last (most recent) entry in a worker's history provided this general code agreed with at least half of the general codes of the remaining entries. When this criterion was not met, the worker's history was printed out for hand coding. Of the 44,095 workers on the OHH file, all but 1526 workers met this criterion and could thus be coded by computer.

The remaining 1526 were coded and checked by E. Gilbert according to the following considerations:

In most cases, one general category definitely predominated, both with respect to the number of entries and the number of years spent in the category. Usually the reason the criterion for computer coding was not met was that the last code on the OHH was in disagreement with the remaining codes.

In cases where there was no obvious dominance, the following rules were observed.

1. If one occupation was somewhat borderline with respect to the competing general categories, the worker was coded to the other. For example,

   a) Combinations of clerical (1) and service (4) codes were coded to 4.

   b) Combinations of clerical (1) and craftsmen (3) codes were coded to 3.

   c) Combinations of technical (1) and craftsmen (3) codes were coded to 3.

   d) Combinations of less skilled craftsmen (3) (such as helpers and metal fabricators) and service workers (4) were coded to 4.

e) Technicians were coded 1 (although in some instances their Bureau of Census codes were in the 400's).

2. If a worker had terminated before 1970, priority was given to his most recent occupation.

3. If a worker continued to work into the 1970's his recent experience was given low priority.

Obviously the above codes are fairly crude and must be interpreted and used with caution. Recall however that 96.5% of the workers met the criterion for computer coding. For the vast majority of workers, the general code should give a good indication of general occupational category.

Special Codes

Whenever the following special codes occurred at least twice, they were included as a special code. Up to two special codes could be used. If more than two occurred, priority was in the order listed below.

085 = radiation monitor (coded 1)
690,692 = reactor operator (coded 5)
chemical operator (coded 6)
502 = millwright (coded 2)
522 = steamfitter (coded 3)
525 = power operator (coded 4)

Because both codes 690 and 692 were used for both reactor and chemical operators, the computer searched for certain key letter combinations to distinguish the two. If "PILE" or "REAC" occurred, the worker was coded 5. If "CHEM," "PROC" or "SEP" occurred, the worker was coded 6. If none of these occurred, the worker's history was printed out for hand coding. This list included 224 workers which were coded as described below.

In some instances other occupational titles of the workers or work locations clarified the situation and he was coded accordingly. In other cases, it was clear from the job title that the worker was neither a reactor nor chemical operator (examples "back tender" or "calibrator") in which case he was not given a special code. In the remaining instances, the special code 5 was used. Usually these were workers with the designation "utility operator."

II. Extractions from the Hanford Mortality System (HMO)

The latest HMO file, containing data on 5,441 deaths occurring before May 1, 1977, was provided to PNL in mid-1979. Deaths from the latest Social Security Administration (SSA) search (those occurring from April 1, 1974 to May 1, 1977) were included in HMO only if death certificates were subsequently obtained. PNL edits of this file are described in the section on OHH versus HMO edits.

The information on HMO was used to make PNL's mortality file. Since receiving the HMO referred to above, the following additions and deletions have been made in PNL's mortality file.

1. (9/12/79) Seventy-five (75) deaths identified in the latest SSA search without certificates were added. This list was obtained from Oak Ridge and is labeled "Hanford-No Death Certificates." (List 1) (Eleven workers on this list noted as "alive" were not added.)

2. ( ) Fifteen (15) workers who were previously on HMO as dead without certificates were deleted from PNL's mortality file. These are listed as "SSA-Alive on Mort. File" (List 2).

3. ( ) Twenty-one (21) new certificates were obtained, and the information added to PNL's file. Of the 21, five had been included in the list described in 2 above. These deaths are listed on a memo dated 8/24/79 and entitled "SSA Death Clearance" (List 3).

III. Edits of HMO (Mortality) versus OHH (Occupational)

1. We checked to see if workers on HMO were included on OHH. Three workers were found that were not on OHH and were checked at HEHF. Two had incorrect research numbers and were corrected. One should not have been in the study and was deleted.

2. We listed those workers whose last entry on OHH occurred after the date of death. There were 307 such workers. In all but 13 cases, the discrepancy was less than one year. For the 294 workers with these slight discrepancies, we changed the final OHH date to the date of death. For 13 workers, the final OHH date occurred more than one year after the date of death. These 13 workers were checked at HEHF. In 10 cases the date of death was verified and the final OHH date adjusted. Of the remaining three, two had incorrect dates of death and were corrected. The final worker was still living--after this edit he was found on a list of deletions (see HMO documentation).

3. Dates of birth on HMO and OHH were compared. We found 327 workers with conflicting years of birth. The OHH date is more likely to be accurate. Also there is no opportunity for possible alteration of birthdates for

live workers. There were five workers with the date of birth equal to the date of death on HMO, an obvious error. Of the 327 workers, an additional 91 workers had discrepancies in birthdates of five or more years while 41 workers had discrepancies of 10 or more years. This latter group was checked by HEHF. In seven instances, the date on HMO proved correct. In the remaining cases no evidence could be found to indicate the OHH date was in error. Both dates were retained on our master file.

IV. Edits and Extractions from the Hanford Radiation Occupational (HRO) File

The HRO file used to produce our master file was provided to PNL in September 1979. (PNL edits of an earlier version of HRO, provided early in 1979, identified problems with offsite exposure data. These problems were resolved at Personnel Dosimetry and 1978 data added to produce the current file.) This file contains 277,644 yearly exposure records for 36,546 workers. A payroll number record for each worker is also included. Each exposure record includes the worker's research number, the site code, an indicator for on-site versus off-site exposure, the year of exposure, and the amount (in centirems) of the following types of exposure: beta, gamma, x-ray, neutron, tritium, rings, penetrating, skin, and extremity. We first performed a series of edits on this file (described in Section A), and then prepared a file of extracted information to be linked with occupational and mortality data (Section B).

Section A: Edits

The following edits were performed.

1. We checked for years of exposure that were out of range (44-78) or not in the proper sequence. No such errors were found.

2. We checked to see if the research number for exposure records matched the preceding payroll record research number. All matched.

3. We checked for exact duplicates of records. Three were found and deleted.

4. We checked for multiple onsite records in a single year which were not duplicates. No such multiple records were found.

5. All annual onsite penetrating doses which exceeded 5 rem were printed out. From this printout we identified 3 workers with 1000 rem neutron

exposures erroneously entered in 1977 (keypunch error). After checking with Personnel Dosimetry, these were removed from the file.

6. The offsite exposure records for all workers with multiple entries were printed out. From this printout we identified seven instances in which the same or very similar offsite exposure had been included on the file twice (either in different years for the same site, or for different sites in the same year). These cases were checked out by Personnel Dosimetry, resulting in 22 corrections to our file.

7. We found that in 1974, a limited number of characters had been used for offsite exposure so that exposures over 10 rem were included in two different entries. A subsequent edit by Personnel Dosimetry removed one of the entries as a duplicate. We are still working on resolution of this problem.

Section B: Extracted File

The following items were included in our HRO extract.

1. Research number.

2. Penetrating dose for each year 1944-1978. This dose is the sum of offsite and onsite exposure for the particular year. A -7 is used for years the person did not have exposure data.

3. Number of onsite records.

4. First, second, and last dates with onsite records.

5. Total offsite exposure.

6. Year of first positive offsite exposure.

7. Amount of first positive offsite exposure.

8. Number of offsite exposure records.

9. total neutron exposure.

10. Number of positive neutron exposures.

11. Year of first and last positive neutron exposures.

12. Code to describe payroll numbers. The purpose of these codes is to identify workers who should not be on HRO (an aid in resolving discrepancies between OHH and HRO). See the attached list of companies corresponding to various payroll numbers.

    1 - only codes present are codes containing Y or Z

2 - only codes present are OG, AG, EG, FG, HG, G, IG (and possibly code containing Y or Z) (Those workers with codes 1 and 2 should not be on file)

3 - only codes present are BG, DG (and possibly those listed in 1 and 2)

4 - Vitro code included (CG, CV, V)

5 - Y or Z + valid code

6 - OG, AG, FG, G or IG + valid code

7 - BG or DG + another valid code

In addition, a special file was created for the 3,215 workers with positive neutron exposure. This special file includes all the items above plus neutron exposure for each year 1944-1978.

V. Edits of OHH (Occupational) versus HRO (Dosimetry)

1. All workers on HRO should be on OHH although the reverse need not be true. However, preliminary runs indicated that HRO contained some workers who were employed only by contractors that would not have been included on OHH. In particular those workers with payroll codes 1 and 2 (see HRO documentation) should not have been included in HRO. Preliminary runs also indicated that in some instances workers had different research numbers on HRO and OHH. Apparently the number had been changed on OHH but had not on HRO. This problem was identified by checking numbers against our old master file made in 1975.

   To handle this problem we first listed all workers on HRO who did not have matches on OHH and did not have payroll codes 1 or 2. There were 459 such workers. We also listed 22 workers with a payroll code of 1 and 189 workers with a payroll code of 2. (This group should not have been included on OHH.)

   Of the 459 workers on the above list 317 had dosimetry only in 1978. In these instances the problem was probably that OHH was not sufficiently up-to-date to include these very recent workers. No attempt was made to find matches for these workers. Until further updating, the study will be restricted to workers employed prior to 1978. An additional three workers had only a single offsite exposure.

   Of the 139 remaining workers, 89 were very recent workers initially employed 1974 or later. Fifty workers had been employed much earlier, generally in the forties. As an initial step in checking for research numbers which differed between the two files, we listed all workers on OHH but not HRO. This list should contain all potential mismatches.

We then tried to find possible research number discrepancies by comparing research numbers as well as calendar years of employment and dosimetry. Using this method, matches for 26 of the early workers and 15 of the recent workers were found. These potential matches were then verified at HEHF. The remaining 24 early workers were further checked at HEHF. Final results of the outcome of these investigations is summarized below.

All discrepancies for the 50 early workers were resolved. Of the 50, 35 had different numbers on the two files. In these cases the incorrect number (usually HRO) was corrected. Eight workers should have been on OHH but were not. These workers were added to OHH. Seven workers should not have been on HRO and were removed.

Of the 89 recent workers, 15 matches were found. The dosimetry records for the remaining workers will be retained on our files, but no further effort was made to track down their OHH records. Of the 74 workers in question, 37 had a single dosimetry entry, 25 had two entries, 7 had three entries, 2 had four entries, 2 had five entries, and 1 had six entries.

Summary table for 670 workers
on HRO but not on OHH

211 with invalid payroll codes
317 with dosimetry only in 1978
3 with offsite dosimetry only
7 identified by HEHF as incorrectly included on HRO
538 workers to be excluded from master file

35 early workers with different numbers on HRO and OHH
15 recent workers (initial employment date 1973 or later) with different numbers on HRO and OHH
8 early workers who should have been included on OHH but were not
58 workers requiring corrections but who are now on file with matches

74 recent workers who are unresolved - retained on file without OHH data

2. A) We made a list of workers for whom the initial date of dosimetry (on HRO) preceded the initial employment date (OHH). There were 109 such workers. For 32 workers, the discrepancy exceeded one year.

B) For terminated workers, we made a list of workers for whom the final dosimetry date (on HRO) was later than the final employment date (OHH). There were 1200 such workers. For 354 workers the discrepancy exceeded one year.

Complete resolution of these discrepancies did not seem feasible at this time. All annual dosimetry values as well as OHH dates will be retained on the master file for treatment as desired.

3. We listed workers with final active status and with last entries on both OHH and HRO 1977 or earlier. These 594 workers may need to be checked for possible termination.

APPENDIX B

THE IARC PROTOCOL

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THE IARC PROTOCOL

The material that follows is taken from Cardis and Kaldor (1989), Protocol of combined Analyses of Cancer Mortality Among Nuclear Industry Workers. Internal Report no 89/005, International Agency for Research on Cancer (IARC), Lyon, France.

MINIMUM SET OF VARIABLES FOR INDIVIDUALS IN EACH COHORT

In order for a cohort to be included in the study, investigators must provide the following variables for each individual in the cohort (see Appendix C for details of format).

1. Within-study identification number (this should not be any number, such as social security or health insurance numbers, that could allow identification of the worker outside this study);
2. Sex;
3. Date of birth (year of birth is acceptable);
4. Date of end of study (i.e., date of last complete follow-up of the cohort);
5. Date of last known vital status, defined as follows: if individual has died, give date of death; if individual is known to be lost to follow-up or to have emigrated, give date last known to be alive or date of emigration; otherwise, give the end of study date (year is acceptable);
6. Date of start of employment as a member in the cohort under consideration (year is acceptable);
7. Date of start of study follow-up if later than the date of start of the facility (year is acceptable);
8. Date of last known employment in the cohort under consideration (year is acceptable);
9. Whole body external radiation exposure for each year of employment in the facility:
   - year

- facility (codes, including "other" or unknown, to be provided by participants)

- available estimate (in mSv) of whole body exposure to the following radiation types (please code "NM" if not monitored and "NA" if monitored but not available; if exposure was received in several facilities, give the total of the exposure estimates for the year, from each facility where the worker was employed)

  - X and τ-rays
  - neutrons
  - tritium
  - total

10. Internal exposures (see dosimetry section for details)

Use the following codes for all variables in this section: -1 if the information is not available for any worker in this facility; 0 if not applicable, i.e., the worker was neither monitored nor exposed; 99 if unknown.

- plutonium:
  - year of first confirmed deposition
  - year of first monitoring
- uranium:
  - year of first exposure
  - year of first monitoring
- other radionuclides:
  - year of first exposure
  - year of first monitoring

11. Socioeconomic status (see socioeconomic section for details p. 17);

12. For cohort members who are known to have died, the underlying cause of death, given as ICD code (4 digits, if available), and accompanied by the ICD revision number used for the coding.

ADDITIONAL VARIABLES

Apart from the minimum set of variables given in 1-12 above, there are a number of other variables which are of interest. It is, however, recognized that they will not be available for all members of study cohorts; their availability is therefore not given as criteria for inclusion of a study in the combined analyses.

13. Race (1=caucasian; 2=black; 3=asian; 4=others);

14. Associated causes of death (from death certificate), if cancer, given as ICD code (4 digits if available) and ICD revision number used for coding;

15. Exposure to plutonium:

    - year;
    - estimated current systemic deposition, in μCi, for each year of exposure;

16. For exposures taking place outside the facilities covered by the study, and which were not included in variable 9 above, give, for each year of exposure:

    - year;
    - available estimate of external exposure in mSv.

      If only cumulative exposure estimate is available, give last year of exposure and cumulative dose.

APPENDIX C

DESCRIPTION OF SOURCE FILES

APPENDIX C

DESCRIPTION OF SOURCE FILES

This appendix provides additional detail on files that served as sources of information for the Hanford Mortality Study database, and which are briefly described in Section 1.2. In some cases, these files included variables that we did not use, and for which we do not have adequate information to interpret appropriately. Such variables are either omitted, or, in some cases, are listed without detailed descriptions. Readers interested in more information need to contact personnel at the Hanford Environmental Health Foundation or PNL's Health Physics Department.

OCCUPATIONAL HEALTH HISTORIES (OHH88 and OHH_OP)

The OHH88 file was received from HEHF in 1988 and includes both operations and construction workers. OHH_OP is a subset of this file consisting of operations workers hired prior to 1979. Each worker has one personnel identification record and usually several work history records indicating his/her status at various points in time. These two types of records are described below. The file also included additional variables that were never used in creating the mortality study database.

Personnel identification record:

	Variable	Columns
1)	Record type	1 - 2
	10 = Personnel Identification record	
2)	Social Security number	3 - 11
3)	Payroll number	12 - 18
4)	Last name	19 - 36
5)	First name	37 - 51
6)	Middle initial	52
7)	Birth date	53 - 58
	month (1 - 12) day (1 - 31) year (0 - 99)	
8)	Sex	78
	M = Male, F = Female	
9)	Race	79
	W = White, other than W = Non-white	
10)	Century for birth year	105
	8 = 1800's 9 = 1900's	

Work history record:

	Variable	Columns
1)	Record type	1 - 2
	20 = Work History record	
2)	Social Security number	3 - 11
3)	Job status	12 - 13
	H = Hired I = Inactive T = Terminated D = Dead R = Retired	
4)	Job title	14 - 31
	Alphanumeric description of the job	
5)	Beginning date[1]	38 - 43
	month (1 - 12) day (1 - 31) year (44 - 88)	
6)	Ending date[1]	44 - 49
	month (1 - 12) day (1 - 31) year (44 - 88)	
7)	Bureau of Census job code	59 - 61
	See Appendix E.	

[1] A given work history record will have either a beginning date or an ending date, but not both. These are on the file in sequence.

"ALSO KNOWN AS" FILE (HEHF_AKA)

This file contains alternative Social Security numbers and names under which workers have been known as indicated below. The file is part of a larger file that also contains data on siblings and other relatives of workers.

	Variable	Columns
1)	Record type 15 = Relative/Sibling/Also Known As record	1 - 2
2)	Current Social Security number	3 - 11
3)	Relation A = Also Known As record	12
4)	Alternative Social Security number or name	13 - 25
5)	First name if 4) is last name	26 - 41
6)	Middle initial if 4) is last name	42
7)	Birth date month (1 - 12) day (1 - 31) year (0 - 99, century can be determined from year)	75 - 80

HANFORD MORTALITY FILE (HMO91)

Several files containing mortality data have been received from HEHF at different times, and these serve as the basis for updating mortality data. The file described below was created at PNL by merging a file containing mortality data from HEHF with cause of death codes from the National Center for Health Statistics (NCHS).

	Variable	Columns
1)	Social Security Number	1 - 9
2)	First name	11 - 23
3)	Middle initial	25
4)	Last name	27 - 40
5)	Birth date	42 - 48
	month (1 - 12) century (18 or 19) year (0 - 99)	
6)	State of death code	50 - 51

AL - 01	IL - 17	MT - 30	RI - 44
AK - 02	IN - 18	NE - 31	SC - 45
AZ - 04	IA - 19	NV - 32	SD - 46
Ar - 05	KS - 20	NH - 33	TN - 47
CA - 06	KY - 21	NJ - 34	TX - 48
CO - 08	LA - 22	NM - 35	UT - 49
CT - 09	ME - 23	NY - 36	VT - 50
DE - 10	MD - 24	NC - 37	VA - 51
DC - 11	MA - 25	ND - 38	WA - 53
FL - 12	MI - 26	OH - 39	WV - 54
GA - 13	MN - 27	OK - 40	WI - 55
HI - 15	MS - 28	OR - 41	WY - 56
ID - 16	MO - 29	PA - 42	
Canal Zone - 07		Virgin Islands - 52	
Guam - 14		Foreign country - 99	
Puerto Rico - 43			

7)	Death date month (1 - 12) year (44 - 91)	53 - 57
8)	Sex M = Male, F = Female	59

9)	Type of work code O = Operations, C = Construction, X = Operations & Construction	67
10)	Death certificate status Blank = HEHF has death certificate X = HEHF does not have death certificate	69
11)	ICD9 underlying cause of death	73 - 76
12)	ICD8 underlying cause of death	78 - 81
13)	First ICD9 associated cancer cause of death	87 - 90
14)	First ICD8 associated cancer cause of death	92 - 95
15)	Second ICD9 associated cancer cause of death	97 - 100
16)	Second ICD8 associated cancer cause of death	102 - 105
17)	Third ICD9 associated cancer cause of death	107 - 110
18)	Third ICD8 associated cancer cause of death	112 - 115
19)	Fourth ICD9 associated cancer cause of death	117 - 120
20)	Fourth ICD8 associated cancer cause of death	122 - 125
21)	Fifth ICD9 associated cancer cause of death	127 - 130
22)	Fifth ICD8 associated cancer cause of death	132 - 135

NOTE: A value of -777 for variables 11 or 12 indicates "not available". A value of -777 for variables 13 - 22 indicates "not applicable."

OCCUPATIONAL RADIATION EXPOSURE FILES (ORE)

These files are provided by PNL's Health Physics Department and are the source of information on external radiation exposure. The identifier on these files is the variable Occupational Radiation Exposure Number (OREN), which is a special number used by PNL's Health Physics Department. The first file described below (personnel identification file) provides both the OREN and the Social Security numbers, which allow us to link dosimetry data with data from other sources. The file also provides other demographic data, which can be used to verify similar data from HEHF. Additional records (not described here) provide data on addresses and alternative Social Security numbers and names under which workers may have been known.

Separate files were provided for data for the period 1944-1982 and for the period 1983-1989, and the format and names of variables are slightly different for these two periods. For the period 1944-1982, the whole body dose, used in most dose-response analyses, is calculated as the sum of the penetrating dose, 35% of the x-ray dose, the fast neutron dose, and the slow neutron dose. The shallow dose is calculated as the sum of the whole body dose, 65% of the x-ray dose, and the non-penetrating dose. For the period 1983-1989, the whole body dose is calculated as the sum of the deep dose and the neutron dose. The shallow dose is as given.

The company codes and payroll numbers were used as indicated to determine if the dose was received in operations work. It is noted that the basic determination of whether workers were ever employed in operations work is based on data from HEHF. In future analyses, we plan to include all doses for these workers, even those not received in operations work.

Personnel identification file:

	Variable	Columns
1)	Occupational Radiation Exposure Number (OREN)	4 - 9
2)	First and middle initials	11 - 12
3)	Last name	14 - 31
4)	Social Security number	33 - 41
5)	Birth date	49 - 54
	year (0 - 99, century can be determined from year) month (1 - 12) day (1 - 31)	
6)	Sex	58
	M = Male, F = Female	
7)	Death Date	82 - 87
	year (44 - 89) month (1 - 12) day (1 - 31)	

1944 - 1982 Hanford dosimetry file:

	Variable	Columns
1)	OREN	4 - 9
2)	Company code[1]	11
3)	Payroll number[1]	13 - 17
4)	Beginning wear date for dosimeter	35 - 40
	year (44 - 82) month (1 - 12) day (1 - 31)	
5)	Ending wear date for any dosimeter	42 - 47
	year (44 - 82) month (1 - 12) day (1 - 31)	
6)	Type of measurement	51 - 52
	B = Badge (film badge or TLD) FR = Finger Ring TR = Tritium	
7)	Non-penetrating dose (mrem)	54 - 59
8)	Penetrating dose (mrem)	61 - 66
9)	Fast neutron dose (mrem)	68 - 73
10)	Slow neutron dose (mrem)	75 - 80

11)	Extremity dose (mrem)	82 - 87
12)	X-ray dose (mrem)	89 - 94
13)	Tritium dose	96 - 100
14)	Offsite location code	102 - 103

The presence of such a code indicates the dose was received offsite.

AR Argonne National Laboraory, IL
BA Bettis - Pittsburgh, PA
BR Brookhaven National Laboratory, NY
HQ AEC, ERDA, or DOE Headquarters
IF Idaho Falls, ID
KA K.A.P.L., NY
LA Los Alamos, NM
NT Nuclear Test Site, NV
OR Oak Ridge, NN
RF Rocky Flats, CO
SR Savannah River, SC
US Department of the Interior, U.S. Military, or Civil Defense Disaster Council
UN Universities
OL Other Locations
PT Pacific Test Site
VA Vallecitos Nuclear Center, Pleasanton, CA

[1]Company codes and payroll numbers indicate whether doses were received while employed as a operations, construction or other type of worker. If the company code is T, or if the first two columns of the payroll number contain a Y or Z, then the dose was received in construction work. If the company code is 9, then the dose was received while employed by AEC, ERDA or DOE. If the company code is G, then the dose was received while employed by General Telephone Company. AEC, ERDA, DOE, and General Telephone are not considered operations contractors. If the company code is X, then the worker was employed by more than one contractor in that year; we have included the X code in the operations definition. All other designations indicate the dose was received while employed by an operations contractor.

1983 - 1989 Hanford dosimetry file:

	Variable	Columns
1)	OREN	4 - 9
2)	Company code[1]	11
3)	Payroll number[1]	13 - 17
4)	Beginning wear date for dosimeter	35 - 40
	year (83 - 89) month (1 - 12) day (1 - 31)	
5)	Ending wear date for dosimeter	42 - 47
	year (83 - 89) month (1 - 12) day (1 - 31)	
6)	Dosimeter type	51 - 52

The following codes indicate badge for monitoring whole body radiation:
'B ' beta-photon badge
' 5' multi-purpose badge
' 1' basic badge
' ' undefined, but treated as beta-photon badge
'B5' multi-pupose badge
' B' beta-photon badge

The following codes indicate rings for monitoring dose to extemities of the body body:
'BR' ring on right hand
' R' ring
'FR' finger ring
'AR' ring on left hand

[1]Company codes and payroll numbers indicate whether doses were received while employed as a operations, construction or other type of worker. If the company code is T, or if the first two columns of the payroll number contain a Y or Z, then the dose was received in construction work. If the company code is 9, then the dose was received while employed by AEC, ERDA, or DOE. If the company code is G, then the dose was received while employed by General Telephone Company. AEC, ERDA, DOE, and General Telephone are not considered operations contractors. If the company code is X, then the worker was employed by more than one contractor in that year; we have included the X code in the operations definition. All other designations indicate the dose was received while employed by an operations contractor.

7)	Penetrating dose (mrem)	61 - 66
8)	Neutron dose (mrem)	68 - 73

9)	Extremity dose (mrem)	82 - 87
10)	Offsite location code	102 - 103

The presence of such a code indicates the dose was received offsite. See 1944-1982 file for codes.

FILE WITH DATA ON INTERNAL DEPOSITION (INDEP)

This file includes all Hanford workers with one or more confirmed internal depositions of plutonium or other radionuclides. There is a separate record for each deposition that includes type and date, although the date is not available in some cases. Only variables indicated with an asterisk were used in creating INT89, and detailed descriptions of other variables are not given. Estimated doses from depositions (variables 15-19) were available only for very recent depositions, and are thus not useful to us at this time.

Variable		Columns
1)	Last name, first and middle initials	1 - 26
2)	Payroll number	32 - 36
*3)	Social Security Number	38 - 46
4)	Company	48 - 54
5)	Hanford termination date for former employees	56 - 63
6)	Offsite intake flag	65
*7)	Value[1]	67 - 71
*8)	Pu value[1]	75 - 79
9)	Intake flag	81
*10)	Isotope code	85 - 89

PU238, PU239, and PUTOT all indicate that deposition is plutonium, with PUTOT indicating a plutonium mixture. Standard chemical or radioisotope symbols denote other isotopes.

11)	Pu-238 indicator	91
12)	Intake information	97 - 110
13)	Status as of January 6, 1989	112
14)	Notes	114 - 123
15)	Maximum annual lung dose from internal deposition	125 - 128

16)	Lung dose for 1987	130 - 133
17)	Lung dose for 1988	135 - 138
18)	Lung dose for 1989	140 - 143
19)	Year maximum lung dose calculated	145 - 148

[1]Variables 7 and 8 indicate the magnitude of the deposition expressed as a percentage of the ICRP-2 maximum permissible body burden (% MPBB) for the particular isotope. When variable 10 is indicated as "PUTOT", then variable 7 indicates the Pu-239 or the Pu-alpha deposition, and variable 8 indicates the sum of variable 7 and the estimated %MPBB from Pu-241; Pu-241 is a beta emitter not readily detectable by direct or indirect bioassay. When variable 10 is something other than "PUTOT", variable 7 indicates the % MPBB, and variable 8 is 0.0. In creating INT89 from INDEP, we extracted the maximum of variables 7 and 8.

FILES USED FOR PREVIOUS ANALYSES OF HANFORD MORTALITY DATA (MST79)

As indicated in the introduction to this report, the file providing the data used in recent analyses was made in 1979, and is referred to as MST79. The description of this file given below refers to the original file as it existed in 1980. The file was created (as described in Appendix A) by merging the Occupational Health History file (as it existed in 1979) with the file of external dosimetry, and then adding mortality data, Several versions of this file have been made as mortality was updated, but the basic format has remained very similar to that given here.

The file CEDR78 is also described. This is the first file sent to CEDR, and is the same as MST79, except that a few variables that were intended primarily for internal use, were excluded.

	Variable	Columns
1)	Research number	1 - 9
	A unique number assigned to each worker in the study	
2)	Date of birth[1]	10 - 16
3)	Sex	17
	1 = Male, 2 = Female	
4)	Race	18
	1 = White, 2 = Non-white	
5)	Date of initial employment[1]	19 - 25
6)	Year of last recorded employment[1]	26 - 32
7)	Last recorded employment code	33
	1 = hire date, 2 = termination date, 3 = inactive, 4 = retirement, 5 = still employed, 6 = died, 7 = disability	
8)	General occupation code	34
	1 = white collar, 2 = nuclear, 3 = craftsman, 4 = service	

9)	Specific occupation code #1	35
	1 = radiation monitor, 2 = millwright, 3 = steam fitter, 4 = power operator, 5 = reactor operator, 6 = chemical operator	
10)	Specific occupation code #2	36
	(same definitions as those for code #1)	
11)	Total penetrating dose (in centirem)	37 - 42
12)	Estimated penetrating dose for 1944 (in centirem)	43 - 47
13)	Estimated penetrating dose for 1945 (in centirem)	48 - 52
.		
.		
.		
46)	Estimated penetrating dose for 1978 (in centirem)	213 - 217
47)	Number of onsite dosimetry records	218 - 219
48)	Year of first onsite dose	220 - 221
49)	First onsite flag	222
	0 = year of first onsite dose is as recorded on HRO 1 = year of first onsite dose set equal to initial employment year	
50)	Year of second onsite dose	223 - 224
51)	Year of last onsite dose	225 - 226
52)	Last onsite flag	227
	0 = year of last onsite dose is as recorded on HRO 1 = year of last onsite dose set equal to last employment year	
53)	Total offsite penetrating dose (in centirem)	228 - 233
54)	Year of first offsite dose	234 - 235
55)	Amount of first offsite dose (in centirem)	236 - 240
56)	Number of offsite dosimetry records	241 - 242
57)	Total neutron dose (in centirem)	243 - 248
58)	Number of positive neutron dosimetry records	249 - 250
59)	Year of first positive neutron dose	251 - 252
60)	Year of last positive neutron dose	253 - 254
61)	Payroll number flag	255
62)	Birth date from death certificate	256 - 262
63)	Year of internal deposition	289 - 290
64)	Amount of internal deposition	291 - 293

Recorded as % of MPBB, <5 recorded as 1

65) Internal deposition type #1 294

1 = Plutonium, 2 = Americium, 3 = Cesium,
4 = Curium, 5 = Europium, 6 = Promethium,
7 = Strontium, 8 = Uranium

66) Internal deposition type #2 295

Same definitions as those for type #1

68) Date of death[1] 304 -307

month (1 - 12)
year (44 - 81)

70) ICD8 primary cause 312 - 315

71) State of death code 316 - 317

See codes from HMO91

[1]Dates were calculated as follows: year + (month-1)/12 + (day-0.5)/365. If the date was December 31, the result was corrected by subtracting .001.

CEDR78

This file, consisting of five records for each worker, was created at PNL by extracting the most important variables from MST79. Like MST79, the file includes dosimetry data for 1944-1978 and mortality data for 1944-1981. In addition, mortality data for 1982-1985 is provided for deaths occurring in the State of Washington.

	Variable	Record #	Columns
1)	Study identification number	1	1 - 5
2)	Date of Birth[1]	1	6 - 13
3)	Sex	1	14 - 15
	1 = Male, 2= Female		
4)	Race	1	16 - 17
	1 = White, 2 = Non-white		
5)	Initial employment date[1]	1	18 - 24
6)	Last date known to be employed[1]	1	25 - 31
7)	General occupational code	1	32 - 33
	1 = White collar 2 = Nuclear 3 = Craftsmen or operative 4 = Service		
8)	Total (cumulative) whole body penetrating dose (in centirem)	1	34 - 39
9)	Whole body penetrating dose recorded for 1944 (in centirem)	2	1 - 5
10)	Whole body penetrating dose recorded for 1945 (in centirem)	2	6 - 10
.			
.			
.			
24)	Whole body penetrating dose recorded for 1959 (in centirem)	2	76 - 80
25)	Whole body penetrating dose recorded for 1960 (in centirem)	3	1 - 5
.			
.			
.			
40)	Whole body penetrating dose recorded for 1975 (in centirem)	3	76 - 80

41)	Whole body penetrating dose recorded for 1976 (in centirem)	4	1 - 5
42)	Whole body penetrating dose recorded for 1977 (in centirem)	4	6 - 10
43)	Whole body penetrating dose recorded for 1978 (in centirem)	4	11 - 15
44)	Number of years with on-site dosimetry records	5	1 - 3
45)	Year of first on-site dosimetry record	5	4 - 6
46)	Year of last on-site dosimetry record	5	7 - 9
47)	Total off-site penetrating dose (in centirem) The doses given by variables 8-43 include off-site dose.	5	10 - 16
48)	Year of first off-site dosimetry record	5	17 - 19
49)	Amount of first offsite dose (in centirem)	5	20 - 25
50)	Number of off-site dosimetry records	5	26 - 28
51)	Year of internal plutonium deposition (-7 indicates no plutonium deposition)	5	29 - 31
52)	Amount of plutonium deposition Recorded as percent of maximum permissible body burden, < 5% coded as 1, -77 indicates no plutonium deposition	5	32 - 35
53)	Depositions other than plutonium 0 = No deposition 1 = Plutonium only 2 = Americium 3 = Cesium 4 = Curium 5 = Europium 6 = Promethium 7 = Strontium 8 = Uranium	5	36 - 37
54)	Month of death	5	38 - 40
55)	Year of death	5	41 - 42
56)	State of death See codes from HMO91.	5	43 - 45
57)	ICD8 underlying cause of death (-77 = not available)	5	46 - 48
58)	Associated cause of death #1	5	49 - 51

	(-77 = not applicable)		
59)	Associated cause of death #2	5	52 - 54
	(-77 = not applicable)		
60)	Associated cause of death #3	5	55 - 57
	(-77 = not applicable)		
61)	Associated cause of death #4	5	58 - 60
	(-77 = not applicable)		
62)	Associated cause of death #5	5	61 - 63
	(-77 = not applicable)		

[1]These dates are indicated with three decimal places. They were calculated in this manner: year - 1900 + (month-1)/12 + (day-0.5)/365. If the date was December 31, the result was corrected by subtracting .001.

APPENDIX D

DESCRIPTION OF FILES IN HANFORD MORTALITY STUDY DATABASE

APPENDIX D

DESCRIPTION OF FILES IN HANFORD MORTALITY STUDY DATABASE

A complete description of the files listed in Section 1.3 is given in this appendix.

KEY File

This file contains information on all workers found either on OHH88 or on MST79, that is, on all workers who are candidates for inclusion in the complete Hanford study population. Each worker has 11 records on this file indicating his/her identifying information as it appears on each of 11 files. The first record gives the Social Security number (SSN), name, sex, and birth date judged most likely to be correct. The remaining records with their codes are as follows:

2 = MST79
3 = OHH88
4 = ORE
5 = HMO91
6 = SSN change forms from PNL's Health Physics Department
7 = HEHF_AKA (Alternative SSNs)
8 = List of SSN changes received from HEHF on 8-27-87
9 = Probability linkages and other sources
A = HEHF_AKA (Alternative names)
B = ORE name change file

If a worker does not appear on a particular file, the record for that file will be blank except for the file sequence number (which is the same for all records for a given worker), and the information source. Formats for each of the 11 records follow:

Record 1: For all variables, this record gives the data that is currently judged most likely to be correct

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	1, designates that file contains information judged most likely to be correct	
3)	SSN	9 - 18
4)	Last name	20 - 37
5)	First name	38 - 52
6)	Initial	53
7)	Sex	55
	1 = Male, 2 = Female, 7 = Unknown	
6)	Birth date	59 - 64
	Two-digit numeric codes for year, month and day, blank or -7-7-7 to indicate not available	
7)	Death date	66 - 71
	Two-digit numeric codes for year, month and day, blank or -7-7-7 to indicate not available	
8)	Research number	73 - 78
9)	Date of last change to this record	80 - 85
	Year, month and day	

Record 2:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	2 = MST79	
3)	SSN	10 - 18
4)	Sex	55
	1 = Male, 2 = Female, 7 = Unknown	
5)	Birth date	58 - 64
	Recorded with three decimal places. Blank or -77.000 to indicate not available. Calculated in this manner: year - 1900 + (month-1)/12 + (day-0.5)/365	
6)	Death date	66 - 71
	Two-digit numeric codes for year, month and day, blank or -7-7-7 to indicate not available	
7)	Alternate SSN	73 - 81
	Some workers appeared on MST79 under 2 different SSNs as described in Section 2.3.	
8)	Date of the information	83 - 88
	79-7-7 for all workers	

Record 3:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	3 = OHH88	
3)	SSN	10 - 18
4)	Last name	20 - 37
5)	First name	38 - 52
6)	Initial	53
7)	Sex	55
	M = Male, F = Female, U or blank = Unknown	
8)	Birth date	59 - 64
	Two-digit numeric codes for year, month and day, blank or -7-7-7 to indicate not available	
9)	Death date	66 - 71
	Two-digit numeric codes for year, month and day, blank or -7-7-7 to indicate not available	
10)	Date of this information	73 - 78
	8808-7 for all workers	

Record 4:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	4 = ORE	
3)	SSN	10 - 18
4)	Last name	20 - 37
5)	First initial	38
6)	Middle initial	53
7)	Sex	55
	M = Male, F = Female, U or blank = Unknown	
8)	Birth date	59 - 64
	Two-digit numeric codes for year, month and day, blank to indicate not available	
9)	Death date	66 - 71
	Two-digit numeric codes for year, month and day, blank to indicate not available	
10)	OREN	73 - 78
	A unique number assigned to each worker in the ORE System	
11)	Date of this information	80 - 85
	8905-7 for all workers	

Record 5:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	5 = HMO91	
3)	SSN	10 - 18
4)	Last name	20 - 37
5)	First name	38 - 52
6)	Initial	53
7)	Sex	55
	M = Male, F = Female, U or blank = Unknown	
8)	Birth date	57 - 64
	Two-digit numeric codes for century, year, month and day, blank to indicate not available	
9)	Death date	66 - 71
	Two-digit numeric codes for year, month, and day, blank to indicate not available	
10)	Date of this information	73 - 78
	9106-7 for all workers	

Record 6:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	6 = SSN change forms from PNL Dosimetry Records through August, 1992	
3)	Old SSN	10 - 18
4)	New SSN	20 - 28
5)	Old name	30 - 51
6)	New name	53 - 74
7)	Other OREN #1	76 - 81
8)	Other OREN #2	83 - 88
7)	Date of last change to this record	90 - 95
	Two-digit numeric codes for year, month, and day, blank to indicate not available	

Record 7:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	7 = HEHF_AKA (alternative SSNs)	
3)	Currently accepted SSN	10 - 18
4)	AKA SSN #1	20 - 28
5)	AKA SSN #2	30 - 38
6)	AKA SSN #3	40 - 48
7)	Date of this information	50 - 55
	8808-7 for all workers	

Record 8:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	8 = List SSN and name changes received from HEHF (8/27/87)	
3)	New SSN #1	10 - 18
4)	Old SSN #1	20 - 28
5)	New Name #1	30 - 48
6)	New SSN #2	50 - 58
7)	Old SSN #2	60 - 68
8)	New Name #2	70 - 88
9)	Date of this information	90 - 95
	870827 for all workers	

Record 9:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	9 = Probability linkages and other sources	
3)	SSN #1	10 - 18
4)	SSN #2	20 - 28
5)	SSN #3	30 - 38
6)	Other research number #1[1]	40 - 45
7)	Other research number #2[1]	47 - 52
8)	Other research number #3[1]	54 - 59
9)	Date of last change to this record	61 - 66

[1]Many of the "duplicates" described in Section 2.3 had been assigned more than one research number before it was discovered that they were duplicates.

Record 10:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	A = HEHF_AKA (alterntive names)	
3)	First alternative name	10 - 39
4)	Second alternative name	41 - 70
5)	Third alternative name	72 -101
6)	Fourth alternative name	103 -132
7)	Date of this information	134 -139
	8808-7 for all workers	

Record 11:

	Variable	Columns
1)	File sequence number (to enable sorting)	1 - 6
2)	Information source	8
	B = ORE (alternative names)	
3)	First alternative name	10 - 30
4)	Second alternative name	32 - 52
5)	Third alternative name	54 - 74
6)	Fourth alternative name	76 - 96
7)	Fifth alternative name	98 -118
8)	Date of this information	134 -139
	8808-7 for all workers	

JOB89

This file is an edited and abbreviated form of OHH_OP, described in Appendix C. As with OHH_OP, each worker has one personnel identification record and usually several work history records, one for each time that a change in work status occurs (as described in Chapter 3). These two types of records are described below.

Personnel identification record:

	Variable	Columns
1)	Record type	1 - 2
	10 = Personnel Identification record	
2)	Research number	6 - 11
3)	Birth date	53 - 58
	month (1 - 12) day (1 - 31) year (0 - 99)	
4)	Sex	78
	M = Male, F = Female	
5)	Race	79
	W = White, other than W = Non-white	
6)	Century for birth year	105
	8 = 1800's 9 = 1900's	

Work history record:

	Variable	Columns
1)	Record type	1 - 2
	20 = Work History record	
2)	Research number	6 - 11
3)	Date of entry into this job or social class	16 - 21
	year (44 - 88) month (1 - 12) day (1 - 31)	
4)	Bureau of Census Job code (see Appendix E)	24 - 26
5)	Social class code (see Section 3.1.2)	29 - 30
6)	Date of exit from this job or social class	33 - 38
	year (44 - 88) month (1 - 12) day (1 - 31)	
7)	Job status at date of exit	41
	H = Hired I = Inactive T = Terminated D = Dead R = Retired	

DOS89:

This file was created at PNL from the ORE and MST79 files. For workers who were monitored for external radiation, it contains records giving detailed dosimetry data for each year of monitoring.

	Variable	Columns
1)	Research number	1 - 6
2)	Sex 1 = Male, 2 = Female	7
3)	Birth date century (18 or 19), year (0 - 99) month (1 - 12), day (1 - 31)	8 - 15
4)	Year of external exposure	16 - 17
5)	Type of employment during monitoring period O = Operations C = Construction X = Undetermined or both operations and construction D = DOE, ERDA, AEC, GTE and early service crew (FBI, Army, BPA, etc.)	18 - 19
6)	Penetrating dose from photons (mSv) Including gamma rays and 35% of x-rays	20 - 27
7)	Dose from neutrons (mSv)	28 - 35
8)	Dose from tritium	36 - 43
9)	Total whole body penetrating dose (mSv) Sum of variables 6, 7 and 8	44 - 51
10)	Dose from x-rays (mSv) Available only from 1957-1972	52 - 59
11)	Extremity dose (mSv) Measured with a finger ring. -7.000 to indicate no extremity monitoring, 0.000 to indicate an actual zero reading	60 - 67
12)	Non-penetrating (beta) dose (mSv)	68 - 75
13)	Dose from fast neutrons (mSv) Not available after 1982	76 - 83
14)	Dose from slow neutrons Not available after 1982	84 - 91

INT89

This file was created at PNL from the INDEP file, and includes data on all workers with confirmed depositions of plutonium and other radionuclides.

	Variable	Columns
1)	Research number	4 - 9
2)	Year of plutonium deposition -7 = no Pu deposition or year of Pu deposition not available	11 - 12
3)	Amount of plutonium deposition Expressed as a percentage of the ICRP-2 Maximum Permissible Body Burden (MPBB) for the particular isotope. -7 = no Pu deposition.	14 - 19
4)	Type of deposition other than plutonium 0 = no deposition (includes strontium depositions with 0.0 amount) 1 = plutonium depositions only 2 = americium 3 = cesium 4 = curium 5 = europium 6 = promethium 7 = strontium (included here only if amount > 0.0) 8 = uranium	21
5)	Year of deposition other than plutonium -7 = no non-Pu deposition or year of non-Pu deposition not available	23 - 24
6)	Amount of deposition other than plutonium Expressed as a percentage of the ICRP-2 Maximum Permissible Body Burden (MPBB) for the particular isotope. -7 = no non-Pu deposition or amount not available.	26 - 32
7)	Flag for strontium deposition < 1% MPBB 0 = no Sr deposition or a Sr deposition > 1% MPBB 1 = Sr deposition < 1% MPBB (These depositions are considered insignificant, and can be ignored for most purposes.)	34

IARC89

These files were created at PNL, and include 1944-1989 dosimetry data, 1944-1989 mortality data for deaths occurring in the state of Washington, and 1944-1986 mortality data for deaths occurring outside the state of Washington. The first two files follow the format specified in the IARC protocol (Appendix B). The first and third files include one record for each worker. The second file, which contains external dosimetry data, include one record for each year that a worker was monitored for external radiation exposure. The ADD89 files are coded in the same manner as IARC89, but include workers not on IARC89 as explained in Section 1.3.

First file:

	Variable	Columns
1)	Research number	1 - 6
2)	Sex	7
	1 = Male, 2 = Female	
3)	Date of birth	8 - 15
	century (18 or 19) year (0 - 99) month (1 - 12) day (1 - 31)	
4)	End of study	16 - 21
	861231 on all records	
5)	Date of death	22 - 27
	year (44 - 89[1], -7 if not dead) month (1 - 12, -7 if not dead) day (-7 for all workers)	
6)	Date of initial employment	28 - 33
	year (44 - 78) month (1 - 12) day (1 - 31)	

[1]The end of the follow-up period is considered to be December 31, 1986, and deaths occurring after this date should not be included in cohort-based analyses. However, deaths occurring in the State of Washington in the period 1987-89 are included on the file.

7)	Date of start of follow-up -7-7-7 on all records	34 - 39
8)	Date of last known employment year (44 - 89) month (1 - 12) day (1 - 31)	40 - 45
9)	Year of plutonium deposition -7 indicates no plutonium deposition 0 indicates date not available	46 - 47
10)	Year of first plutonium monitoring -7 on all records to indicate not available	48 - 49
11)	Year of first uranium deposition -7 indicates no plutonium deposition 0 indicates date not available	50 - 51
12)	Year of first uranium monitoring -7 on all records to indicate not available	52 - 53
13)	Type of deposition other than plutonium 0 = No internal deposition (including strontium depositions with a zero amount) 1 = Plutonium deposition only 2 = Americium 3 = Cesium 4 = Curium 5 = Europium 6 = Promethium 7 = Strontium (only if amount > 0.0) 8 = Uranium	54 - 55
14)	Year of deposition other than plutonium -7 indicates no plutonium deposition 0 indicates date not available	56 - 57
15)	Longest general social class (see Section 3.1.2) -7 = not available	58 - 59
16)	Underlying cause of death -777 to indicate alive as of 1/1/89 or death occurred outside of WA after 1986 or not available	60 - 63
17)	ICD revision number 8 = 8th revision on all records	64

18)	Number of external exposure records 0 = No external exposure data, >0 = Number of records on second file	65 - 66

Second file:

	Variable	Columns
1)	Research number	1 - 6
2)	Sex 1 = Male, 2 = Female	7
3)	Date of birth century (18 or 19), year (0 - 99), month (1 - 12), day (1 - 31)	8 - 15
4)	Year of external exposure	16 - 17
5)	Facility 01 on all records to indicate Hanford	18 - 19
6)	Dose from gamma and x-rays (mSv)	20 - 27
7)	Dose from neutrons (mSv)	28 - 35
8)	Dose from tritium (mSv)	36 - 43
9)	Total whole body penetrating dose (mSv) Sum of variables 6, 7 and 8	44 - 51
10)	X-ray dose (mSv)	52 - 59
11)	Extremity dose (mSv) -7.000 to indicate no extremity monitoring, 0.000 to indicate an actual zero reading	60 - 67

Third file:

	Variable	Columns
1)	Research number	1 - 6
2)	Sex	7
	1 = Male, 2 = Female	
3)	Date of birth	8 - 15
	century (18 or 19), year (0 - 99), month (1 - 12), day (1 - 31)	
4)	Race	16
	1 = White, 2 = Non-white	
5)	Amount of plutonium deposition	17 - 21
	Recorded as percent of Maximum Permissible Body Burden (MPBB), 0.0 indicates <5%, -7.0 = no plutonium deposition	
6)	Amount of other type of deposition	22 - 28
	Recorded as percent of MPBB, <5% coded as 1.0, -7.0 = no other deposition	
7)	Strontium deposition flag	29
	0 = No Sr deposition or a Sr deposition > 1% MPBB 1 = Strontium deposition < 1% MPBB (These depositions are considered insignificant, and can be ignored for most purposes.)	
8)	State of death code	30 - 31
	See codes on HMO91, -7 = not applicable or not available	
9)	Overlap flag	32
	0 = Not in Rocky Flats or ORNL study population 1 = Also in ORNL study population 2 = Also in Rocky Flats study population	
10)	Study # in population indicated by overlap flag	33 - 38
	0 = Not applicable	
11)	Associated cancer #1	39 - 42
	-777 = No associated cancer	
12)	Associated cancer #2	43 - 46
	-777 = Less than 2 associated cancers	
13)	Associated cancer #3	47 - 50
	-777 = Less than 3 associated cancers	

14) Associated cancer #4 51 - 54

-777 = Less than 4 associated cancers

15) Associated cancer #5 55 - 58

-777 = Less than 5 associated cancers

16) Last social class code (see Section 3.1.2) 59 - 60

-7 = Not available

17) Longest general social class (see Section 3.1.2) 61 - 62

-7 = Not available

18) Longest social class 63 - 64

-7 = Not available

19) Length of employment 65 - 71

Length of actual employment at Hanford (in years), 1944 through 1985. Does not count periods between termination and rehire dates. Because this variable is based entirely on the OHH file, it also does not count periods where monitoring data are available, but where there was no indication of employment based on the OHH file.

20) Year of first off-site exposure record[1] 72 - 73

-7 = Not applicable

21) Amount of first offsite exposure (mSv) 74 - 81

-7.000 = Not applicable

22) Year of second off-site exposure record[1] 82 - 83

-7 = Not applicable

23) Amount of second off-site exposure (mSv) 84 - 91

-7.000 = Not applicable

24) Year of third off-site exposure record[1] 92 - 93

-7 = Not applicable

25) Amount of third off-site exposure (mSv) 94 -101

-7.000 = Not applicable

26) Year of fourth off-site exposure record[1] 102 -103

-7 = Not applicable

27) Amount of fourth off-site exposure (mSv) 104 -111

-7.000 = Not applicable

28) Year of fifth off-site exposure record[1] 112 -113

-7 = Not applicable

29)	Amount of fifth off-site exposure (mSv) -7.000 = Not applicable	114 - 121
30)	Year of sixth off-site exposure record[1] -7 = Not applicable	122 - 123
31)	Amount of sixth off-site exposure (mSv) -7.000 = Not applicable	124 - 131

[1]Off-site exposures are recorded in the year the information was received, and often indicate dose accumulated over several years.

APPENDIX E

BUREAU OF CENSUS JOB CATEGORY CODES

APPENDIX E

BUREAU OF CENSUS JOB CATEGORY CODES

The codes that follow were extracted from Bureau of Census (1971), Alphabetical Index of industries and Occupations, 1970. Census of the Population, U.S. Government Printing Office, Washington, DC. The codes were used to assign job categories on the OHH files, and in preparing the file JOB89, described in Section 3, and in Appendix D.

OCCUPATIONAL CLASSIFICATION SYSTEM

Equivalent numeric codes follow the alphabetic codes. Either code may be utilized, depending on the processing method. "N.e.c." means "not elsewhere classified."

Occupation Code	PROFESSIONAL, TECHNICAL, AND KINDRED WORKERS
001	Accountants
002	Architects
	Computer specialists
003	Computer programmers
004	Computer systems analysts
005	Computer specialists, n.e.c.
	Engineers
006	Aeronautical and astronautical engineers
010	Chemical engineers
011	Civil engineers
012	Electrical and electronic engineers
013	Industrial engineers
014	Mechanical engineers
015	Metallurgical and materials engineers
020	Mining engineers
021	Petroleum engineers
022	Sales engineers
023	Engineers, n.e.c.
024	Farm management advisors
025	Foresters and conservationists
026	Home management advisors
	Lawyers and judges
030	Judges
031	Lawyers
	Librarians, archivists, and curators
032	Librarians
033	Archivists and curators
	Mathematical specialists
034	Actuaries
035	Mathematicians
036	Statisticians
	Life and physical scientists
042	Agricultural scientists
043	Atmospheric and space scientists
044	Biological scientists
045	Chemists
051	Geologists
052	Marine scientists
053	Physicists and astronomers
054	Life and physical scientists, n.e.c.
055	Operations and systems researchers and analysts
056	Personnel and labor relations workers
	Physicians, dentists, and related practitioners
061	Chiropractors
062	Dentists
063	Optometrists
064	Pharmacists
065	Physicians, medical and osteopathic
071	Podiatrists
072	Veterinarians
073	Health practitioners, n.e.c.

Occupation Code	PROFESSIONAL, TECHNICAL, AND KINDRED WORKERS—Continued
	Nurses, dietitians, and therapists
074	Dietitians
075	Registered nurses
076	Therapists
	Health technologists and technicians
080	Clinical laboratory technologists and technicians
081	Dental hygienists
082	Health record technologists and technicians
083	Radiologic technologists and technicians
084	Therapy assistants
085	Health technologists and technicians, n.e.c.
	Religious workers
086	Clergymen
090	Religious workers, n.e.c.
	Social scientists
091	Economists
092	Political scientists
093	Psychologists
094	Sociologists
095	Urban and regional planners
096	Social scientists, n.e.c.
	Social and recreation workers
100	Social workers
101	Recreation workers
	Teachers, college and university
102	Agriculture teachers
103	Atmospheric, earth, marine, and space teachers
104	Biology teachers
105	Chemistry teachers
110	Physics teachers
111	Engineering teachers
112	Mathematics teachers
113	Health specialties teachers
114	Psychology teachers
115	Business and commerce teachers
116	Economics teachers
120	History teachers
121	Sociology teachers
122	Social science teachers, n.e.c.
123	Art, drama, and music teachers
124	Coaches and physical education teachers
125	Education teachers
126	English teachers
130	Foreign language teachers
131	Home economics teachers
132	Law teachers
133	Theology teachers
134	Trade, industrial, and technical teachers
135	Miscellaneous teachers, college and university
140	Teachers, college and university, subject not specified

X

pation Code — PROFESSIONAL, TECHNICAL, AND KINDRED WORKERS—Continued

Teachers, except college and university
- 141 Adult education teachers
- N (142) Elementary school teachers
- 143 Prekindergarten and kindergarten teachers
- 144 Secondary school teachers
- 145 Teachers, except college and university, n.e.c.

Engineering and science technicians
- 150 Agriculture and biological technicians, except health
- 151 Chemical technicians
- 152 Draftsmen
- 153 Electrical and electronic engineering technicians
- 154 Industrial engineering technicians
- 155 Mechanical engineering technicians
- 156 Mathematical technicians
- 161 Surveyors
- 162 Engineering and science technicians, n.e.c.

Technicians, except health, and engineering and science
- 163 Airplane pilots
- 164 Air traffic controllers
- 165 Embalmers
- 170 Flight engineers
- 171 Radio operators
- 172 Tool programmers, numerical control
- 173 Technicians, n.e.c.
- 174 Vocational and educational counselors

Writers, artists, and entertainers
- 175 Actors
- 180 Athletes and kindred workers
- 181 Authors
- 182 Dancers
- 183 Designers
- 184 Editors and reporters
- 185 Musicians and composers
- 190 Painters and sculptors
- 191 Photographers
- 192 Public relations men and publicity writers
- 193 Radio and television announcers
- 194 Writers, artists, and entertainers, n.e.c.
- 195 Research workers, not specified

MANAGERS AND ADMINISTRATORS, EXCEPT FARM

- 201 Assessors, controllers, and treasurers; local public administration
- 202 Bank officers and financial managers
- 203 Buyers and shippers, farm products
- 205 Buyers, wholesale and retail trade
- 210 Credit men
- 211 Funeral directors
- 212 Health administrators
- 213 Construction inspectors, public administration
- 215 Inspectors, except construction, public administration
- 216 Managers and superintendents, building
- 220 Office managers, n.e.c.
- 221 Officers, pilots, and pursers; ship
- 222 Officials and administrators; public administration, n.e.c.
- 223 Officials of lodges, societies, and unions
- 224 Postmasters and mail superintendents
- 225 Purchasing agents and buyers, n.e.c.
- 226 Railroad conductors

pation Code — MANAGERS AND ADMINISTRATORS, FARM—Continued

- 230 Restaurant, cafeteria, and bar managers
- 231 Sales managers and department heads, retail trade
- 233 Sales managers, except retail trade
- 235 School administrators, college
- 240 School administrators, elementary and secondary
- 245 Managers and administrators, n.e.c.

SALES WORKERS

- 260 Advertising agents and salesmen
- 261 Auctioneers
- 262 Demonstrators
- 264 Hucksters and peddlers
- 265 Insurance agents, brokers, and underwriters
- 266 Newsboys
- 270 Real estate agents and brokers
- 271 Stock and bond salesmen
- 280 Salesmen and sales clerks, n.e.c.[1]

CLERICAL AND KINDRED WORKERS

- 301 Bank tellers
- 303 Billing clerks
- P (305) Bookkeepers
- 310 Cashiers
- 311 Clerical assistants, social welfare
- 312 Clerical supervisors, n.e.c.
- 313 Collectors, bill and account
- 314 Counter clerks, except food
- 315 Dispatchers and starters, vehicle
- 320 Enumerators and interviewers
- 321 Estimators and investigators, n.e.c.
- 323 Expediters and production controllers
- 325 File clerks
- 326 Insurance adjusters, examiners, and investigators
- 330 Library attendants and assistants
- 331 Mail carriers, post office
- 332 Mail handlers, except post office
- 333 Messengers and office boys
- 334 Meter readers, utilities

Office machine operators
- 341 Bookkeeping and billing machine operators
- 342 Calculating machine operators
- 343 Computer and peripheral equipment operators
- 344 Duplicating machine operators

[1] Category "280 Salesmen and sales clerks, n.e.c." was subdivided in the Census into 5 occupation groups dependent on industry. The industry codes are shown in parentheses.

Occ. Code
- 281 Sales representatives, manufacturing industries (Ind. 107-399)
- 282 Sales representatives, wholesale trade (Ind. 017-058, 507-599)
- 283 Sales clerks, retail trade (Ind. 608-699 except 618, 639, 649, 667, 668, 688)
- 284 Salesmen, retail trade (Ind. 607, 618, 639, 649, 667, 668, 688)
- 285 Salesmen of services and construction (Ind. 067-078, 407-499, 707-947)

Occupation Code	CLERICAL AND KINDRED WORKERS—Continued
	Office machine operators—Continued
345	Key punch operators
350	Tabulating machine operators
355	Office machine operators, n.e.c.
360	Payroll and timekeeping clerks
361	Postal clerks
362	Proofreaders
363	Real estate appraisers
364	Receptionists
	Secretaries
370	Secretaries, legal
371	Secretaries, medical
Q (372)	Secretaries, n.e.c.
374	Shipping and receiving clerks
375	Statistical clerks
376	Stenographers
381	Stock clerks and storekeepers
382	Teacher aides, exc. school monitors
383	Telegraph messengers
384	Telegraph operators
385	Telephone operators
390	Ticket, station, and express agents
391	Typists
392	Weighers
394	Miscellaneous clerical workers
395	Not specified clerical workers

CRAFTSMEN AND KINDRED WORKERS

401	Automobile accessories installers
402	Bakers
403	Blacksmiths
404	Boilermakers
405	Bookbinders
410	Brickmasons and stonemasons
411	Brickmasons and stonemasons, apprentices
412	Bulldozer operators
413	Cabinetmakers
R (415)	Carpenters
416	Carpenter apprentices
420	Carpet installers
421	Cement and concrete finishers
422	Compositors and typesetters
423	Printing trades apprentices, exc. pressmen
424	Cranemen, derrickmen, and hoistmen
425	Decorators and window dressers
426	Dental laboratory technicians
430	Electricians
431	Electrician apprentices
433	Electric power linemen and cablemen
434	Electrotypers and stereotypers
435	Engravers, exc. photoengravers
436	Excavating, grading, and road machine operators; exc. bulldozer
440	Floor layers, exc. tile setters
441	Foremen, n.e.c.
442	Forgemen and hammermen
443	Furniture and wood finishers
444	Furriers
445	Glaziers
446	Heat treaters, annealers, and temperers
450	Inspectors, scalers, and graders; log and lumber
452	Inspectors, n.e.c.

Occupation Code	CRAFTSMEN AND KINDRED WORKERS—Continued
453	Jewelers and watchmakers
454	Job and die setters, metal
455	Locomotive engineers
456	Locomotive firemen
461	Machinists
462	Machinist apprentices
	Mechanics and repairmen
470	Air conditioning, heating, and refrigeration
471	Aircraft
472	Automobile body repairmen
S (473)	Automobile mechanics
474	Automobile mechanic apprentices
475	Data processing machine repairmen
480	Farm implement
481	Heavy equipment mechanics, incl. diesel
482	Household appliance and accessory installers and mechanics
483	Loom fixers
484	Office machine
485	Radio and television
486	Railroad and car shop
491	Mechanic, exc. auto, apprentices
492	Miscellaneous mechanics and repairmen
495	Not specified mechanics and repairmen
501	Millers; grain, flour, and feed
502	Millwrights
503	Molders, metal
504	Molder apprentices
505	Motion picture projectionists
506	Opticians, and lens grinders and polishers
510	Painters, construction and maintenance
511	Painter apprentices
512	Paperhangers
514	Pattern and model makers, exc. paper
515	Photoengravers and lithographers
516	Piano and organ tuners and repairmen
520	Plasterers
521	Plasterer apprentices
522	Plumbers and pipe fitters
523	Plumber and pipe fitter apprentices
525	Power station operators
530	Pressmen and plate printers, printing
531	Pressman apprentices
533	Rollers and finishers, metal
534	Roofers and slaters
535	Sheetmetal workers and tinsmiths
536	Sheetmetal apprentices
540	Shipfitters
542	Shoe repairmen
543	Sign painters and letterers
545	Stationary engineers
546	Stone cutters and stone carvers
550	Structural metal craftsmen
551	Tailors
552	Telephone installers and repairmen
554	Telephone linemen and splicers
560	Tile setters
561	Tool and die makers
562	Tool and die maker apprentices
563	Upholsterers
571	Specified craft apprentices, n.e.c.
572	Not specified apprentices

575 Craftsmen and kindred workers, n.e.c.
580 Former members of the Armed Forces

OPERATIVES, EXCEPT TRANSPORT

601 Asbestos and insulation workers
T (602) Assemblers
603 Blasters and powdermen
604 Bottling and canning operatives
605 Chainmen, rodmen, and axmen; surveying
610 Checkers, examiners, and inspectors; manufacturing
611 Clothing ironers and pressers
612 Cutting operatives, n.e.c.
613 Dressmakers and seamstresses, except factory
614 Drillers, earth
615 Dry wall installers and lathers
620 Dyers
621 Filers, polishers, sanders, and buffers
622 Furnacemen, smeltermen, and pourers
623 Garage workers and gas station attendants
624 Graders and sorters, manufacturing
625 Produce graders and packers, except factory and farm
626 Heaters, metal
630 Laundry and dry cleaning operatives, n.e.c.
631 Meat cutters and butchers, exc. manufacturing
633 Meat cutters and butchers, manufacturing
634 Meat wrappers, retail trade
635 Metal platers
636 Milliners
640 Mine operatives, n.e.c.
641 Mixing operatives
642 Oilers and greasers, exc. auto
643 Packers and wrappers, except meat and produce
644 Painters, manufactured articles
645 Photographic process workers
Precision machine operatives
650 Drill press operatives
651 Grinding machine operatives
652 Lathe and milling machine operatives
653 Precision machine operatives, n.e.c.
656 Punch and stamping press operatives
660 Riveters and fasteners
661 Sailors and deckhands
662 Sawyers
663 Sewers and stitchers
664 Shoemaking machine operatives
665 Solderers
666 Stationary firemen
Textile operatives
670 Carding, lapping, and combing operatives
671 Knitters, loopers, and toppers
672 Spinners, twisters, and winders
673 Weavers
674 Textile operatives, n.e.c.
680 Welders and flame-cutters
681 Winding operatives, n.e.c.
690 Machine operatives, miscellaneous specified
692 Machine operatives, not specified
694 Miscellaneous operatives
695 Not specified operatives

701 Boatmen and canalmen
703 Bus drivers
704 Conductors and motormen, urban rail transit
705 Deliverymen and routemen
706 Fork lift and tow motor operatives
710 Motormen; mine, factory, logging camp, etc.
711 Parking attendants
712 Railroad brakemen
713 Railroad switchmen
714 Taxicab drivers and chauffeurs
U (715) Truck drivers

LABORERS, EXCEPT FARM

740 Animal caretakers, exc. farm
750 Carpenters' helpers
V (751) Construction laborers, exc. carpenters' helpers
752 Fishermen and oystermen
753 Freight and material handlers
754 Garbage collectors
755 Gardeners and groundskeepers, exc. farm
760 Longshoremen and stevedores
761 Lumbermen, raftsmen, and woodchoppers
762 Stock handlers
763 Teamsters
764 Vehicle washers and equipment cleaners
770 Warehousemen, n.e.c.
780 Miscellaneous laborers
785 Not specified laborers

FARMERS AND FARM MANAGERS

W (801) Farmers (owners and tenants)
802 Farm managers

FARM LABORERS AND FARM FOREMEN

821 Farm foremen
822 Farm laborers, wage workers
823 Farm laborers, unpaid family workers
824 Farm service laborers, self-employed

SERVICE WORKERS, EXC. PRIVATE HOUSEHOLD

Cleaning service workers
901 Chambermaids and maids, except private household
902 Cleaners and charwomen
X (903) Janitors and sextons

Food service workers
910 Bartenders
911 Busboys
912 Cooks, except private household
913 Dishwashers
914 Food counter and fountain workers
Y (915) Waiters
916 Food service workers, n.e.c., except private household

Occupation Code	SERVICE WORKERS, EXC. PRIVATE HOUSEHOLD--Continued
	Health service workers
921	Dental assistants
922	Health aides, exc. nursing
923	Health trainees
924	Lay midwives
925	Nursing aides, orderlies, and attendants
926	Practical nurses
	Personal service workers
931	Airline stewardesses
932	Attendants, recreation and amusement
933	Attendants, personal service, n.e.c.
934	Baggage porters and bellhops
935	Barbers
910	Boarding and lodging house keepers
941	Bootblacks
942	Child care workers, exc. private household
943	Elevator operators
944	Hairdressers and cosmetologists
945	Personal service apprentices
950	Housekeepers, exc. private household
952	School monitors
953	Ushers, recreation and amusement
954	Welfare service aides
	Protective service workers
960	Crossing guards and bridge tenders
961	Firemen, fire protection
962	Guards and watchmen
963	Marshals and constables
964	Policemen and detectives
965	Sheriffs and bailiffs

Occupation Code	PRIVATE HOUSEHOLD WORKERS
980	Child care workers, private household
981	Cooks, private household
982	Housekeepers, private household
983	Laundresses, private household
Z (984)	Maids and servants, private household
995	OCCUPATION NOT REPORTED[2]
	ALLOCATION CATEGORIES[3]
196	Professional, technical, and kindred workers - allocated
246	Managers and administrators, except farm - allocated
296	Sales workers - allocated
396	Clerical and kindred workers - allocated
586	Craftsmen and kindred workers - allocated
696	Operatives, except transport - allocated
726	Transport equipment operatives - allocated
796	Laborers, except farm - allocated
806	Farmers and farm managers - allocated
816	Farm laborers and farm foremen - allocated
976	Service workers, exc. private household - allocated
986	Private household workers - allocated

[2] This code is used to identify not reported occupations surveys where the not reported cases are not allocated

[3] Those returns from the Population Census which do n have an occupation entry are allocated among the maj occupation groups during computer processing. These cases a labeled with the code for the "allocation" category to whic they are assigned. (See text, page IV).

APPENDIX F

ALGORITHM FOR CONVERTING ICD9 TO ICD8 CAUSE OF DEATH CODES

APPENDIX F

ALGORITHM FOR CONVERTING ICD9 TO ICD8 CAUSE OF DEATH CODES

The system used to convert ninth revision cause of death codes (WHO, 1977) to eighth revision cause of death codes (WHO, 1965) is given below for those codes that would be considered as malignant neoplasms under either the ICD8 or ICD9 system.

ICD9 code	ICD8 code
140	140
141	141
142	142
143	143
1431	1431
144	144
145	145
146	146
147	147
148	148
149	149
150	150
151	151
152	152
153	153
154	154
155	155
1552	1978
156	156
157	157
158	158
159	159
160	160
161	161
162	162
1620	1620
1622	1621
1623	1621
1624	1621
1625	1621
163	1630
164	1631
1640	1942
1641	1711
165	1639
170	170
171	171
172	172
173	173
174	174
175	174
179	1829
180	180
181	181
182	182
1821	1829
183	183
184	184
185	185
186	186
187	187
1877	1735
188	188
1890	1890
1891	1891
1892	1892
1893	1899
1894	1899
1898	1899
1899	1899
190	190
191	191
192	192
193	193
194	194
195	195
196	196
197	197
1970	1970
1971	1971
1972	1972
1973	1973
1977	1977
198	198
199	199
2000	2000
2001	2001
2002	2022
2008	2022
201	201
2020	2020
2021	2021
2022	2022
2023	2022
2024	2022
2025	2022
2026	2022
2028	2022
2029	2022
203	203
2040	2040
2041	2041
2042	2049
2048	2049
2049	2049
2050	2050
2051	2051
2052	2059
2053	2022
2058	2059
2059	2059
2060	2060
2061	2061
2062	2069
2068	2069
2069	2069
2070	2072
2071	208
2072	2079
2078	2079
2080	2070
2081	2071
2082	2079
2088	2079
2089	2079
2384	208
2898	209

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