ROCKETDYNE WORKER HEALTH STUDY

Appendix B

INTERNATIONAL EPIDEMIOLOGY INSTITUTE

Study Topics

July 13, 2005

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Appendix B. Study Topics

Appendix B covers a group of diverse topics that were addressed during the conduct of the study.

Appendix B1. Asbestos

Asbestos. Asbestos was used in thermal system insulation materials in several locations at Atomics International, including the sodium pit of Building 143 and in the sodium loops in Building 6. Small amounts of asbestos also could be found at test stands in some miscellaneous materials such as gaskets and wiring insulation, but it was not extensively used in thermal system insulation. To evaluate whether asbestos exposure might have resulted in an increased cancer risk in this population, an attempt was made to identify workers who developed or died from mesothelioma. All Rocketdyne workers, including the 5,801 radiation workers, were included in this evaluation.

Identifying workers who died from mesothelioma was not straightforward because it was only in 1999 that mesothelioma *per se* was classified as a cause of death in ICD10 (C45). Prior to 1999, mesothelioma deaths had to be identified or estimated from surrogates such as cancer of the pleura or cancer of the peritoneum in ICD9 (163, 158.8, 158.9). For deaths back to 1950 there is no generally accepted range of ICD codes that might indicate death due to mesothelioma. For example, if the cause of death was listed as mesothelioma without mention of site, an “other cancer” code (ICD8, 199.1) most often would be assigned. Attempts to obtain a comprehensive listings of possible ICD codes included contacting CDC and NCHS, Harvard University, the SEER registries, IARC, NRPB and investigators such as Julian Peto in the United Kingdom (Peto et al., 1981). An article by the Wisconsin Division of Health, the lead agency for the EPA’s School Asbestos Programs since 1979, was also informative (Anderson et al., 1991). The “likely” and possible codes for which death certificates were searched for mention of mesothelioma included the following:

ICD (years)	Likely Codes	Possible codes
10th (1999+)	C45	
9th (1979-98)	163, 158.8, 158.9	199.1, 199.9, 212.4, 229.9
8th (1968-78)	163.0	158.8, 158.9, 199.1, 212.3, 212.4, 228
7th (1958-67)	162.2	158, 197.9, 211, 212, 227
6th (1950-57)	162.2	158, 197.9, 211, 212, 227

Death information from the NDI also included contributing causes of death and these were also sought for possible mesothelioma involvement. To date, there were 11 deaths with “likely codes” of which 8 were found to have mention of mesothelioma on the death certificate. The other 3 deaths were found to be lung cancer cases dying in 1968 for which cause of death had been incorrectly coded using the ICD7 for lung cancer (which was the same code as cancer of the pleura in ICD8). UCLA reported 4 mesotheliomas in their cohort (CHEM FINAL REPT 1999), and 3 of our 7 mesothelioma deaths occurred after 1994 when the UCLA follow up ended. An evaluation of the work histories revealed nothing remarkable about the job held at Rocketdyne/Atomics International. No mesothelioma deaths occurred among SSFL workers, 1 occurred among radiation workers and 7 among the other Rocketdyne workers.

It should be noted that we did not exclude in any of the SMR analyses the 3 lung cancers that were mis-coded as pleural cancers. In 1967 lung cancer was coded as 163 (ICD7), but in 1968 cancers of the pleura was coded as 163 (ICD8). Occasionally the wrong code was used during these transitional years. Because the CA rates used to compute expected values used these incorrect values we did not change the observed numbers since we had no way of correcting the expected numbers.

In additional to the mortality evaluation, linkage with the California Surveillance Program for cancer incidence in Los Angeles county was performed. Workers with mesothelioma histology codes (M-9500, M-9501, M-9502, M-9503 and M-9055) were identified and their job histories and death certificates were being evaluated. Two incident cases overlapped with the 7 deaths due to mesothelioma mentioned above. One worker had a “deferred” cause of death on his certificate and thus was not identified from the mortality searches. Several had mention of “mesothelioma” on their death certificates, but were not coded to any of our possible categories above, e.g., causes of death included suicide, hypertension and melanoma. One worker was diagnosed with mesothelioma in 1990 and is still alive. Additional workers who developed mesothelioma were identified from Rocketdyne files, e.g., compensation claims and Human Resource evaluations. One worker did not have a Kardex work history. Another had worked in the U.S. Navy. Searching over 2,000 death reports from the NDI for contributing causes of death did not identify any additional mesotheliomas. Nor did searches of the available 4,000 death certificates from the Boeing Company.

For the causes of death due to mesothelioma in ICD10 and surrogate “likely” causes in the other ICDs, we computed observed to expected ratios to learn whether their might be an observable increase in comparison with the general population of California (OBS = 8, EXP = 6.3; SMR = 1.27; 95% CI = 0.55-2.49). However, it should be noted that 3 of these deaths were lung cancers mis-coded as mesothelioma.

For the totality of workers who developed or died of mesothelioma, we looked at their work histories to learn whether any clusters of occupations in time and place have occurred that might suggest a common exposure to asbestos. Most workers were employed at Canoga Park or DeSota Avenue and few workers (2) were employed at SSFL, few were radiation workers (5), several were short-term workers, several had asbestos exposure prior to Rocketdyne employment (e.g., one worker was a financial planner at Rocketdyne who’s asbestos exposure had occurred 40 years previously). Workers identified appeared to be an eclectic group with no discernible similarities. Job titles included research engineer, lathe machinist, physician, buyer, estimator, truck driver, stock room clerk, propulsion test technician, mechanic AER, rocket assembler, and sheet metal. The sources of identifying the 22 mesothelioma diagnoses are also eclectic.

Job Category	**No.**	**%**
SSFL-Non-Administrative	1	4.6
Test Stand Engineer	1	4.6
Non-SSFL Non-Administrative	11	50.0
Non-SSFL Administrative	4	18.2
Radiation Monitored	5	22.7
Total	22	100.0

There was little suggestion of an asbestos problem based on mortality evaluations (8 observed vs 6.3 expected) and the “total” 22 cases identified from cancer registry linkage, available death searches, multiple cause of death evaluations and company records is about what would be roughly expected (i.e., cases about 3 times deaths).

REFERENCES

Anderson HA, Hanrahan LP, Schirmer J, Higgins D, Sarow P. Mesothelioma among employees with likely contact with in-place asbestos-containing building materials. Ann NY Acad Sci 643:550-572, 1991.

Peto J, Henderson BE, Pike MC, et al. Trends in mesothelioma incidence in the United States and the forecast epidemic due to asbestos exposure during World War II. In Peto R, Schneiderman M (eds) Quantitation of Occupational Cancer. Banbury Report 9. Cold Spring Harbor Laboratory, 1981, pp 51-85.

Appendix B2. Beryllium

Beryllium. Beryllium powder was mixed with oxidizers for use in experimental rocket propellants in some research areas and thrust chambers of the Mars Orbiter Engine (RS 21) was made of beryllium metal. A beryllium neutron reflector was used in the development of the SNAP rocket. The number of workers exposed to beryllium appeared small but a mortality analysis was conducted to learn the extent of any potential problem.

An evaluation of the death certificates for all causes of death with a potential for beryllium contribution was conducted. All Rocketdyne workers, including the 5,801 radiation workers were included in this evaluation. Over 10,000 deaths were evaluated covering the years 1950 through 1999, with 4 different ICD classifications. Codes for each of these ICD classifications were selected that corresponded to acute berylliosis, chronic beryllium disease, other chronic interstitial pneumonia, other pneumoconioses and related diseases, or pulmonary fibrosis. Only 1 of 28 matches had a specific beryllium code (ICD8 - 516.0). 25 matches were “pulmonary fibrosis” and 2 were “other” interstitial lung disease. Only the one beryllium code had mention of beryllium on the death certificate.

This analysis was extended later to include all multiple causes of death (available from NDI). No new cases of beryllium disease were found.

All ICD codes with specific mention of beryllium *(ICD10 - J63.2 ; ICD9 - 503; ICD8 - 516.0; ICD7 - 524)* were included as were the less specific diagnoses that might indicate possible beryllium involvement. The codes evaluated were:

ICD10 (1999+)

Definite:	J63.2	**Berylliosis** (lung). Pneumoconiosis due to inhalation of **beryllium**.
Definite:	J84.9	Interstitial pneumonia

ICD9 (1979-98)

Likely:	503	Pneumoconiososis due to other inorganic dust (including **Berylliosis**)
Possible:	508.9	Respiratory conditions due to unspecified external agent
Possible:	515	Postinflammatory pulmonary fibrosis

ICD8 (1968-78)

Likely:	516.0	Other pneumoconioses and related disease, due to inhalation of other inorganic dust (including **Berylliosis**)
Possible:	517	Other chronic interstititial pneumonia

ICD7/6 (1950-67)

Likely:	524	Other specified pneumoconiosis and pulmonary fibrosis of occupational origin
Possible:	523.3	Pneumoconiosis NOS

The causes of death also were evaluated in a group of over 95 workers who were identified as having potential for exposure to beryllium from company records such as the HSIS air sampling database. Thirteen of these workers had died but none had any of the “beryllium” diseases or possible diseases listed above.

Summary. The mortality data provided little indication of excessive exposure to beryllium. However, multiple causes of death could be evaluated only after 1978 from the NDI linkages. California death tapes do not include multiple causes of deaths. The NDI data were supplemented with evaluation of the over 4,000 death certificates available from the Boeing Company and from the various state departments of vital statistics.

Appendix B3. Personnel Listings

Rocketdyne Personnel Assignment Listings (Phone books). We located and computerized the Rocketdyne phone books for the period from 1956 to 1994, with the exception of 1967-1969 and 1971-1972 which could not be found. The phone books listed the specific test stand where a person worked. Complete rosters were available for the period 1956-1966, which covered both the highest employment period at SSFL and the greatest amount of chemical usage. Although phone books prior to 1956 where not available, this was of little consequence since it is likely that neither TCE nor hydrazine were used extensively before 1956.

The phone books proved to be valuable in two ways. First, they allow us to place test mechanics at specific test stands during specific years. This ability, coupled with the knowledge of where and when specific chemicals were used, allowed a better estimate of exposure to specific chemicals. Second, the phone books identified a large number of additional test stand mechanics not in our Kardex database or in the previous study cohort. To obtain work history information on these workers, however, it was necessary to identify the specific facility or division within Rockwell/Rocketdyne where the workers transferred taking their Kardex cards with them. This transfer information often was found on nearly 55,000 medical index cards that we had scanned into an accessible database. Armed with employee name and transfer division, Boeing personnel were able to locate the "missing" Kardex cards for most of these test stand mechanics who had been employed in the 1950s and 1960s.

Appendix B4. Medical Index Cards

Medical Index Cards. Over 55,000 medical index cards were available in the Boeing medical offices. They often included personal information such as name, social security number, serial number, date of birth, date of hire, date of transfer, date of termination. As above (B3), they were extremely helpful in directing our efforts to obtain missing Kardex cards for test stand mechanics identified from the personnel listings (phone books). They were also used in quality control measures to confirm spellings of names, important dates, social security numbers and whether a worker was actually employed at Rocketdyne (i.e., whether a serial number was present).

Appendix B5. Medical Records

Medical Records. As discussed fully in the Chemical paper, a conscientious medial assistant interviewed workers who were undergoing special physical examination because of working with toxic substances. Often recorded was the test stand and actual chemicals worked with. These records were used to validate our chemical exposure assignments. Unfortunately, in the late 1960s it appears that records for all workers who had terminated employment were destroyed so the early years were not complete.

Use of medical records. There are two sources of medical information, 55,000 medical index cards and 28,000 medical history folders. The medical index cards were useful in locating workers who transferred and in confirming or supplying identifying information such as social security number, serial number, date of birth and date of hire. The actual medical records, available for over half the work force, was used to confirm the fact of chemical exposure and in some instances actually provide exposure information for those workers not found in the phone book listings. From a sample of over 120 medical history folders, we found specific information on chemical exposures, on the specific test stand where the employee worked, and on smoking history. The medical records also indicated, and later confirmed by interviews with employees and with medical personnel who worked 1967-95, that not all test stand mechanics received medical examinations. It appears that test stand mechanics who worked with hydrazines or other toxic chemicals received routine or specialized medical exams, whereas, most mechanics working at the large test stands did not. Prior to the late 1960s, medical records were kept only for about 5 to 7 years after a worker terminated employ and so are not complete for some of the earliest workers.

Appendix B6
Quality Control Procedures

Data Entry Errors

Work histories of Rocketdyne employees prior to 1972 were recorded on Kardex brand work history forms. Pertinent personal identifier, demographic variables, and work history from these records was keyed into a Microsoft Access database. As with any large-scale data entry operation, some degree of keying error will occur. In order to minimize these errors, a number of quality controls mechanisms were implemented.

In addition to the hard-copies of the Kardex records, Rocketdyne also provided an image-based database (Alchemy) containing some personal identifiers (name and SSN) for most of the Kardex records. Data from extracted from the Alchemy database and was pre-loaded into the Access data entry system. During the keying operation, if the keyed values for name, date of birth, and Social Security number (SSN) were identical to the value extracted from the Alchemy system, the keyed value was accepted. If the keyed value was different from the Alchemy value or the Alchemy value was missing, the data entry system warned the data entry operator, and required the value to be typed again. In addition, at the conclusion of data entry, any discrepancies between the keyed values and the Alchemy systems in key personal identifiers were manually reviewed and corrected in the Access system.

Missing /Incorrect Personal Identifiers and Duplicate Records

Because of the complexity of this study, it was necessary to utilize a large number of datasets from various sources, such as Rocketdyne electronic human resources records, keyed Kardex Access database, Rocketdyne provided radiation folders, Rocketdyne provided radiation dosimetry records, radiation monitoring agencies, Rocketdyne medical history folders, and from vital status files agencies such as Social Security administration, HCFA, PBI, and others. Every dataset was converted into a SAS dataset, and then underwent a series of procedures in order to fill in missing or reconcile discrepant key personal identifiers such as SSN, name, and date of birth. The methods to do these comparisons typically consisted of 1) identifying discrepant or missing names and/or date of birth once the datasets were merged by SSN; and 2) performing ‘soft’ merges based on name and/or date of birth and identifying missing or incorrect SSNs. If the dataset was supposed to have a unique record for each person, another set of procedures were run in order to identify duplicate records, again by SSN and/or name.

These procedures where often tedious and required an extensive amount of manual review in order to either confirm a correct soft match, or to determine the correct personal identifier or records once a discrepancy or duplicate was discovered. Corrections were made to a modified version to the original dataset (when possible), or hard-coded into the SAS programs that created the file from its original format into SAS. After each dataset underwent these QC procedures, they were then incorporated into a single master relational database.

Job History Categorization

For analytical purposes, it is necessary to categorize persons into discrete categories, such as “Test Stand Mechanic”, “hourly” versus “salary”, or “administrative” versus “non-administrative”, and “Santa Susana” versus “non-Santa Susana” based on a potentially complex work history. For example, a person could have started their career as an non-non-administrative worker, then worked at Santa Susana as a test stand mechanic, and finished their career as a salaried engineer. A hierarchical priority based on ever having a particular job type was developed in order to categorize persons into 10 discrete job type categories. Hourly/salaried status was determined based the time spent in hourly jobs as a percentage of their total career time. Administrative/non-administrative status was determined based on the final job category placement. Santa Susana status was based on ever having worked at a Santa Susana facility. A number of procedures were performed to test the accuracy of these algorithms.

First, a listing of all job titles within four mutually exclusive categories (hourly and administrative, hourly and non-administrative, salaried and non-administrative, and salaried and non-administrative) of worker types was created. An industrial hygienist then reviewed the job titles within each of the four categories. For the most common job titles that did not appear in the appropriate category, the complete work histories of a sample of workers with that particular job title were reviewed by an industrial hygienist.

Also, a random sample of 25 hourly and 25 salaried Santa Susana workers, and 15 hourly and 15 salaried radiation workers was drawn, and underwent a thorough review to determine if the ‘hourly’/’salary’ designation was accurate. All Santa Susana workers were determined to have been assigned correctly. Within the radiation workers, one worker had insufficient work history to accurately determine final hourly/salaried status.

During data entry into the Access database, for efficiency, persons with work histories with no positions at the Santa Susana facility had only the first job keyed. Therefore, if this person terminated prior to 1972, the hourly/salary designation of this job type would be the only electronic record available to calculate time spent within either hourly or salaried jobs. In order to test if this method was accurate to properly classify persons as either hourly or salaried, a random sample of 25 hourly and 25 salaried Santa Susana workers with job history records from Kardex records only were sampled. A manual review of the entire Kardex work history was conducted, and time spent within each job pay type was calculated. One person out of the sample was classified as salaried (based on their first job), although they spent over 20% of their total career time as hourly. Therefore the method used to assign pay type to non-Santa Susana workers who terminated prior to 1972 was measured to be 98% accurate.

Industrial Hygiene Chemical Exposure

In order to test the accuracy of the chemical exposure assessment, we selected six test stand mechanics from each of the six chemical exposures (total time as a test stand mechanic, TCE Flush time, Number of TCE Flushes per year per mechanic, TCE Utility time, likely hydrazine and possible hydrazine exposure time) including mechanics with no exposure. An industrial hygienist performed a thorough review of these work histories directly from the raw Kardex or human resources provided electronic file, with special emphasis on test stand location, chemical used at that test stand location during that time period, job type, and time within each position. The independent results were then compared with the calculated results generated from the computer programs. For all selected persons, the value derived from manual review matched the computed generated value.

Radiation Dosimetry

A number of radiation dosimetry data sources where obtained to reconstruct the entire dose history for Rocketdyne workers. In addition to the personal identifier check outlines above, a number of quality control procedures where performed on the dose histories in order to check the accuracy and completeness of the individual sources. One procedure consisted of calculating a worker's career dose at a specific date in two or more radiation data sources, and comparing the values. Doing so would determine the relative completeness of the individual data sources. If discrepancies were found, a manual review of each of the dose histories could then identify chronological gaps in dose history within one of the data sources, or inaccurate, misclassified, or miskeyed dose readings. More details on the approach to radiation dosimetry can be found in the Dosimetry Paper and Uranium Aluminide Paper.

Appendix B7: Distinguishing Pay Type and Administrative/Non-Administrative Jobs

Determining Hourly/Salaried Status

Position records from both the Kardex and human resources electronic file were appended together into a complete Rocketdyne workforce work history database. Positions with zero days (i.e. records for an administrative change only) were deleted from the entire work history database. Every position had a start date, an end date, (from which the number of days worked at the position was calculated), a numeric *job code*, and a numeric *pay code*. Rocketdyne Human Resources personnel provided a list that linked pay type (i.e. hourly or salaried) to the majority of numeric pay codes. This list was used to assign a pay-type of either 'Hourly', or 'Salaried', to each *position* based on the pay-code. However, for about 14% of the positions, the pay code was either missing, or was not on the list provided by Rocketdyne.

In order to assign an Hourly/Salaried designation to the missing pay code positions, we used the frequency of the pay type among each specific *job code*. That is, all positions were subset into 3 datasets: those with an 1) 'Hourly', 2) 'Salaried', or 3) ‘Unknown’ pay-type. Among the hourly and salaried positions datasets, the number of times the pay-type occurred within each unique job code was calculated. These two datasets were merged together by job-code, to produce the following:

JobCode	JobTitle	HourlyCount	SalaryCount
111	Mechanic	90	10
222	Engineer	10	90
333	Expeditor	40	60

The percentage of salaried pay-type was then calculated for each *job code* (SalaryPercent = SalaryCount/(HourlyCount + SalaryCount) * 100). If a particular job-code had a salary percentage GREATER OR EQUAL TO 80%, THEN THAT JOB CODE WAS CONSIDERED A SALARIED JOBCODE. Otherwise, it was considered to be an hourly job code.

Once pay-type was determined for all job codes, the assigned pay-type was merged onto unknown pay-type positions dataset by job code. This allowed a known pay-type to be assigned for over 97% of the 238,000 positions in the RD workforce work history database.

In order to assign a *pay-type to a person*, the sum of the days a particular person spent in each of the 3 pay-type categories (hourly, salaried, or unknown) was calculated. The percentage of time spent in positions with a salaried pay-type (among positions with a KNOWN pay-type) was then calculated for each person as (SalaryPercent = SalaryDays/(SalaryDays + HourlyDays) * 100). A person was considered salaried IF THEY SPENT GREATER THAN OR EQUAL TO 80% OF THEIR WORK HISTORY IN SALARIED POSITIONS. If a person did not have at least one position in their work history with a known pay type, they were categorized as an 'Unknown' pay-type. Otherwise, persons were able to be categorized as either a 'salary' or 'hourly' worker. This allowed for the categorization of 92% of all RD employees as either hourly or salaried based on the keyed work history.

For efficiency, entire work histories were not originally keyed for radiation workers who did not hold positions at the Santa Susanna facility for greater than six months. Because pay type was an important confounder in our statistical analyses, a manual review of the work histories of these approximately 1,900 radiation workers was performed. to classify each worker as either 'Salaried' or 'Hourly'. Administrative/Non-Administrative status was also determined for these workers (see Administrative section). Incorporating these radiation workers increased categorization to 95% of all Rocketdyne employees as either hourly or salaried, and 99% of eligible workers.

Determining Worker Category

Each employee was categorized into a person-level category based on their entire work history such that it best reflected their potential exposure to chemicals in the work place environment. Unlike the pay-type designation, which used the percentage of time within each pay-type, the worker category designation used an ever/never approach giving higher priority to jobs with the greatest potential for chemical exposure. That is, if an employee ever worked as a test stand mechanic, they were categorized as a test stand mechanic, even if they spent the majority of their career in other job categories. The priority ordering used for categorizing workers was:

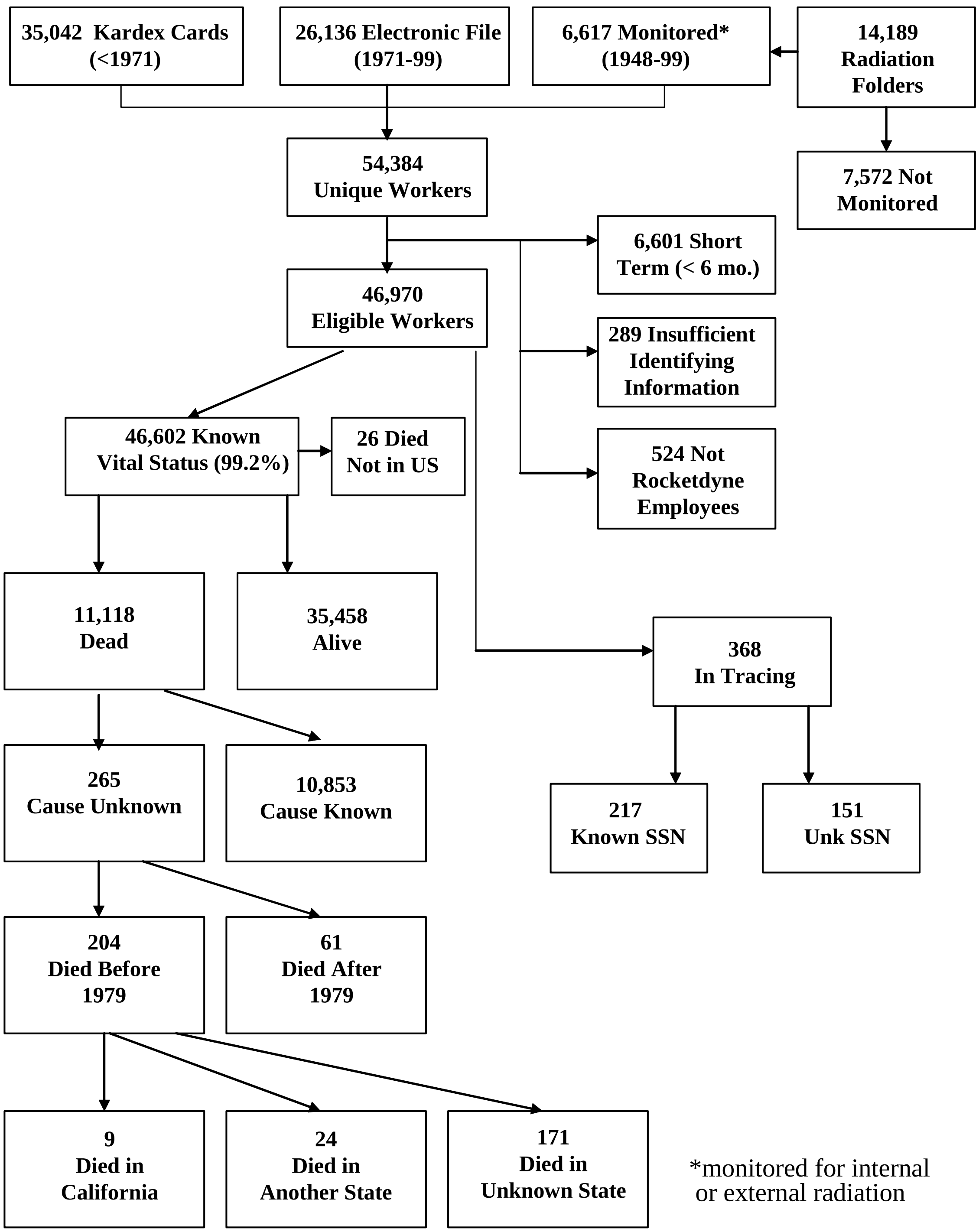
1) Test Stand Mechanic
2) Research Mechanic
3) Research Engineer
4) Test Stand Engineer
5) Instrument Mechanics
6) Inspectors
7) SSFL - Non-administrative
8) SSFL - Administrative
9) NonSSFL - Non-administrative
10) NonSSFL - Administrative

Administrative/Non-Administrative Status

The designation of administrative versus non-administrative was based upon the final person-level category in which a worker was placed. Administrative status was given to research engineers, test stand engineers, and SSFL and Non-SSFL Administrative workers. Non-administrative status was assigned to test stand mechanics, research mechanics, instrument mechanics, inspectors, and SSFL and Non-SSFL non-administrative workers. Thorough checking procedures were performed in order to verify the accuracy of these designations (see Quality Control section, B6).

Appendix B8 Vital Status Tracing and Cause of Death Determination Flowchart

Figure 1. Vital Status of Total Rocketdyne Workforce



*monitored for internal or external radiation

Appendix B9. Additional Cancer Incidence Discussion

Cancer Incidence

- The study was designed as a mortality investigation to extend the previous mortality study conducted by UCLA an additional 5 years. This extension, coupled with a larger study size and more comprehensive assessment of exposures, would provide an adequate test to the hypotheses raised in the previous study regarding possible increases in cancer deaths due to radiation and hydrazines.
- Cancer incidence analyses were not vigorously pursued for several reasons. First, the coverage would be incomplete. Although the United States has a national death registry which began in 1979, we do not have a national cancer registry. California has a cancer registry, but it began in 1988 and thus would miss cancers that occurred in the prior 40 years of study follow-up (which began in 1948) and it would miss all cancers that were diagnosed in other states. Los Angeles County has a cancer registry which began in 1973, but would miss cancers that were diagnosed in the prior 25 years of study follow-up and those diagnosed among residents of other counties in California (such as Ventura) as well as cancers that occurred in other states.
- Second, it would not be feasible to obtain information on cancer incidence for workers diagnosed with cancer in California and not covered by the existing cancer registries or for workers who left the state. The mortality investigation indicated that at least 25% of workers had moved out of the state for other employment opportunities or for retirement. Workers had moved to each of the 50 states. Current or last addresses are not available for most of the workers and they are not easily obtained. For those who died, the next of kin would have to be located and permissions received to access medical records. Not only would the cost be prohibitively high, but the difficulties in obtaining complete and accurate data would render results difficult to interpret.
- Third, it was felt that for the cancers of primary interest (i.e., lung cancer and leukemia), that mortality was a good indicator of incidence because the case fatality rate was so high, especially during the lengthy period of follow-up for the investigation (1948-99).
- Finally, a comprehensive mortality coverage of all workers for all years of the study was believed to be a sounder methodologic approach than an incomplete cancer incidence evaluation of an unknown number of workers who remained in the state of California. One limitation in conducting a cancer incidence study in California is that although the number of cancers occurring in and after 1988 among residents could be determined (the numerator), rates could not be accurately estimated because it is not known how many workers are living in California during the period of cancer registration (i.e., the denominator is not known). Given the mobile nature of the worker population and their age, the number of non-California residents might be substantial, and accurate estimates of "person-years" of observation while in cachement areas covered by the cancer registries would be problematic.
- This is not to say that cancer incidence was not looked at. We had matched our

entire worker file with the Los Angeles cancer registry (1973-1999). The matches were used in our evaluation of mesothelioma occurrence as described in Appendix B1. We also note that 36% of the cancers diagnosed in LA county occurred prior to 1988, indicating a minimum percentage of cancers that would be missed if the California registry were relied upon.

- The LA Registry was also used to evaluate the accuracy of the cause of death registrations for workers whose cancers had been diagnosed in LA county.
- We also evaluated the correspondence between cancer incidence and cancer death with regard to the primary cancers of interest. For the combined Radiation and Chemical Cohorts, 172 lung cancers were diagnosed over the years 1973-1999 of whom 156 workers had died (90.7%). For all cancers combined, there were 1,101 diagnoses of cancer of whom 694 (63%) had died. These evaluations indicate that a comprehensive mortality evaluation of all workers, including those who moved throughout the United States, would be a methodologically sound and statistically powerful approach to evaluate possible workplace hazards, in contrast to a cancer incidence study with incomplete calendar years of coverage for an unspecified underlying population (at least at the current time).