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EPIDEMIOLOGICAL STUDY  
OF  
VINYL CHLORIDE WORKERS

Final Report

May 3, 1974

Submitted to  
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EXHIBIT 1

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#### FIGURE

1. Flow Chart of Follow-up Procedure

#### ATTACHMENTS

- A. Plant Contact Form
- B. Plant Background Form
- C. Job History Form
- D. Follow-up Letter

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## EPIDEMIOLOGICAL STUDY OF VINYL CHLORIDE WORKERS

Final Report - May 2, 1974

### I. SUMMARY

Eight thousand three hundred and eighty four men who had had at least one year of occupational exposure to vinyl chloride before December 31, 1972, were followed in a historical prospective mortality study. The major findings of the study are:

1. The overall mortality of the study population was approximately 75 percent of what would be expected in a comparable population of U. S. males.
2. No cause of death showed a statistically significant excess over what would be expected in a comparable U. S. male population.
3. No new deaths identified as angiosarcoma of the liver were found.
4. All previously known Angiosarcoma deaths in the study population during the study period were found as part of the routine study procedure.
5. Cancers of the liver (primarily angiosarcoma), respiratory system, brain, and cancers of unknown primary site, as well as lymphosarcoma, occurred more often than expected in those members of the study population with the greatest exposure. Even though the excesses were not statistically significant, the findings warrant further study.
6. Other cancers occurred at lower levels than in the general male population, with the exception of cancers of the buccal cavity and pharynx. There was an excess of these

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cancers, which however was inversely related to exposure.

The explanation for this finding is not apparent.

## II. INTRODUCTION

The study was begun by Tabershaw/Cooper, Associates, Inc. on June 15, 1973, under contract from the Manufacturing Chemists Association. The original eight month period of the contract was later extended by two months, in consideration of logistical problems arising from the number of plants which participated in the study.

The objectives of the study are:

- (1) To compare the mortality of individuals who have worked in vinyl chloride plants with that of the general population;
- (2) To compare mortality patterns within the population of vinyl chloride workers, based upon estimated occupational exposure; and
- (3) To compare mortality among vinyl chloride workers with the mortality of other groups which TCA, Inc. has studied.

The study took the form of a historical prospective mortality study. The study population consisted of individuals who had worked for at least one year in a job involving exposure to vinyl chloride before December 31, 1972, and included retired and terminated as well as active workers. For each such worker the date of birth and an employment history were obtained, and the vital status of the worker as of December 31, 1972, was ascertained. For those found to have died, those death certificates that were available were obtained and the cause of death determined. The observed mortality was compared with that of the United States male population.

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### III. SELECTION OF STUDY PLANTS

The Manufacturing Chemists Association identified 43 United States plants belonging to 19 companies, which either produced vinyl chloride or used it in the production of polyvinyl chloride. The name and address of a responsible liaison person at each company and plant was provided to TCA, Inc. (Attachment A).

A brief questionnaire was sent to each plant to obtain an estimate of the exposed population and to find out how far back in time personnel records could be obtained, and to determine whether job histories were available for retired and terminated workers (Attachment B).

All the plants responded. On the basis of the replies, four plants were dropped from the study because they had begun operation after 1968. It was felt that exposures in such plants would be too recent and too brief to provide useful data. Study of one other plant was deferred because it had stopped production of vinyl chloride seven years ago, and appeared to present difficulties in identifying an exposed population.

In addition, three more plants were excluded from analysis because, when data analysis began, it was found that information from these plants was defective in one of several respects (e.g., no exposure data, no job histories available for terminated employees, etc.).

The present report therefore deals with 35 domestic plants involved in either VCM or PVC production, which provided a study population of 8384 individuals.

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#### IV. DATA COLLECTION

In each plant, data were collected for each worker stated by the plant management to have been employed for at least one year in a job involving exposure to vinyl chloride. In some plants, particularly those producing the monomer, this determination could be made on the basis of job titles. Usually, however, exposure was a function of both job title and the location of the job in the plant, so that the assessment of exposure had to be made on a case-by-case basis by plant officials.

Data were collected for as far back in time as complete records were kept. In most cases this covered the entire history of the plant. In others, records were kept for a fixed period such as a decade. In a few, records were kept for different periods, depending on whether the worker had died on the job or had left employment.

In the latter case it was necessary to exercise care in defining the period for which study data were to be collected. For example, if a plant kept records for five years on those who left employment, but kept them indefinitely for those who died on the job, no termination could be included in the study unless it occurred within the last five years. Data from the earlier period would be biased for the purpose of this study, since a worker had to die to be in the records for the earlier period. The policy therefore was to determine how long each kind of record was kept (quit, discharged, retired and alive, retired and deceased, died while employed) and to define the study period as the shortest of these.

One problem which arose in the PVC plants resulted from the fact that a worker could transfer within the plant from exposed to non-exposed jobs. Therefore, even though the number of workers in exposed jobs at a given

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time may have been a small proportion of the total work force, it was necessary to search every worker's record to find those who might in the past have had over a year's experience in exposed jobs. Several of the PVC plants undertook to conduct this search themselves.

As a result, plant data were collected in two ways. In some plants, a TCA, Inc., team visited the establishment, copied the records designated by management as representing exposed workers, and obtained sufficiently detailed exposure estimates to produce a job history. In others, the plants were provided by TCA, Inc. with standard forms which they filled out for workers whom they identified as exposed. Three basic forms were used, depending on whether the worker was known to be alive, known to be dead, or was of unknown status. In all three cases a work history with estimated exposure was recorded, the differences being in the ancillary data required. Attachment C shows such a form for workers known to be dead.

Approximately 5000 of the study population came from plants visited by TCA, Inc., while the remainder came from plants which had filled out the forms themselves.

#### V. THE MEASUREMENT OF EXPOSURE

The job history forms (Attachment C) were originally designed in the expectation that vinyl chloride exposure on each job could be quantified in parts per million. This proved generally to be impossible. However, industrial hygiene and safety personnel in each plant were able to identify certain jobs and locations as involving the highest exposures in the plant, and to classify other exposures as medium or low relative to the "high" represented by the jobs with the greatest exposure. Therefore, the attempt

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to obtain objective exposure data was abandoned, and each exposed job in the worker's history was scored 1, 2, or 3 to indicate low, medium or high estimated exposure.

This gross classification has two major failings, as a result of the subjective nature of the estimates. The first is that the scores represent estimated relative exposure within a given plant. It is therefore possible that, in objective terms, a "high" score in one plant corresponds to a "medium" or even "low" score in another. The second is that exposures in most plants have tended to decrease over time, so that a worker with long service may have had jobs in the remote past which involved "low" exposure relative to other jobs at that time, but which might be "high" in comparison with current exposures in the same job. This subjective classification is therefore of questionable validity in characterizing the exposure of a given worker. For epidemiological purposes, however, those who have high scores can reasonably be expected, on the average, to have had the greatest exposure, while those with low scores will have had the least, even though the true exposure in each group may vary considerably from person to person.

The estimated exposure history of each worker was summarized by calculating An Exposure Index (EI). This was done by multiplying the number of months on each job by the exposure score, totalling these overall exposed jobs, and dividing by the total number of months of exposure.

#### VI. FOLLOW-UP OF STUDY POPULATION

A follow-up procedure was instituted for those who had left employment and whose vital status could not be determined at the local plant. A portion of the terminations was traced by mail, using a form letter sent to the last

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known address. Attachment D shows such a letter. If the letter was returned as undeliverable, the procedure shown in Figure 1 was used to obtain a current address.

The remainder of the terminations was traced through a retail credit bureau. The latter was also done for a portion of those who could not be found by the mail follow-up.

Approximately 5500 of the study population came from plants in which direct mail follow up was employed. In the remainder of the population follow-ups was by retail credit bureau. There was no significant difference between the success rates of the two methodologies.

Table 1 shows the vital status of the study population as of December 31, 1972. Follow-up is 85 percent complete, although follow-up data were still being received at the time the files were closed for this report. Of the 352 workers known to be dead, death certificates have been received for all but 24.

The mortality calculations in the succeeding sections of this report are based only on those workers who were successfully traced, which is equivalent to assuming that mortality among those not found is the same as among those who were found. In order to examine the reasonableness of this assumption, the differences between those found and not found are examined briefly as part of the following section.

#### VII. DESCRIPTION OF STUDY POPULATION

Table 2 shows the distribution of those successfully traced, by year of birth and number of months of exposure. The median birth year was 1931 (compared with 1920 for those not found) and the median duration of employment in an exposed job was 80 months (44 months in those not found). The

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shortest exposures occur in both the oldest men, most of whose working life was over when vinyl chloride came into general use, and the youngest men, whose date of hire was closer to the closing date of the study.

Although nearly half of the study population had less than 60 months of exposed employment, there were nevertheless 855 workers with 20 years or more exposure, and 1641 with 15 years or more.

Table 3 shows the distribution by duration of exposure and the year in which exposure began. The median year in which exposure began was 1962 (versus 1953 for those not found). Notice that almost half the study population first entered exposed employment in the decade 1960-69. This reflects the fact that a great many plants first began vinyl chloride operations in that decade and means that these workers have not been followed for any substantial length of time after their exposure occurred.

Table 4 shows the relationship between duration of exposure and Exposure Index (EI). The median EI is 1.44 (1.75 for those not found). There does not appear to be a close relationship between the EI and the duration of exposure, that is, workers with a higher EI do not differ substantially in duration of exposure from those with a lower EI. One implication is that in assessing the relationship between mortality and exposure, both duration and level of exposure should be examined separately, as well as in combination.

The data shown above for those not found indicates that they were born (and began their exposure) about 10 years before the group on which follow-up was complete, and had about half the duration of employment with a slightly higher EI. Typically, their employment in an exposed job ended before 1960. The bulk of these workers came from older plants from

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which data were collected late in the study.

Although there appears to be nothing very unusual about this group in terms of work history and exposure, it is nevertheless true that their exposures took place further back in time than that of the group successfully traced. It is therefore possible that their mortality, after a substantial latent period, might show a somewhat different pattern of mortality from the traced group.

#### VIII. CALCULATION OF RISK OF DEATH

The usual method of describing the risk of death in a study of this kind is to express the number of deaths which actually occurred as a percentage of the number which would have been expected in a comparable male population observed over the same age and time intervals. This statistic is called the Standardized Mortality Ratio (SMR).

In order to calculate the number of expected deaths it is first necessary to calculate the number of years for which each worker was observed, and to classify these years of observation by the age intervals into which they fell and the birth date of the worker.

Table 5 shows such a calculation for the 7128 vinyl chloride workers on whom follow-up was complete. This group represents 77,846 person-years of observation. For example, the table shows that for workers born in the years 1925-29, there were 2725 person-years of observation in the age interval 30-34, and an easy calculation shows that these person-years were lived in a period whose midpoint was about 1960. Therefore, the number of deaths to be expected in this cell of the table is the number of deaths occurring in 1960 among 2725 males aged 30-34 in a comparable non-exposed population.

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In the present study the U. S. male population was used as the standard of comparison, and the age-specific U. S. male death rates for the appropriate ages and years were applied to the corresponding cells of Table 5 to obtain the expected deaths.<sup>1</sup> This was done for all causes of death together, and for each of the 35 causes for which detailed mortality rates are published on a national basis (omitting such causes as breast cancer, congenital malformations, and diseases of infancy).

Table 6 shows observed and expected deaths, and the SMR, for each of these causes for the total study group. In calculating the SMR's for specific causes, the 24 deaths for which no certificates were found were assumed to have the same cause distribution as those for which certificates were available.

In the standard population, each SMR would be equal to 100. Therefore, the statistical significance of the deviation of each SMR in the study population from the expected value of 100 was tested. A single asterisk indicates those SMR's which differed significantly from 100 at the 5 percent level, that is, which had a probability of .05 or less of occurring by chance. A double asterisk indicates those which were significant at the 1 percent level. SMR's based on fewer than 5 observed cases were not tested for significance.<sup>2</sup> The practical interpretation of these statistical statements will be examined below.

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<sup>1</sup> Each diagonal in Table 5 corresponds to experience centered around a given year. For the first three diagonals (from left to right) 1950 rates were used; for the next three, 1955, 1959 and 1965 rates were used; for the last two, 1967 rates were used.

<sup>2</sup> Large-sample tests of significance were derived from: Chiang, C. L., "Standard error of the age-adjusted death rate," Vital Statistics Special Reports, 47 (1961) pp 275-285.

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Table 7 shows the same SMR's for workers with an Exposure Index below 1.5 versus those at 1.5 or above. The dividing point of 1.5 represents a level halfway between "low" and "medium."

Table 8 shows similar results for workers with less than 5 years exposure versus those with 5 years or more.

In order to examine the possible interaction between duration and level of exposure, the study population was divided into 4 groups on the basis of both EI (low vs high) and duration of exposure (short vs long) using the same dichotomization as Tables 7 and 8.

Table 9 shows the results for short versus long exposure in the low EI group, and Table 10 shows the same comparison in the high EI group.

In each of the above tables, deaths for which certificates had not been received were assumed to be distributed as a uniform percentage of all causes. The cause specific SMR's were therefore adjusted upward by a percentage which varied in each subgroup. Table II shows the distribution of uncertified deaths in each group, and the resulting percentage by which the cause specific SMR's were increased.

#### IX. ANALYSIS

The overall mortality of the study population is statistically significantly lower than that of the U. S. male population. There were 352 observed deaths compared with 467 expected, for an SMR of 75.

Table 6 shows that no specific cause of death was statistically significantly greater than expected. Several, particularly heart disease, accidents and "other diseases" not detailed in the tables, were significantly below their expected values.

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When the study population is divided according to length and duration of exposure (Tables 7 and 8) and combinations of these measurements (Tables 9 and 10) three major patterns emerge.

For malignant neoplasms as a whole, the SMR increases with increasing exposure, whether measured by level, duration, or both. In the high exposure group with 5 years or more exposure (Table 10) there are 36 observed cases and 26.11 expected.

For cardiovascular - renal diseases as a group, there are also increases in the SMR with increasing exposure, but the number of observed cases remain less than expected, the differences being statistically significant in all groups except the high exposure, long duration group in Table 11.

For all other causes, there are no consistent relationships with exposure.

Within the malignant neoplasms, the largest (although not statistically) significant SMR is in cancers of the buccal cavity and pharynx, with 5 observed, 2.84 expected, and an SMR of 189. However, Tables 7 to 10 show that all these cases have Exposure Indexes below 1.5, and 4 out of the 5 have less than 5 years exposure.

Cancer of the digestive system shows no excess in the study population as a whole. However, in those workers with Exposure Indexes of 1.5 or higher, there are 12 observed cases where 9.14 are expected (table 7). In the subgroup of the above workers with 5 years or more exposure, there are 11 observed cases and 7.47 expected.

Respiratory cancer shows a slight excess in the total group, and a similar pattern for different exposure categories, with 13 observed versus 10.28 expected when the Exposure Index is 1.5 or higher, and 12 observed versus 8.50 expected when, in addition, the duration of exposure is 5 years

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or more.

Malignant neoplasms of other and unspecified sites show an excess in the total group, and an increase with both level and duration of exposure (Tables 7 and 8). The relationship with exposure is more pronounced, since those with exposures of less than 5 years have fewer cases than expected.

The lymphosarcomas, although occurring at about the expected rate when the whole group is considered, are concentrated almost entirely in the high exposure long duration group. In that category there are 4 cases observed and 1.84 expected.

Cancers of the genital and urinary organs, and leukemia, have fewer cases than expected. The number of cases is too small to examine any trends.

#### X. DISCUSSION

The favorable overall mortality of the study population is a phenomenon commonly observed in working populations. Studies of several occupational groups have shown that, even if there is an occupational hazard which greatly increases the risk of death from a particular cause, the overall mortality may well be favorable. Table 12 shows the SMR's obtained in a number of recent studies of other occupational groups. Although for technical reasons these SMR's are not strictly comparable, the overall mortality in the present study is clearly favorable.

SMR's which are higher than expected may be worthy of attention even if they are not statistically significant. This is especially true in the present study since the number of deaths from many causes is quite small, and even a relatively high SMR may not reach statistical significance.

If, in addition, a particular cause shows a consistent pattern of increase with exposure or estimated exposure, the findings are particularly

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unknown. About 40 percent of the observed deaths were due to brain cancer. In the general male population, about 22 percent of this category is due to brain cancer, so that not only is the mortality from this cause excessive, but brain cancer is overrepresented.

The possibility exists based on the lack of specificity of some of the listed causes that some of the brain cancers were not primary, but metastases from another unidentified site such as the lung.

The cancers of the buccal cavity and pharynx are difficult to explain because of their occurrence in the low exposure - short exposure group. It is possible that this is a chance occurrence, or that exposures to other substances were involved.

#### XI. POSSIBLE BIASES IN THE CALCULATION OF RISK

There are three areas in which bias could have entered the calculation of the above SMR's. The first is the choice of the U. S. male population as a standard. The second is the absence of 15 percent of the population who were not found. The third is the discovery, as the study ended, of a group of 1500 workers whose exposures occurred up to 35 years ago, and who are not included in the study group.

The choice of the U. S. male population was not entirely appropriate. The study population was concentrated almost entirely in the Eastern half of the United States, whose normal mortality is slightly higher than that of the whole country. This implies that the correct expected values should have been slightly higher than the ones which were used, and the corresponding SMR's slightly lower. This has no practical significance except for those malignancies in which the SMR's were above 100. However, regional differences in mortality from those causes is such that these SMR's would have been at most 1.5 to 3 percent lower, with no substantive difference in the results.

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The workers who could not be traced may conceivably contain a disproportionate number of deaths, which could increase the overall SMR. It appears unlikely that the distribution of causes would be substantially different. However, without actual data in hand, the possibility cannot be ruled out that either some new causes of death might become significant, or that some of the relationships found in this study might be diluted.

The same comments apply even more to the group of 1500 workers discovered too late to be included in the study group, since they would provide data in precisely the area (very long exposure and long latency) in which the present study is relatively weak.

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Table 1

Follow-up Status of 8384 Vinyl Chloride Workers

|         | Total | Alive | Dead | Unknown | Death Certificates |            |
|---------|-------|-------|------|---------|--------------------|------------|
|         |       |       |      |         | Rec'd.             | Not Rec'd. |
| Number  | 8384  | 6776  | 352  | 1256    | 328                | 24         |
| Percent | 100.0 | 80.8  | 4.2  | 15.0    | 92.7               | 7.3        |

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Table 2

Distribution of Months in Exposed Employment by Birth Year,  
for 7128 Vinyl Chloride Workers with Completed Follow-up

| Year of birth | Total | Months of exposure |        |         |         |         |         |         | Unknown |
|---------------|-------|--------------------|--------|---------|---------|---------|---------|---------|---------|
|               |       | <60                | 60-119 | 120-179 | 180-239 | 240-299 | 300-359 | 360-419 |         |
| 1875-79       | 1     | 1                  |        |         |         |         |         |         |         |
| 1880-84       | 5     |                    | 2      | 2       | 1       |         |         |         |         |
| 1885-89       | 7     | 1                  | 3      | 3       |         |         |         |         |         |
| 1890-94       | 21    | 3                  | 7      | 9       | 2       |         |         |         |         |
| 1895-99       | 38    | 10                 | 4      | 9       | 12      | 2       |         |         | 1       |
| 1900-04       | 89    | 9                  | 13     | 21      | 22      | 17      | 6       |         | 1       |
| 1905-09       | 214   | 33                 | 27     | 35      | 37      | 43      | 34      | 3       | 2       |
| 1910-14       | 404   | 79                 | 62     | 58      | 72      | 73      | 43      | 15      | 2       |
| 1915-19       | 648   | 145                | 96     | 80      | 120     | 105     | 84      | 13      | 5       |
| 1920-24       | 897   | 229                | 191    | 98      | 143     | 160     | 64      | 8       | 4       |
| 1925-29       | 940   | 276                | 214    | 118     | 169     | 139     | 20      |         | 4       |
| 1930-34       | 877   | 287                | 252    | 128     | 181     | 26      |         |         | 3       |
| 1935-39       | 986   | 454                | 378    | 120     | 27      |         |         |         | 7       |
| 1940-44       | 1169  | 664                | 481    | 16      |         |         |         |         | 8       |
| 1945-49       | 700   | 632                | 66     |         |         |         |         |         | 2       |
| 1950-54       | 132   | 132                |        |         |         |         |         |         |         |
| Total         | 7128  | 2955               | 1796   | 697     | 786     | 565     | 25      | 39      | 39      |

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Table 3

Distribution of Months in Exposed Employment by Year  
in Which Exposure Began, for 7128 Vinyl Chloride Workers with Completed Follow-up

| Year Exp.<br>Started | Total | Months of Exposure |        |         |         |         |         |         | Unknown |
|----------------------|-------|--------------------|--------|---------|---------|---------|---------|---------|---------|
|                      |       | <60                | 60-119 | 120-179 | 180-239 | 240-299 | 300-359 | 360-419 |         |
| 1930-39              | 35    | 2                  | 4      | 1       | 4       | 6       | 13      | 5       |         |
| 1940-49              | 1048  | 135                | 93     | 119     | 151     | 277     | 237     | 34      | 2       |
| 1950-59              | 1962  | 389                | 257    | 383     | 631     | 282     |         |         | 20      |
| 1960-69              | 3368  | 1714               | 1442   | 195     |         |         |         |         | 17      |
| 1970-71              | 715   | 715                |        |         |         |         |         |         |         |
| Total                | 7128  | 2955               | 1796   | 698     | 786     | 565     | 250     | 39      | 39      |

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**Table 4**  
**Distribution by Months of Exposed Employment and**  
**Exposure Index**  
**for 7128 Vinyl Chloride Workers with Complete Follow-up**

| Exposure Index | Total | Months of exposure |        |         |         |         |         |         | Unknown |
|----------------|-------|--------------------|--------|---------|---------|---------|---------|---------|---------|
|                |       | <60                | 60-119 | 120-179 | 180-239 | 240-299 | 300-359 | 360-419 |         |
| 1.0-1.4        | 4032  | 1715               | 1125   | 402     | 406     | 274     | 92      | 18      |         |
| 1.5 +          | 3057  | 1240               | 671    | 295     | 380     | 291     | 159     | 21      |         |
| Unknown        | 39    |                    |        |         |         |         |         |         | 39      |
| Total          | 7128  | 2955               | 1796   | 697     | 786     | 565     | 251     | 39      | 39      |

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Table 5

Person Years of Observation by Year of Birth and  
Age for Vinyl Chloride Workers

| Age   | Totals | Year of Birth |      |      |      |      |      |      |      |       |       |       |      |      |      |      |      |
|-------|--------|---------------|------|------|------|------|------|------|------|-------|-------|-------|------|------|------|------|------|
|       |        | 1875          | 1880 | 1885 | 1890 | 1895 | 1900 | 1905 | 1910 | 1915  | 1920  | 1925  | 1930 | 1935 | 1940 | 1945 | 1950 |
|       |        | 1879          | 1884 | 1889 | 1894 | 1899 | 1904 | 1909 | 1914 | 1919  | 1924  | 1929  | 1934 | 1939 | 1944 | 1949 | 1954 |
| Total | 77846  | 13            | 92   | 124  | 317  | 705  | 1662 | 4055 | 6710 | 11038 | 14305 | 13807 | 9408 | 7239 | 6174 | 2023 | 174  |
| 15-19 | 134    |               |      |      |      |      |      |      |      |       | 1     | 11    | 12   | 5    | 53   | 21   | 31   |
| 20-24 | 4070   |               |      |      |      |      |      |      |      | 39    | 180   | 572   | 440  | 475  | 920  | 1301 | 143  |
| 25-29 | 12076  |               |      |      |      |      |      |      | 32   | 335   | 1090  | 1882  | 1642 | 2173 | 4221 | 701  |      |
| 30-34 | 13861  |               |      |      |      |      |      | 14   | 264  | 1054  | 2183  | 2725  | 2863 | 3778 | 980  |      |      |
| 35-39 | 13550  |               |      |      |      |      | 3    | 221  | 697  | 1685  | 2742  | 3688  | 3706 | 808  |      |      |      |
| 40-44 | 12031  |               |      |      |      | 5    | 70   | 524  | 1028 | 2044  | 3502  | 4113  | 745  |      |      |      |      |
| 45-49 | 9527   |               |      |      |      | 56   | 241  | 710  | 1226 | 2531  | 3847  | 816   |      |      |      |      |      |
| 50-54 | 6368   |               |      |      | 35   | 135  | 334  | 762  | 1574 | 2768  | 760   |       |      |      |      |      |      |
| 55-59 | 3632   |               |      | 22   | 88   | 155  | 363  | 886  | 1636 | 482   |       |       |      |      |      |      |      |
| 60-64 | 1684   |               | 14   | 35   | 77   | 142  | 341  | 822  | 253  |       |       |       |      |      |      |      |      |
| 65-69 | 632    | 2             | 25   | 31   | 62   | 126  | 270  | 116  |      |       |       |       |      |      |      |      |      |
| 70-74 | 202    | 5             | 23   | 20   | 43   | 71   | 40   |      |      |       |       |       |      |      |      |      |      |
| 75-79 | 58     | 5             | 15   | 11   | 12   | 15   |      |      |      |       |       |       |      |      |      |      |      |
| 80-84 | 16     | 1             | 10   | 5    |      |      |      |      |      |       |       |       |      |      |      |      |      |
| 85-89 | 5      |               | 5    |      |      |      |      |      |      |       |       |       |      |      |      |      |      |

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TABLE 6

## OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS IN VINYL CHLORIDE WORKERS

| Cause of death with I.C.D. number                                   | obs/exp    | SMR <sup>1</sup> |
|---------------------------------------------------------------------|------------|------------------|
| All causes                                                          | 352/467.28 | 75**             |
| Tuberculosis (001-019)                                              | 1/5.71     | 19               |
| Tuberculosis of respiratory system (001-008)                        | 1/5.34     | 20               |
| Malignant neoplasms (140-205)                                       | 79/77.16   | 110              |
| Malignant neoplasms, buccal cavity and pharynx (140-148)            | 5/2.84     | 189              |
| Malignant neoplasms, digestive organs and peritoneum (150-159)      | 19/21.67   | 94               |
| Malignant neoplasms, respiratory system (160-164)                   | 25/23.93   | 112              |
| Malignant neoplasms, genital organs (170-179)                       | 3/3.55     | 91               |
| Malignant neoplasms, urinary organs (180-181)                       | 1/3.60     | 30               |
| Malignant neoplasms, other and unspecified sites (190-199)          | 17/11.75   | 155              |
| Leukemia and aleukemia (204)                                        | 3/3.77     | 85               |
| Lymphosarcoma, lymphatic and hematopoietic tissues (200-203, 205)   | 6/6.06     | 106              |
| Diabetes mellitus (260)                                             | 7/6.31     | 120              |
| Major cardiovascular and renal diseases (330-334, 400-468, 592-594) | 155/207.46 | 80**             |
| Vascular lesions affecting CNS (330-334)                            | 13/24.48   | 57**             |
| Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)   | 5/6.87     | 78               |
| Arteriosclerotic heart disease (420)                                | 121/137.33 | 95               |
| Nonrheumatic endocarditis (421, 422)                                | 1/6.58     | 16               |
| Hypertensive heart disease (440-443)                                | 3/9.33     | 35               |
| Other hypertensive disease (444-447)                                | 3/2.60     | 124              |
| Chronic & unspecified nephritis & renal sclerosis (592-594)         | 0/4.27     | 0                |
| Influenza and pneumonia (480-493)                                   | 5/9.96     | 54*              |
| Ulcer of stomach and duodenum (540, 541)                            | 2/3.83     | 56               |
| Appendicitis (550-553)                                              | 0/0.66     | 0                |
| Hernia and intestinal obstruction (560, 561, 570)                   | 1/1.51     | 71               |
| Gastritis, duodenitis, enteritis and colitis (543, 571, 572)        | 1/1.31     | 82               |
| Cirrhosis of liver (581)                                            | 3/15.60    | 21               |
| Hyperplasia of prostate (610)                                       | 0/0.39     | 0                |
| Symptoms, senility and ill-defined conditions (780-795)             | 1/7.34     | 15               |
| All other diseases (residual)                                       | 21/45.78   | 49**             |
| Motor vehicle accidents (810-835)                                   | 17/32.70   | 56**             |
| Other accidents (800-802, 840-962)                                  | 18/30.64   | 63**             |
| Suicide (963, 970-979)                                              | 16/16.83   | 102              |
| Homicide (964, 980-985)                                             | 1/11.98    | 9                |
| Number of workers                                                   | 7128       |                  |
| Person-years                                                        | 77846      |                  |

<sup>1</sup>SMR's adjusted for deaths with cause unknown. See Table 11.

\*Significant at 5% level.

\*\*Significant at 1% level.

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OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS IN VINYL CHLORIDE WORKERS,  
BY ESTIMATED LEVEL OF EXPOSURE

| Cause of death with I.C.D. number                                   | EI <1.5    |                  | EI ≥1.5    |                  |
|---------------------------------------------------------------------|------------|------------------|------------|------------------|
|                                                                     | obs/exp    | SMR <sup>1</sup> | obs/exp    | SMR <sup>1</sup> |
| All causes                                                          | 188/270.33 | 70**             | 157/195.68 | 80**             |
| Tuberculosis (001-019)                                              |            |                  |            |                  |
| Tuberculosis of respiratory system (001-008)                        | 0/3.38     | 0                | 0/2.33     | 0                |
| Malignant neoplasms (140-205)                                       | 0/3.16     | 0                | 0/2.18     | 0                |
| Malignant neoplasms, buccal cavity and pharynx (140-148)            | 37/44.28   | 90               | 41/32.67   | 134              |
| Malignant neoplasms, digestive organs and peritoneum (150-159)      | 5/1.62     | 330              | 0/1.21     | 0                |
| Malignant neoplasms, respiratory system (160-164)                   | 7/12.50    | 60*              | 12/9.14    | 141              |
| Malignant neoplasms, genital organs (170-179)                       | 11/13.56   | 86               | 13/10.28   | 135              |
| Malignant neoplasms, urinary organs (180-181)                       | 2/2.30     | 93               | 1/1.43     | 75               |
| Malignant neoplasms, other and unspecified sites (190-199)          | 1/2.07     | 51               | 0/1.52     | 0                |
| Leukemia and aleukemia (204)                                        | 9/6.57     | 146              | 8/4.52     | 190              |
| Lymphosarcoma, lymphatic and hematopoietic tissues (200-203, 205)   | 1/2.38     | 49               | 2/1.57     | 136              |
| Diabetes mellitus (260)                                             | 1/3.48     | 31               | 5/2.54     | 212              |
| Major cardiovascular and renal diseases (330-334, 400-468, 592-594) | 5/3.65     | 146              | 2/2.65     | 81               |
| Vascular lesions affecting CNS (330-334)                            | 84/120.11  | 75**             | 69/86.99   | 85*              |
| Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)   | 7/14.42    | 52**             | 6/10.06    | 64               |
| Arteriosclerotic heart disease (420)                                | 3/3.98     | 80               | 2/2.85     | 75               |
| Nonrheumatic endocarditis (421, 422)                                | 68/78.94   | 92               | 51/58.05   | 95               |
| Hypertensive heart disease (440-443)                                | 0/4.20     | 0                | 1/2.89     | 38               |
| Other hypertensive disease (444-447)                                | 1/5.48     | 19               | 2/3.86     | 56               |
| Chronic & unspecified nephritis & renal sclerosis (592-594)         | 1/1.52     | 70               | 2/1.07     | 201              |
| Influenza and pneumonia (480-493)                                   | 0/2.50     | 0                | 0/1.77     | 0                |
| Ulcer of stomach and duodenum (540, 541)                            | 5/5.80     | 92               | 0/4.13     | 0                |
| Appendicitis (550-553)                                              | 1/2.21     | 48               | 1/1.60     | 68               |
| Hernia and intestinal obstruction (560, 561, 570)                   | 0/0.39     | 0                | 0/0.27     | 0                |
| Gastritis, duodenitis, enteritis and colitis (543, 571, 572)        | 0/0.88     | 0                | 1/0.63     | 171              |
| Cirrhosis of liver (581)                                            | 0/0.76     | 0                | 1/0.55     | 196              |
| Hyperplasia of prostate (610)                                       | 2/8.90     | 23               | 1/6.64     | 16               |
| Symptoms, senility and ill-defined conditions (780-795)             | 0/0.25     | 0                | 0/0.14     | 0                |
| All other diseases (residual)                                       | 0/4.22     | 0                | 1/3.09     | 34               |
| Motor vehicle accidents (810-835)                                   | 14/21.90   | 68*              | 6/15.89    | 41**             |
| Other accidents (800-802, 840-962)                                  | 8/19.08    | 45**             | 9/13.46    | 72               |
| Suicide (963, 970-979)                                              | 11/17.83   | 66*              | 6/12.67    | 50**             |
| Homicide (964, 980-985)                                             | 9/9.73     | 98               | 7/7.02     | 107              |
|                                                                     | 0/6.98     | 0                | 1/4.94     | 21               |
| Number of workers                                                   | 4032       |                  | 3057       |                  |
| Person-years                                                        | 45354      |                  | 32108      |                  |

<sup>1</sup>SMR's adjusted for deaths with cause unknown. See Table 11.

\*Significant at 5% level.

\*\*Significant at 1% level.

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UCC 080023

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TABLE 8

OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS IN VINYL CHLORIDE WORKERS  
BY DURATION OF EXPOSED EMPLOYMENT

| Cause of death with I.C.D. number                                   | <60 months |                  | ≥60 months |                  |
|---------------------------------------------------------------------|------------|------------------|------------|------------------|
|                                                                     | obs/exp    | SMR <sup>1</sup> | obs/exp    | SMR <sup>1</sup> |
| All causes                                                          | 94/140.53  | 67**             | 251/329.30 | 76**             |
| Tuberculosis (001-019)                                              | 0/2.23     | 0                | 0/3.55     | 0                |
| Tuberculosis of respiratory system (001-008)                        | 0/2.07     | 0                | 0/3.33     | 0                |
| Malignant neoplasms (140-205)                                       | 13/19.96   | 78               | 65/57.61   | 116              |
| Malignant neoplasms, buccal cavity and pharynx (140-148)            | 4/0.70     | 688              | 1/2.16     | 47               |
| Malignant neoplasms, digestive organs and peritoneum (150-159)      | 2/5.26     | 46               | 17/16.56   | 106              |
| Malignant neoplasms, respiratory system (160-164)                   | 3/5.52     | 65               | 21/18.51   | 116              |
| Malignant neoplasms, genital organs (170-179)                       | 0/0.99     | 0                | 3/2.76     | 112              |
| Malignant neoplasms, urinary organs (180-181)                       | 0/0.83     | 0                | 1/2.79     | 37               |
| Malignant neoplasms, other and unspecified sites (190-199)          | 2/3.40     | 71               | 15/8.23    | 187              |
| Leukemia and aleukemia (204)                                        | 1/1.25     | 96               | 2/2.53     | 81               |
| Lymphosarcoma, lymphatic and hematopoietic tissues (200-203, 205)   | 1/2.01     | 60               | 5/4.07     | 126              |
| Diabetes mellitus (260)                                             | 2/1.80     | 134              | 5/4.54     | 113              |
| Major cardiovascular and renal diseases (330-334, 400-468, 592-594) | 28/51.45   | 65**             | 125/157.39 | 81**             |
| Vascular lesions affecting CNS (330-334)                            | 4/5.97     | 81               | 9/18.71    | 49**             |
| Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)   | 2/2.39     | 101              | 3/4.53     | 68               |
| Arteriosclerotic heart disease (420)                                | 21/32.54   | 78*              | 98/105.39  | 96               |
| Nonrheumatic endocarditis (421, 422)                                | 0/1.79     | 0                | 1/5.35     | 20               |
| Hypertensive heart disease (440-443)                                | 1/2.42     | 49               | 2/7.01     | 30               |
| Other hypertensive disease (444-447)                                | 0/0.79     | 0                | 3/1.82     | 170              |
| Chronic & unspecified nephritis & renal sclerosis (592-594)         | 0/1.55     | 0                | 0/2.76     | 0                |
| Influenza and pneumonia (480-493)                                   | 3/2.93     | 123              | 2/7.09     | 29               |
| Ulcer of stomach and duodenum (540, 541)                            | 1/1.07     | 112              | 1/2.78     | 37               |
| Appendicitis (550-553)                                              | 0/0.24     | 0                | 0/0.43     | 0                |
| Hernia and intestinal obstruction (560, 561, 570)                   | 0/0.42     | 0                | 1/1.10     | 93               |
| Gastritis, duodenitis, enteritis and colitis (543, 571, 572)        | 1/0.40     | 301              | 0/0.92     | 0                |
| Cirrhosis of liver (581)                                            | 1/4.49     | 26               | 2/11.18    | 18               |
| Hyperplasia of prostate (610)                                       | 0/0.07     | 0                | 0/0.33     | 0                |
| Symptoms, senility and ill-defined conditions (780-795)             | 1/2.28     | 53               | 0/5.09     | 0                |
| All other diseases (residual)                                       | 4/11.97    | 40               | 16/26.34   | 63*              |
| Motor vehicle accidents (810-835)                                   | 10/16.14   | 75               | 7/16.65    | 43**             |
| Other accidents (800-802, 840-962)                                  | 7/12.94    | 65*              | 10/17.82   | 58*              |
| Suicide (963, 970-979)                                              | 6/6.34     | 114              | 10/10.28   | 100              |
| Homicide (964, 980-985)                                             | 1/5.80     | 20               | 0/6.20     | 0                |
| Number of workers                                                   | 2955       |                  | 4134       |                  |
| Person-years                                                        | 34201      |                  | 43240      |                  |

<sup>1</sup>SMR's adjusted for deaths with cause unknown. See Table 11.

\*Significant at 5% level.

\*\*Significant at 1% level.

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PRIVILEGED AND  
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OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS IN VINYL CHLORIDE WORKERS  
WITH EXPOSURE INDICES BELOW 1.5, BY DURATION OF EXPOSED EMPLOYMENT

| Cause of death with I.C.D. number                                   | ≤60 months exposure |                  | ≥60 months exposure |                  |
|---------------------------------------------------------------------|---------------------|------------------|---------------------|------------------|
|                                                                     | obs/exp             | SMR <sup>1</sup> | obs/exp             | SMR <sup>1</sup> |
| All causes                                                          | 56/89.23            | 63**             | 132/181.28          | 73**             |
| Tuberculosis (001-019)                                              | 0/1.41              | 0                | 0/1.97              | 0                |
| Tuberculosis of respiratory system (001-008)                        | 0/1.31              | 0                | 0/1.85              | 0                |
| Malignant neoplasms (140-205)                                       | 8/12.86             | 73               | 29/31.46            | 93               |
| Malignant neoplasms, buccal cavity and pharynx (140-148)            | 4/0.45              | 1036             | 1/1.17              | 88               |
| Malignant neoplasms, digestive organs and peritoneum (150-159)      | 1/3.43              | 34               | 6/9.08              | 68               |
| Malignant neoplasms, respiratory system (160-164)                   | 2/3.58              | 65               | 9/10.00             | 93               |
| Malignant neoplasms, genital organs (170-179)                       | 0/0.68              | 0                | 2/1.62              | 127              |
| Malignant neoplasms, urinary organs (180-181)                       | 0/0.55              | 0                | 1/1.53              | 67               |
| Malignant neoplasms, other and unspecified sites (190-199)          | 1/0.97              | 120              | 8/4.43              | 187              |
| Leukemia and aleukemia (204)                                        | 0/0.79              | 0                | 1/1.40              | 73               |
| Lymphosarcoma, lymphatic and hematopoietic tissues (200-203,205)    | 0/1.26              | 0                | 1/2.23              | 46               |
| Diabetes mellitus (260)                                             | 2/1.15              | 203              | 3/2.50              | 124              |
| Major cardiovascular and renal diseases (330-334, 400-468, 592-594) | 21/33.38            | 73**             | 63/86.82            | 75**             |
| Vascular lesions affecting CNS (330-334)                            | 2/3.93              | 59               | 5/10.51             | 49*              |
| Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)   | 2/1.50              | 155              | 1/2.49              | 41               |
| Arteriosclerotic heart disease (420)                                | 16/21.14            | 88               | 52/57.87            | 93               |
| Nonrheumatic endocarditis (421, 422)                                | 0/1.18              | 0                | 0/3.02              | 0                |
| Hypertensive heart disease (440-441)                                | 1/1.58              | 74               | 0/3.90              | 0                |
| Other hypertensive disease (444-447)                                | 0/0.50              | 0                | 1/1.02              | 101              |
| Chronic & unspecified nephritis & renal sclerosis (592-594)         | 0/0.97              | 0                | 0/1.53              | 0                |
| Influenza and pneumonia (480-493)                                   | 3/1.86              | 188              | 2/3.95              | 53               |
| Ulcer of stomach and duodenum (540, 541)                            | 0/0.68              | 0                | 1/1.53              | 67               |
| Appendicitis (550-553)                                              | 0/0.15              | 0                | 0/0.24              | 0                |
| Hernia and intestinal obstruction (560, 561, 570)                   | 0/0.27              | 0                | 0/0.61              | 0                |
| Gastritis, duodenitis, enteritis and colitis (543, 571, 572)        | 0/0.26              | 0                | 0/0.51              | 0                |
| Cirrhosis of liver (581)                                            | 1/2.80              | 42               | 1/6.09              | 16               |
| Hyperplasia of prostate (610)                                       | 0/0.05              | 0                | 0/0.20              | 0                |
| Symptoms, senility and ill-defined conditions (780-795)             | 0/1.43              | 0                | 0/2.79              | 0                |
| All other diseases (residual)                                       | 4/7.45              | 63               | 10/12.92            | 79               |
| Motor vehicle accidents (810-835)                                   | 3/9.87              | 35               | 5/9.22              | 56               |
| Other accidents (800-802, 840-962)                                  | 3/7.98              | 44               | 8/9.85              | 83               |
| Suicide (963, 970-979)                                              | 3/4.08              | 86               | 6/5.66              | 109              |
| Homicide (964, 980-985)                                             | 0/3.55              | 0                | 0/3.43              | 0                |
| Number of workers                                                   | 1715                |                  | 2317                |                  |
| Person-years                                                        | 21418               |                  | 23920               |                  |

<sup>1</sup>SMR's adjusted for deaths with cause unknown. See table 11.

\*Significant at 5% level.

\*\*Significant at 1% level.

May 2, 1974

PRIVILEGED AND  
"CONFIDENTIAL MATERIAL  
SUBJECT TO PROTECTIVE  
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UCC 080025

TABLE 10

OBSERVED DEATHS/EXPECTED DEATHS AND STANDARDIZED MORTALITY RATIOS IN VINYL CHLORIDE WORKERS  
WITH EXPOSURE INDICES OF 1.5 OR GREATER, BY DURATION OF EXPOSED EMPLOYMENT

| Cause of death with I.C.D. number                                   | <60 months exposure |                  | ≥60 months exposure |                  |
|---------------------------------------------------------------------|---------------------|------------------|---------------------|------------------|
|                                                                     | obs/exp             | SMR <sup>1</sup> | obs/exp             | SMR <sup>1</sup> |
| All causes                                                          | 38/47.93            | 79               | 119/147.81          | 81*              |
| Tuberculosis (001-019)                                              | 0/0.76              | 0                | 0/1.57              | 0                |
| Tuberculosis of respiratory system (001-008)                        | 0/0.71              | 0                | 0/1.48              | 0                |
| Malignant neoplasms (140-205)                                       | 5/6.57              | 96               | 36/26.11            | 141              |
| Malignant neoplasms, buccal cavity and pharynx (140-148)            | 0/0.23              | 0                | 0/0.99              | 0                |
| Malignant neoplasms, digestive organs and peritoneum (150-159)      | 1/1.67              | 76               | 11/7.47             | 151              |
| Malignant neoplasms, respiratory system (160-164)                   | 1/1.79              | 71               | 12/8.50             | 144              |
| Malignant neoplasms, genital organs (170-179)                       | 0/0.29              | 0                | 1/1.41              | 73               |
| Malignant neoplasms, urinary organs (180-181)                       | 0/0.26              | 0                | 0/1.26              | 0                |
| Malignant neoplasms, other and unspecified sites (190-199)          | 1/1.18              | 107              | 7/3.51              | 204              |
| Leukemia and aleukemia (204)                                        | 1/0.44              | 288              | 1/1.13              | 90               |
| Lymphosarcoma, lymphatic and hematopoietic tissues (200-203, 205)   | 1/0.71              | 178              | 4/1.84              | 222              |
| Diabetes mellitus (260)                                             | 0/0.61              | 0                | 2/2.04              | 100              |
| Major cardiovascular and renal diseases (330-334, 400-468, 592-594) | 7/16.54             | 54**             | 62/70.46            | 90               |
| Vascular lesions affecting CNS (330-334)                            | 2/1.87              | 135              | 4/8.19              | 50               |
| Rheumatic fever & chronic rheumatic heart dis. (400-402, 410-416)   | 0/0.82              | 0                | 2/2.04              | 100              |
| Arteriosclerotic heart disease (420)                                | 5/10.41             | 61*              | 46/47.65            | 98               |
| Nonrheumatic endocarditis (421, 422)                                | 0/0.57              | 0                | 1/2.32              | 44               |
| Hypertensive heart disease (440-443)                                | 0/0.76              | 0                | 2/3.10              | 66               |
| Other hypertensive disease (444-447)                                | 0/0.27              | 0                | 2/0.81              | 253              |
| Chronic & unspecified nephritis & renal sclerosis (592-594)         | 0/0.54              | 0                | 0/1.23              | 0                |
| Influenza and pneumonia (480-493)                                   | 0/0.99              | 0                | 0/3.13              | 0                |
| Ulcer of stomach and duodenum (540, 541)                            | 1/0.35              | 362              | 0/1.25              | 0                |
| Appendicitis (550-553)                                              | 0/0.08              | 0                | 0/0.19              | 0                |
| Hernia and intestinal obstruction (560, 561, 570)                   | 0/0.14              | 0                | 1/0.49              | 209              |
| Gastritis, duodenitis, enteritis and colitis (543, 571, 572)        | 1/0.14              | 904              | 0/0.41              | 0                |
| Cirrhosis of liver (581)                                            | 0/1.56              | 0                | 1/5.08              | 20               |
| Hyperplasia of prostate (610)                                       | 0/0.01              | 0                | 0/0.13              | 0                |
| Symptoms, senility and ill-defined conditions (780-795)             | 1/0.80              | 158              | 0/2.30              | 0                |
| All other diseases (residual)                                       | 0/4.02              | 0                | 6/11.88             | 51*              |
| Motor vehicle accidents (810-835)                                   | 7/6.05              | 146              | 2/7.43              | 28               |
| Other accidents (800-802, 840-962)                                  | 4/4.73              | 107              | 2/7.96              | 26               |
| Suicide (963, 970-979)                                              | 3/2.40              | 158              | 4/4.62              | 88               |
| Homicide (964, 980-985)                                             | 1/2.18              | 58               | 0/2.76              | 0                |
| Number of workers                                                   | 1240                |                  | 1817                |                  |
| Person-years                                                        | 12828               |                  | 19305               |                  |

<sup>1</sup>SMR's adjusted for deaths with cause unknown. See Table 11.

\*Significant at 5% level.

\*\*Significant at 1% level.

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Table 11

Distribution of Deaths by Exposure Category  
and by Whether Cause of Death Was Determined,  
and Correction Factors Used for SMR Calculations

|                           | Total* | Exposure Categories |      |                               |     |                                             |            |            |            |
|---------------------------|--------|---------------------|------|-------------------------------|-----|---------------------------------------------|------------|------------|------------|
|                           |        | Exposure Index      |      | Total Exposure Time in Months |     | Exposure Index and Total Exposure in Months |            |            |            |
|                           |        | <1.5                | ≥1.5 | <60                           | ≥60 | <1.5 & <60                                  | <1.5 & ≥60 | ≥1.5 & <60 | ≥1.5 & ≥60 |
| All causes                | 352    | 188                 | 157  | 94                            | 251 | 56                                          | 132        | 38         | 119        |
| Cause known               | 328    | 176                 | 146  | 78                            | 244 | 48                                          | 128        | 30         | 116        |
| Cause unknown             | 24     | 12                  | 11   | 16                            | 7   | 8                                           | 4          | 8          | 3          |
| Percent increase in SMR's | 7.3    | 6.8                 | 7.5  | 20.5                          | 2.8 | 16.6                                        | 3.1        | 26.6       | 2.5        |

\*Deaths in exposure categories do not add up to deaths in total category because 7 deaths had unknown exposure data, and one of those was of unknown cause.

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Table 12

## Results of Follow-up in Several Occupational Groups

| <u>Study Population</u>                   | <u>Number<br/>Observed</u> | <u>Years of<br/>Observation</u> | <u>SMR<br/>All causes</u> | <u>Reference</u>              |
|-------------------------------------------|----------------------------|---------------------------------|---------------------------|-------------------------------|
| Asbestos building<br>product workers      | 12,402                     | 1951-1963                       | 89                        | Enterline &<br>Kendrick, 1967 |
| Asbestos friction<br>material workers     | 7,510                      | "                               | 89                        | Enterline &<br>Kendrick, 1967 |
| Asbestos textile<br>plant workers         | 1,843                      | "                               | 121                       | Enterline &<br>Kendrick, 1967 |
| Cotton textile<br>workers                 | 6,281                      | "                               | 88                        | Enterline &<br>Kendrick, 1967 |
| White underground<br>uranium miners       | 3,414                      | 1950-1967                       | 159                       | Lundin et al,<br>1969         |
| Steelworkers                              | 59,072                     | 1953-1961                       | 82                        | Lloyd & Ciocco, 1969          |
| Asbestos insulation<br>workers > 20 years | 250                        | 1946-1965                       | 140                       | Tabershaw et al,<br>1970      |
| Coke oven workers                         | 4,661                      | 1951-1966                       | 98                        | Richmond et al, 1972          |
| Asbestos maintenance<br>service, etc.     | 438                        | 1941-1969                       | 124                       | Enterline et<br>al, 1972      |
| Asbestos insulation<br>workers > 20 years | 370                        | 1963-1971                       | 198                       | Hammond &<br>Selikoff, 1972   |
| Asbestos insulation<br>workers            | 17,800                     | 1967-1971                       | 136                       | Hammond &<br>Selikoff, 1972   |
| Uranium mill workers                      | 662                        | 1950-1967                       | 99                        | Archer et al, 1973            |
| Lead smelter workers                      | 2,352                      | 1946-1970                       | 107                       | TCA, Inc., unpublished        |
| Lead battery plant<br>workers             | 4,680                      | 1946-1970                       | 99                        | TCA, Inc., unpublished        |
| Petroleum refinery<br>workers             | 18,916                     | 1962-1971                       | 68                        | TCA, Inc., unpublished        |

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Table 13

## Angiosarcoma Deaths in VCM Epidemiology Study Population

| Study No. | Age at Death | Mos. Exposed | Cause as Given                                                                                                  | Autopsy |
|-----------|--------------|--------------|-----------------------------------------------------------------------------------------------------------------|---------|
| 4250      | 54           | 203          | Cirrhosis of liver (sev. weeks)                                                                                 | yes     |
| 4255      | 60           | 281          | Bleeding from hepatoma (3 days)<br>(Laennecs cirrhosis)                                                         | yes     |
| 5765      | 45           | 167          | Angiosarcoma rt. lobe of liver<br>(10 mos.)                                                                     | yes     |
| 7303      | 38           | 174          | Liver failure (1 mo.)<br>Cancer of liver, primary (15 mos.)                                                     | -       |
| 7376      | 52           | 238          | Cardiac tamponade and massive left<br>hemothorax (mins.)<br>Widely metastatic angiosarcoma<br>of liver (4 mos.) | -       |
| 7385      | 43           | 214          | Hepatic failure<br>Primary carcinoma liver                                                                      | yes     |

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Table 14

## Other Malignancies (190-199, I.C.D.) in VCM Epidemiology Study Population

| Study No. | Age at Death | Mos. Exposed | Cause as Given                                                                                           | Autopsy |
|-----------|--------------|--------------|----------------------------------------------------------------------------------------------------------|---------|
| 2744      | 38           | 186          | Widespread metastatic melanoma<br>(1 yr.)<br>Malignant melanoma of back                                  | yes     |
| 3700      | 48           | 50           | Malignant melanoma with widespread<br>metastases                                                         | no      |
| 2096      | 67           | 69           | Brain tumor (carcinoma) (8 mos.)                                                                         | -       |
| 3946      | 43           | 64           | Meningitis and pneumonitis (5 wks.)<br>Ependymoma, fourth ventricle-brain<br>(2 mos. post-op craniotomy) | no      |
| 4433      | 54           | 81           | Astrocytoma, malignant-left cerebral<br>hemisphere (1 yr.)                                               | yes     |
| 4800      | 61           | 51           | Carcinoma of the brain<br>Arteriosclerosis<br>Pneumonia due to static congestion                         | no      |
| 7279      | 57           | 271          | Brain tumor, glioblastoma multiforme<br>(18 mos.)                                                        | -       |
| 7300      | 44           | 211          | Brain tumor, malignant (2 mos.)                                                                          | -       |
| 7371      | 58           | 249          | Brain tumor, malignant                                                                                   | no      |
| 7306      | 53           | 216          | Thyroid carcinoma with metastases                                                                        | no      |
| 5769      | 52           | 239          | Carcinomatosis<br>Carcinoma vertebral body                                                               | yes     |

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Table 14  
Other Malignancies (cont.)

| Study No. | Age at Death | Mos. Exposed | Cause as Given                                                                                                         | Autopsy |
|-----------|--------------|--------------|------------------------------------------------------------------------------------------------------------------------|---------|
| 5246      | 67           | 201          | Liposarcoma with metastasis (3 mos.)                                                                                   | yes     |
| 2850      | 64           | 193          | Carcinomatosis, primary region not known<br>(Past history, rheumatoid arthritis, myocardial infarction)                | no      |
| 4778      | 54           | 300          | Cardiac arrest (1 hr.)<br>Respiratory arrest and cerebral hypoxia (2 days)<br>Widespread metastatic carcinoma (2 mos.) | -       |
| 4786      | 61           | 318          | Generalized metastasis undifferentiated (7 mos.)<br>Squamous cell carcinoma, primary site undetermined                 | yes     |
| 5783      | 69           | 166          | Metastatic carcinoma of abdomen<br>Critical site undetermined<br>(Pulmonary emphysema)                                 | -       |
| 7301      | 55           | 133          | Carcinomatosis (4 mos.)<br>Primary site undetermined                                                                   | no      |

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UCC 080031

April 15, 1974

Table 15

**Malignant Neoplasms of Buccal Cavity and Pharynx (140-148, I.C.D.)  
in VCM Epidemiology Study Population**

| Study No. | Age at Death | Mos. Exposed | Cause as Given                                                                                                                                                                                      | Autopsy |
|-----------|--------------|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|
| 3003      | 31           | 49           | Carcinoma of lip with metastasis to lung and neck (5 yrs.)                                                                                                                                          | no      |
| 3431      | 56           | 30           | Pulmonary edema (50 min.)<br>Pulmonary metastases<br>(Carcinoma, epidermoid, tongue and mandible)                                                                                                   | no      |
| 3001      | 57           | 71           | Metastatic squamous cell ca. -<br>primary lesion palate                                                                                                                                             | yes     |
| 7365      | 54           | 40           | Atelectasis due to metastasis to mediastinum (4 mos.)<br>Multiple malignant metastases to brain, liver & mediastinum (1 yr.)<br>Adeno-carcinoma of nasal pharynx (2 yrs.)                           | yes     |
| 3354      | 63           | 26           | Massive hemorrhage into tracheo-tree<br>Status post laryngo-pharyngectomy,<br>left radial neck dissection<br>Well-differentiated keratinizing squamous cell carcinoma of left pyriform sinus (mos.) | yes     |

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UCC 080032

VITAL  
STATUS  
UNKNOWN

TERMINATIONS

UNTRACEABLE

phone book

post office

address given

letter undeliverable

no address  
given

letter sent

driver license  
bureau

address given

subject acted  
in 1972

reply received

no records  
on subject

FOLLOWUP

PRIVILEGED AND  
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ORDER"

UCC 080033

VITAL  
STATUS  
KNOWN

ACTIVE  
EMPLOYEES

RETIREES

TERMINATIONS  
LOCATED

Manufacturing Chemists Association VCM Epidemiology Study

Parent Corporation \_\_\_\_\_

Plant Designation \_\_\_\_\_

Address \_\_\_\_\_

Telephone ( ) - ext. \_\_\_\_\_

TABERSHAW-COOPER ASSOCIATES' CONTACT FOR SUBJECT STUDY:

Name \_\_\_\_\_

Title \_\_\_\_\_

Mailing Address \_\_\_\_\_

Street Address (please identify with sufficient precision  
to serve as a taxi-driver's instruction)

Telephone ( ) \_\_\_\_\_

Signed \_\_\_\_\_

Name \_\_\_\_\_

Title \_\_\_\_\_

Company \_\_\_\_\_

Address \_\_\_\_\_

Telephone ( ) - ext. \_\_\_\_\_

PRIVILEGED AND  
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ORDER"

Tabershaw-Cooper Associates, Inc.  
2180 Milvia St., Suite 104  
Berkeley, California 94704

Manufacturing Chemists Association VCM Epidemiological Study

Plant No. \_\_\_\_\_

1. When did this plant begin work involving vinyl chloride? \_\_\_\_\_
2. What is the approximate size of the current work force,  
exclusive of secretarial and office personnel? \_\_\_\_\_
3. Approximately how many of these are employed in jobs in-  
volving some exposure to vinyl chloride? \_\_\_\_\_
4. Please answer the appropriate one of the following  
questions about your retirement plan.
  - a. No retirement plan \_\_\_\_\_
  - b. Voluntary plan, begun in \_\_\_\_\_
  - c. Required of all employees, begun in \_\_\_\_\_
  - d. Now required, formerly voluntary.  
Voluntary plan begun in \_\_\_\_\_  
Required plan begun in \_\_\_\_\_

Remarks: \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

5. Please answer the applicable questions below about  
retention of records. How long are personnel records  
kept
  - a. for those who retired but were not covered by a  
retirement plan? \_\_\_\_\_
  - b. for those who retired under a retirement plan and  
have died? \_\_\_\_\_
  - c. for those who quit or were discharged? \_\_\_\_\_
  - d. for those who died while employed? \_\_\_\_\_

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Tabershaw-Cooper Associates, Inc.

page 2

6. Do the personnel records which are retained contain a record of job titles and dates of job title changes for the individual concerned?
7. Please list the job titles in the current work force which involve some exposure to vinyl chloride.

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ATTACHMENT B (cont.)

UCC 080036

# VCM Epidemiological Study - Individual Work History

Form B - Workers known to have died (please attach copy of death certificate)

1. Date of birth \_\_\_\_\_
2. Date hired \_\_\_\_\_
3. Date of death \_\_\_\_\_
4. Place of death \_\_\_\_\_
- Status at time of death:
  5. Employed \_\_\_\_\_
  6. Retired (give date) \_\_\_\_\_
  7. Terminated (give date) \_\_\_\_\_
8. If death certificate is not available, please give name of worker so that death certificate can be obtained. No contact will be made with relatives or attending physician.

## Job history with estimated exposure

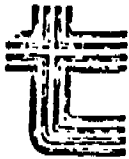
| Job no. | Title | Check estimated exposure in ppm |        |         |      |
|---------|-------|---------------------------------|--------|---------|------|
|         |       | <50                             | 50-199 | 200-500 | >500 |
| 1       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 2       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 3       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 4       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 5       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 6       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |
| 7       | _____ | from                            | _____  |         |      |
|         |       | to                              | _____  |         |      |

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UCC 080037

# tabershaw cooper associates inc

2180 Milvia Street, Berkeley, California 94704. Telephone (415) 845-3355



Dear

We are a research firm concerned with the health of workers in industry in the United States. We have been asked to study certain occupations in order to determine the health of men who have at one time or another worked in these occupations.

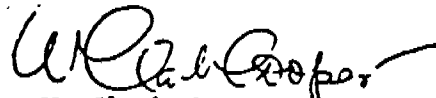
To accomplish this we need to know if those men we are interested in were alive on December 31, 1972. For any of the men who died on or before that date, we need to know the place and date of death. With these facts, we can compare the health statistics of our men with the general population.

To assist us, can you provide information regarding the person whose name appears below? A stamped, addressed return envelope is enclosed for your reply.

Needless to say, any information you give us is strictly confidential.

Thanks for your cooperation and assistance with this project.

Sincerely,

  
W. Clark Cooper, N.D.

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Name:

Date of birth:

Was above named man alive as of 12/31/72? \_\_\_\_\_

If deceased prior to 12/31/72:

Date of death \_\_\_\_\_

Place of death (city and state)  
\_\_\_\_\_  
\_\_\_\_\_

UCC 080038

I hereby certify that the foregoing document is a true, correct and complete copy of the document in my possession.

H. Northrop M.D.  
Herbert Northrop, M.D.

Subscribed and sworn to before me this  
4<sup>th</sup> day of November, 1988.

James Thompson  
Notary Public

My Commission Expires: 4/15/89

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UCC 080039