

MEDICAL OBSERVATIONS
ON
LEAD ANTIKNOCK WORKERS

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Medical Observations on Workmen and Work Environment
in the Organic Lead Antiknock Production Area of
Baton Rouge Manufacturing, Ethyl Corporation

This report presents certain medical observations concerning Ethyl Corporation's antiknock production. Most of the basic data for the report have been collected and recorded systematically and persistently over many years by the Medical Department of Ethyl's Baton Rouge Manufacturing facility. Roy C. A. Bock, M.D., designed and implemented the medical program involved. He also has provided the long-term continuing supervision so vitally necessary for the program to serve the needs of the industry, including the provision and preservation of the data upon which this report is based. Without his strong support and assistance, the studies outlined below could not have been accomplished. The philosophical teachings and technical findings of Robert A. Kehoe, M.D., have been significant influences upon the medical program from the beginning. A number of other physicians have contributed in varying degree to the actual collection of the various types of medical data during this period of time. This collection of medical data is highly unusual in its scope, consistency of collection, and time span covered.

The following observations and comments are limited to areas thought to be of relatively general interest. Only such detail as is thought to be essential for understanding is included. Extensive documentation, including much significant medical information of more strictly professional interest, is available.

I. Lead Restrictions

Routine biological sampling of each worker in the lead antiknock production area of Ethyl's Baton Rouge plant and formal, fixed medical criteria for medical recommendations regarding modification of work assignment to reduce occupational exposure to lead (restrictions) have been available and applied consistently for the past 21 years (i.e., since 1952). However, in 1972 Operators on restriction began to be assigned to work involving essentially no exposure to lead, rather than to reduced exposure to lead. The duration of restrictions would be expected to be altered by this. Such alterations should not be interpreted in the future as representing a change in pre-restriction exposure, of course.

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It should be noted that, over this time span, only one employee at this plant has been classified as having missed time from work due to illness caused by occupational absorption of lead. A review of this case shows that the worker involved had non-specific symptoms associated with a level of lead in urine thought compatible with the production of such symptoms. However, this same individual has a long recorded history of similar symptoms, both prior and subsequent to the work absence classified as due to lead intoxication, when work history and levels of lead in urine were clearly not compatible with lead intoxication. Thus this case should be considered to be "possibly", rather than definitely, related to lead absorption.

- A. Graph 1 shows the rate of restriction activity, expressed as the percentage of the "at risk" worker population entering restriction each year from TEL Operations in 1952 - 1972. The rate of restriction for the last 10 years can be seen to be essentially double that of the previous 11-year period.

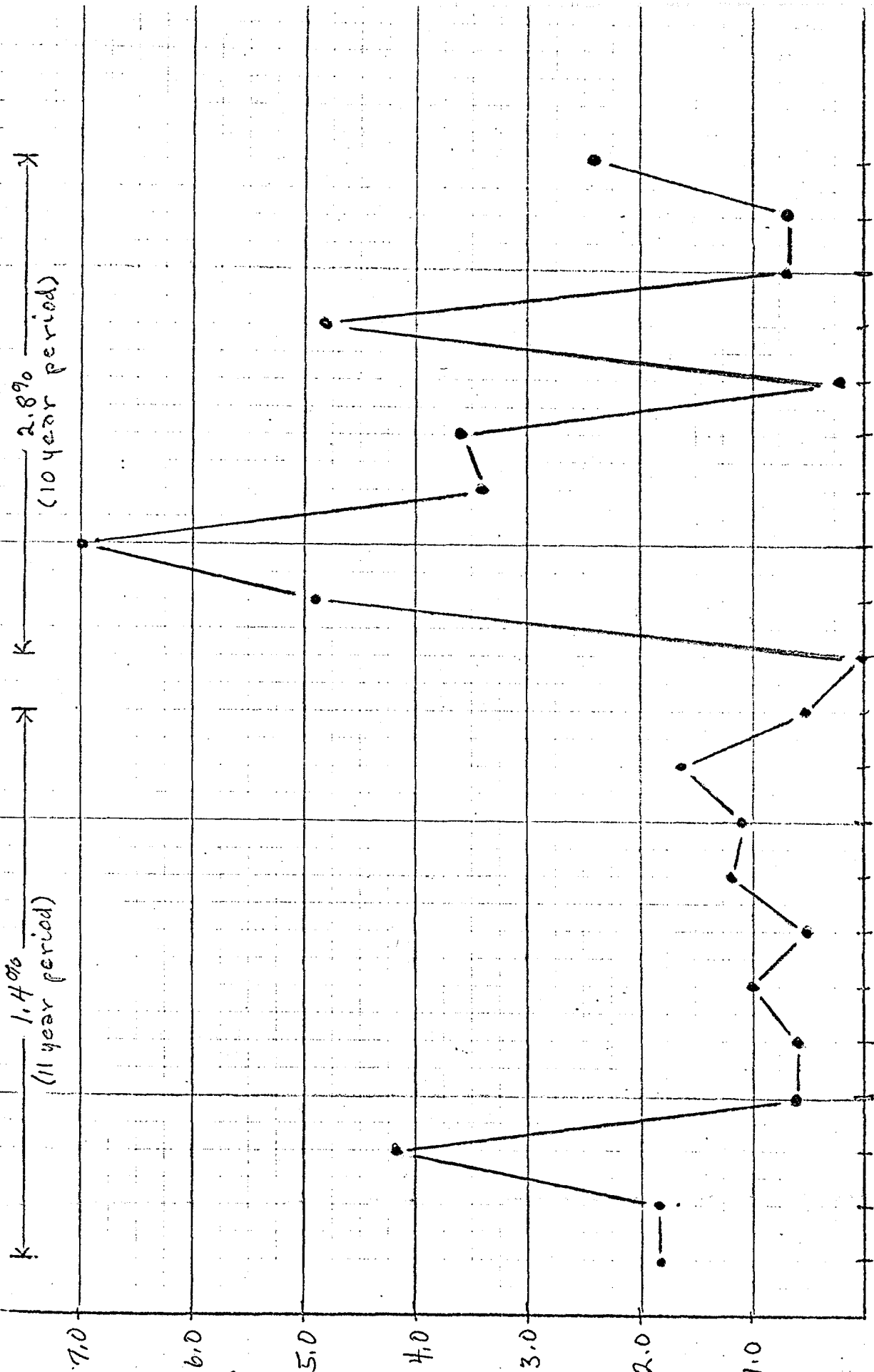
Graphs 2, 3 and 4 show the relationships between air analyses, urinary lead values and number of restrictions for certain areas from 1952 - 1972. It should be noted that restrictions are not expressed as rates here--the size of the denominator ("at risk" population) for these work groups over the years could not be determined very readily. Restriction activity roughly parallels group urinary lead values once levels greater than about 0.09 mg. Pb/l. have been reached. Air analyses and group urinary lead levels show little correlation. A similar lack of correlation has been found in numerous attempts over the years to relate air analyses to urinary lead levels of individual workers.

- B. Graph 5, covering the time period 1944 through 1971, shows the distribution of restrictions by the month in which they began. A degree of season variation is noted. The explanation for this pattern is not obvious.
- C. Graph 6 shows the pattern of the average duration of restrictions for Operations and Maintenance personnel beginning in each of the years since consistent restriction criteria have been in use. As can be seen, the average duration of restrictions has not shown a tendency to increase over the 20-21 year time period.

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1.4% (11 year period) 2.8% (10 year period)

Per Cent of "At Risk" Work Force (TEL Operations) Entering Restriction During Year

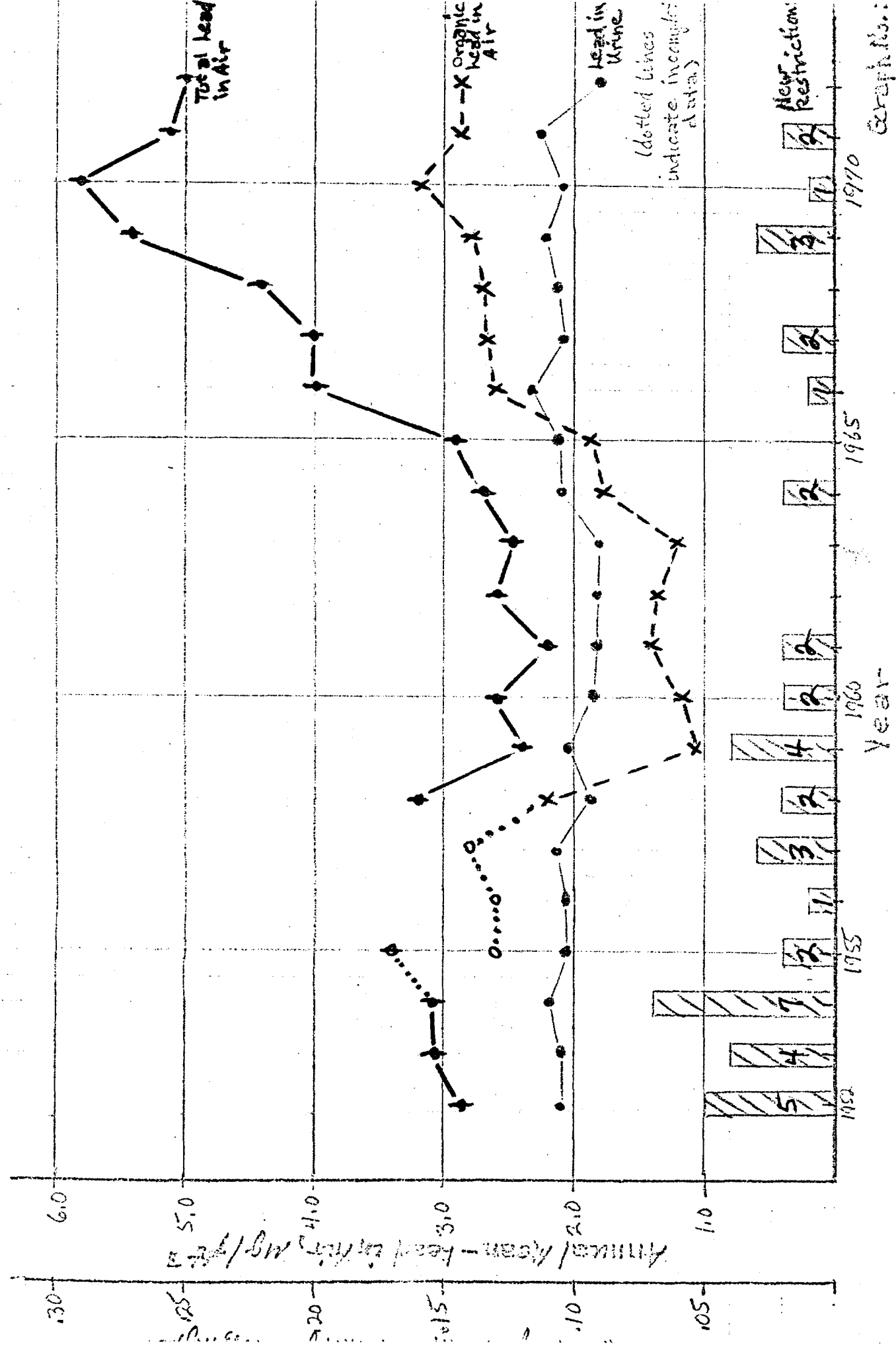


Graph No. 1

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Rates for New Restrictions - TEL Operations Only

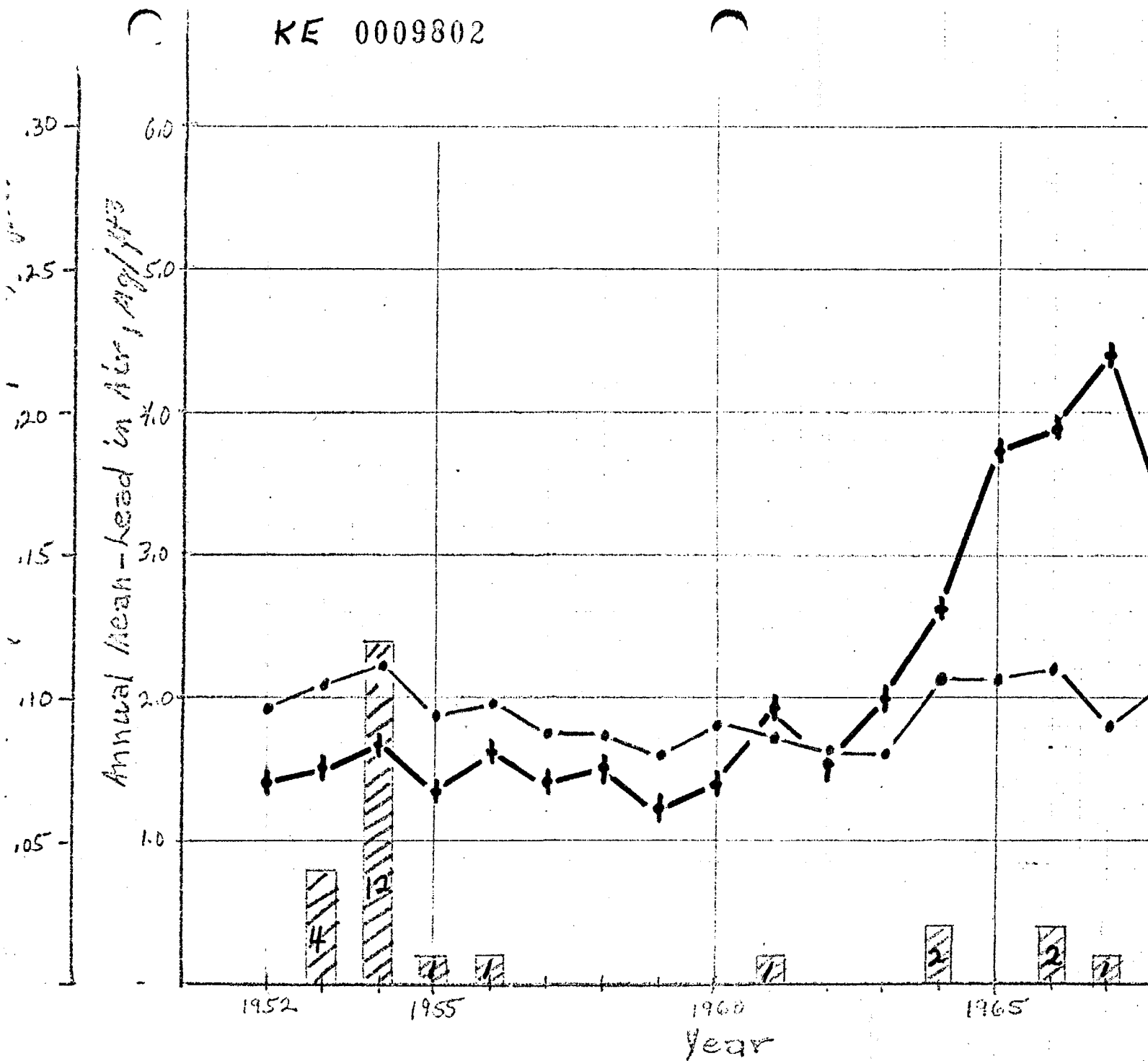
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Furnaces - Comparison of Lead in Air, Group Urinary Lead and Number of New Restrictions

Graph No.:

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5th Floor, TEL - Comparison of Lead in Air, Group Urine and Number of New Restrictions

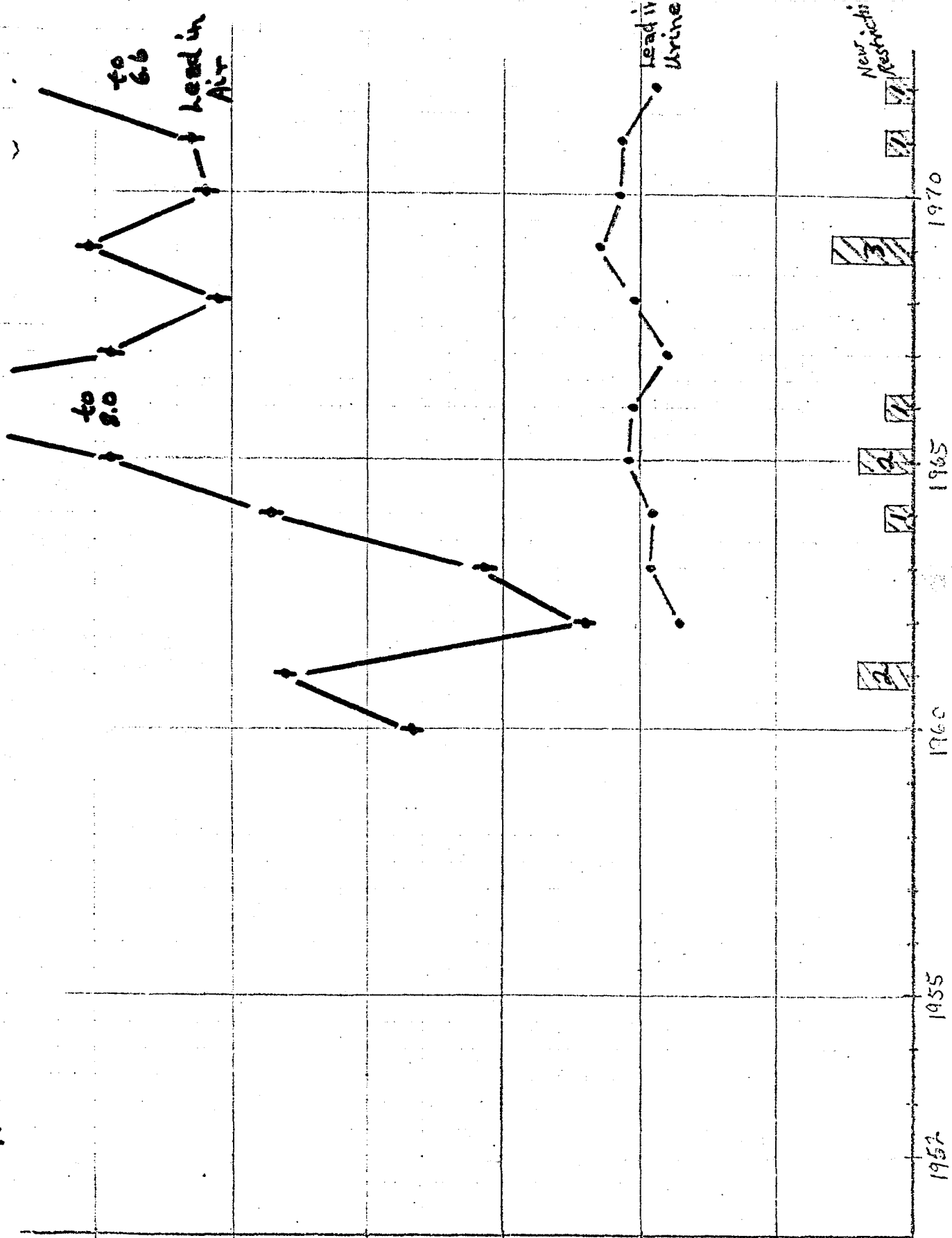
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Annual Mean - Lead in Air, $\mu\text{g}/\text{m}^3$

6.0
5.0
4.0
3.0
2.0
1.0
0.5

0.30
0.25
0.20
0.15
0.10
0.05



Year

1970

1965

1960

1955

1952

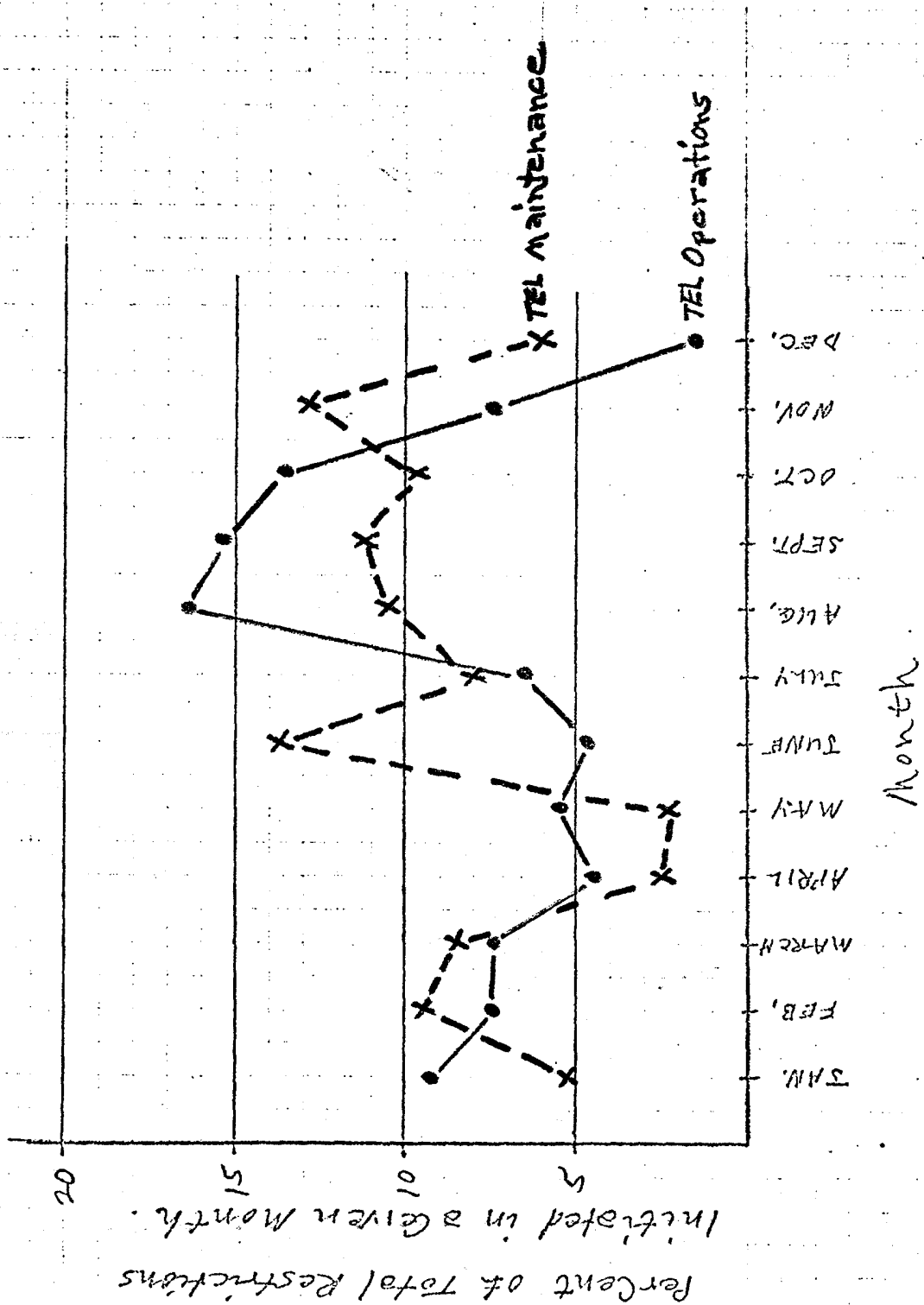
New Restrictions

Graph No. 4

5th Floor, TML - Comparison of Lead in Air, Group Urinary Lead and Number of New Restrictions

(6)

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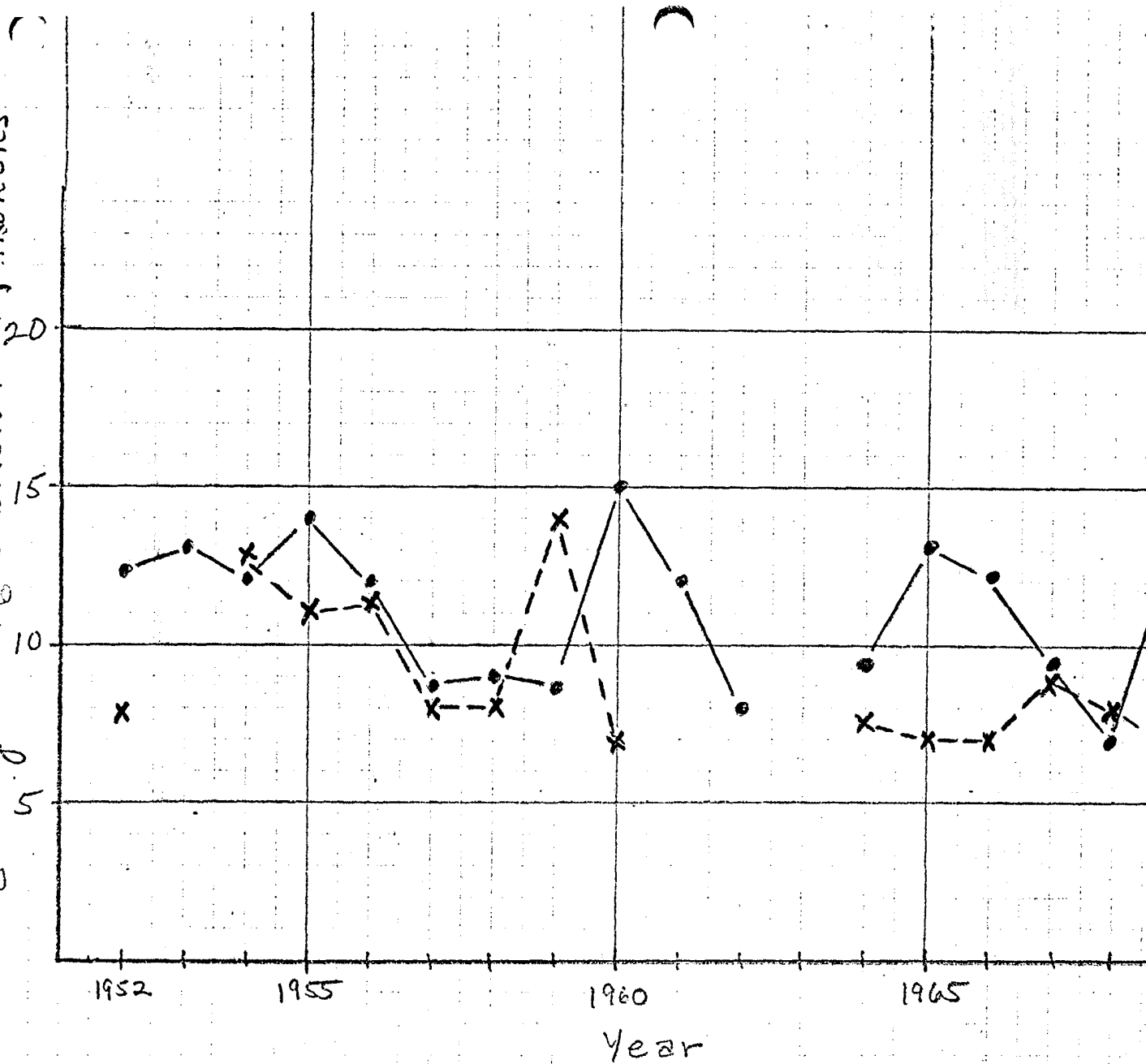


Graph No. 5

Month New Restrictions Began.
1944-1971

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Average Duration of Restrictions
Beginning During a Given Year, months



Duration of Restrictions - 1952-1971

D. Table 1 shows the number of individuals who have had one, two or more restrictions during their career at Ethyl Corporation (through 1972). A comparison for each individual concerning "subsequent" restrictions (i.e., 1st to 2nd, 2nd to 3rd, 1st to 3rd, etc.) over the time period during which consistent restriction (and restoral) criteria have been used indicates that "subsequent" restrictions are as likely to be shorter than any previous restriction as they are to be longer. This means that subsequent restrictions for an individual do not tend to be longer in duration. This in turn indicates that medical management has been adequate to prevent a cumulative "loading" effect on individuals such that their clearing up would be prolonged on subsequent exposures at restriction levels.

E. Summary: Air analyses have shown no usable correlation with biological measurements of worker exposures under the conditions experienced at this plant for the past 10-20 years.

Working conditions and practices (including restriction procedures) have been adequate to prevent any cumulative "loading" effect (as measured by duration of restrictions) on the workers in the TEL area, both as groups and as individuals, over the past 20-21 years, and have been successful in the prevention of overt illness attributable to the occupational absorption of (organic or inorganic) lead.

II. Mortality Experience of TEL Workers

A mortality study has been done covering all TEL Operators and a control (comparison) group of all Sodium Operators and Hydrocarbon Operators and Hydrocarbon Maintenance men on the active rolls (wage roll) at Ethyl Corporation on December 21, 1947. The mortality status of all of these men was determined as of December 31, 1967. There were 592 men in the TEL group representing 11,465 man-years of experience during the 20-year follow-up period. There were 660 men in the non-TEL group representing 12,716 man-years of experience over this same 20-year period. There were 51 deaths in the TEL group and 68 in the non-TEL group. The distributions of death by categories are given in Table 2.

The unadjusted 20-year crude death rates were 4.4/1000 man-years for TEL workers and 5.3/1000 man-years for non-TEL workers. Making appropriate adjustments to correct to the

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RESTRICTIONS 1944 - 1972

Number of Times Same Individual Restricted	Operations	Maintenance	Mixed	Totals
ONE	129	89	-	198
TWO	21	14	2	37
THREE	9	5	-	14
FOUR	3	-	1	4
FIVE	2	-	-	2
MORE THAN FIVE	-	-	-	-
TOTALS	164	88	3	255

TABLE 1

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Causes of Death in 20-Year Period
for TEL and Non-TEL Workers

Cause of Death	Number of Deaths		Percent of Total Deaths Represented by this Category		
	TEL	Non-TEL	TEL	Non-TEL	COMBINED
Infectious & parasitic	-	1	-	1.5	0.8
Malignant neoplasms	8	11	15.7	16.2	16.0
Vascular CNS (Stroke)	2	3	3.9	4.4	4.2
Heart	18	31	35.3	45.6	41.2
Respiratory	1	1	2.0	1.5	1.7
Accidents	13	6	25.5	8.8	16.0
Homicide & Suicide	3	4	5.9	5.9	5.9
Other	6	11	11.8	16.2	14.3
TOTALS	51	68	100.1	100.1	100.1

592 TEL men, 660 Non-TEL men. Time period 12/31/47 - 12/31/67.

TABLE 2

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1950 distribution of U.S. white male population for these groups gave a 20-year death rate of 174/1000 men for TEL workers and 209/1000 men for non-TEL workers. This compared with the published rates of 190/1000 men and 224/1000 men for 1950 U.S. white males in corresponding age brackets. Thus TEL workers showed an "advantage" of 8% and non-TEL workers showed an "advantage" of 7% over U.S. white males by this procedure.

Using a slightly different (but also "standard") approach whereby 20-year U.S. white male death rates (in this case, rates as of 1950) were applied to the TEL and non-TEL distributions of ages to obtain an "expected" number of deaths for all causes and for certain specific disease categories, so that the "expected" deaths could be compared to those actually observed, the information shown in Table 3 was obtained. The overall "advantage" experienced by TEL workers was 12% and by non-TEL workers was 15% by this method. The observed death rate from cardiovascular disease (primarily heart attacks and strokes) was about 17% less for TEL workers than that "expected" on the basis of the general U.S. adult white male experience. The "disadvantage" of 14% observed for TEL workers in the "neoplasm" (cancer) category actually represented but a single "excess" death. If rates for 1960 were used, the "expected" number becomes identical with the "observed" number. Use of 1960 rates does not result in any change in "all causes" or "cardiovascular" figures.

Deaths in the "accidents" category for TEL workers were in excess of the general U.S. white male category, but such scattered reports as are available that concern themselves with males employed in industry show a rate only slightly less than that of the TEL group. The non-TEL deaths in this category were somewhat less than that experienced in the general U.S. white male category and probably were significantly less than would be expected from published "employed in industry" figures.

A third "standard" approach was used which was similar to the previous one but with the "expected" rates for the U.S. white males expressed as an annual (rather than 20-year) rate and coming from a somewhat different source. Applying these rates to the (differing) annual distribution and ages for TEL and non-TEL for each year, and expressing the "observed" deaths as a percentage of the "expected" deaths for each year (so called "Standardized Mortality Ratio" or "SMR"), the

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Expected vs. Observed 20-Year Mortality for TEL and Non-TEL Workers and 1950/U.S./Male/White/General Population

		ALL CAUSES						CARDIOVASCULAR						NEOPLASMS					
Age at Start	No. of Men TEL Non-TEL	1950 Table Rate	TEL		Non-TEL		1950 Table Rate	TEL		Non-TEL		1950 Table Rate	TEL		1950 Table Rate	TEL		Non-TEL Deaths Exp. Obs.	Non-TEL Deaths Exp. Obs.
			Exp.	Obs.	Exp.	Obs.		Exp.	Obs.	Exp.	Obs.		Exp.	Obs.		Exp.	Obs.		
20-24	114	0.041	5	3	3	1	0.007	1	0	0	0	0.004	0	0	0.004	0	0	0	0
25-29	138	0.055	8	7	8	6	0.015	2	2	2	1	0.006	1	1	0.006	1	1	1	1
30-34	152	0.084	13	9	14	13	0.032	5	4	5	8	0.011	2	1	0.011	2	1	2	2
35-39	124	0.129	16	14	19	18	0.059	7	6	9	9	0.019	2	4	0.019	2	4	3	3
40-44	38	0.196	7	10	16	12	0.100	4	4	8	6	0.032	1	1	0.032	1	1	3	3
45-49	20	0.284	6	6	10	11	0.155	3	3	6	6	0.049	1	1	0.049	1	1	2	2
50-54	4	0.394	2	1	6	3	0.227	1	0	3	2	0.069	0	0	0.069	0	0	1	1
55-59	2	0.525	1	1	3	2	0.316	1	1	2	2	0.090	0	0	0.090	0	0	0	0
60-64	-	0.670	-	-	1	2	0.419	-	-	1	2	0.108	-	-	0.108	-	-	0	0
TOTALS	592		58	51	80	68		24	20	36	36		7	8		7	8	12	12
Ratio Observed/Expected			0.879		0.850			0.833		1.000			1.143			1.143		0.917	
"Advantage" Observed by Ethyl Workers			+12.1%		+15.0%			+16.7%		Zero			-14.3%			-14.3%		+8.3%	

Time period 12/31/47 - 12/31/67

TABLE 3

pattern shown by Graph No. 7 was obtained. By this method, the TEL and non-TEL workers showed an overall "advantage" of 32% and 34%, respectively, over the general U.S. white male population of similar age distributions. The SMR's for TEL and non-TEL workers appear to have been rather closely parallel over the 20-year time period covered by this study.

Summary: A mortality study with a 20-year follow-up showed essentially the same death rates, both for specific causes and overall, for TEL workers as compared to non-TEL workers. The rates were less than in the general U.S. white male population for most causes and overall. No unusual patterns of causes of mortality were seen.

III. Health Experience of Long-Term TEL Workers

A detailed analysis has been made of essentially all available medical records on all those TEL Operators who were hired prior to January 1, 1948, and who had worked continuously as TEL Operators through December 31, 1967. Essentially all factors measured and/or recorded were utilized: age, height, weights, blood pressures, hemoglobin content of blood, urinary lead levels, blood lead levels, diagnoses (made or reported at time of periodic examinations, during absences due to personal illness or off-plant injury, etc.), number of absences, duration of absences and types of illnesses causing absences--all were analyzed by diagnostic categories, by year of occurrence and by certain sub-groups (as persons with highest urinary lead levels, persons with lowest urinary lead levels, persons with restrictions, persons never restricted, etc.).

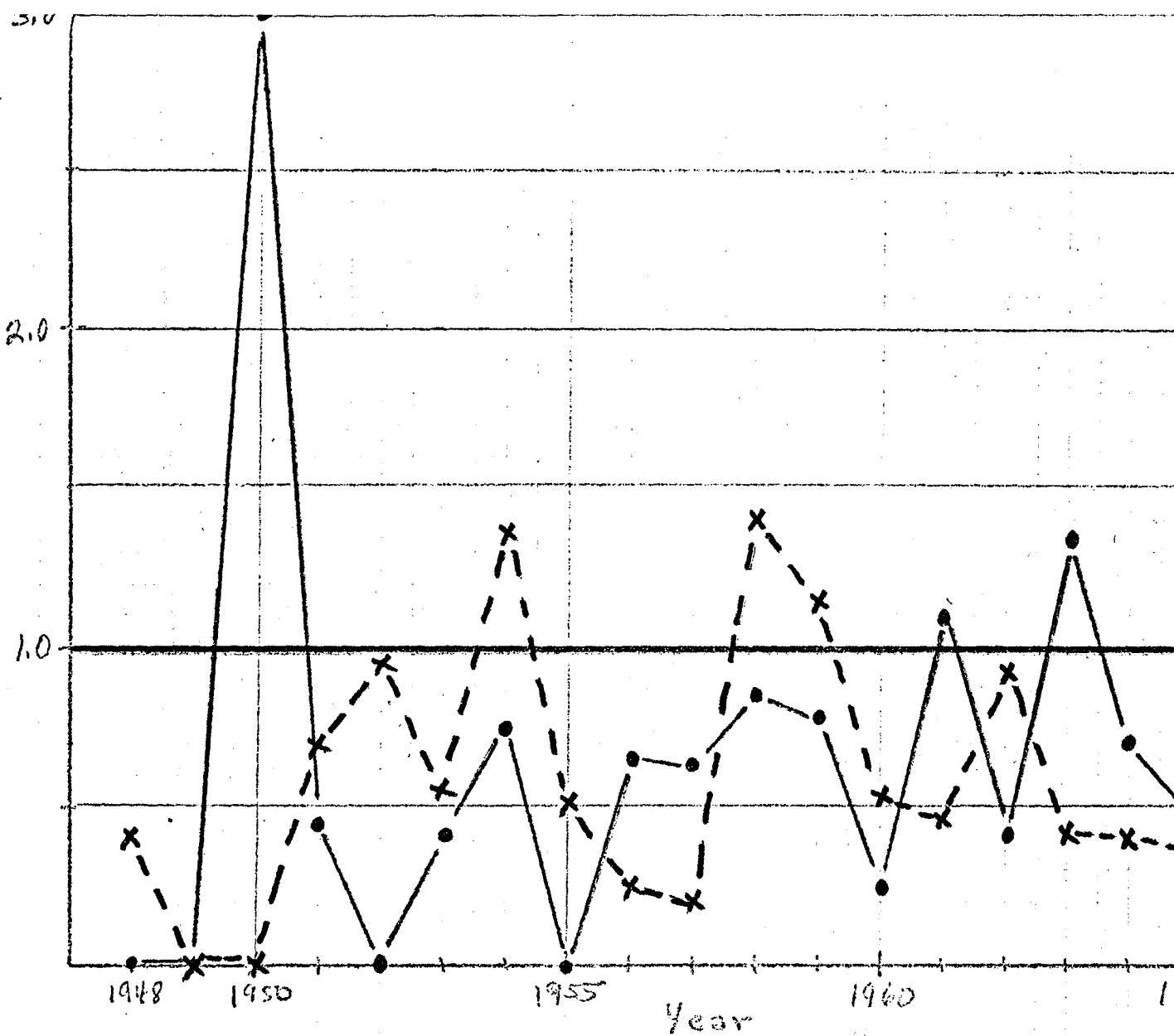
A control (comparison) group, properly matched for age and length of service, was studied for the same factors as mentioned above. The control group came from workers in the Hydrocarbon Operations and Maintenance and the Sodium Operations groups, with careful scrutiny of records to assure that no occupational exposure to lead had occurred for any of these individuals. Unfortunately, no actual values for urinary or blood lead were available for this group.

TEL Maintenance workers were not utilized in this study because their exposure to lead occurs at irregular intervals, with consequent difficulty in expressing their absorption of lead over a long period of time in any meaningful manner. Confining attention to TEL Operators was thought appropriate to magnify or maximize any health effects that might arise from long term absorption of (organic $\pm$ inorganic) lead.

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Ratio of Observed to Expected Deaths



Comparison of Standardized Mortality Ratios (S)
For TEL and Non-TEL Workers, 1948-1967.

The only consistently recorded factor not utilized in this study was experience concerning occupational injuries. Due to the widely dissimilar nature of the physical activities involved in the work of the different groups, a comparison of this type of information was considered to be not justified or useful.

There were 153 men in each group. As of the end of the study period (December 31, 1967), the average age of the TEL workers was 53.2 years, of non-TEL workers, 52.5 years. As of this same date, the average lengths of service were 25.4 years for TEL men and 24.6 years for non-TEL men. The TEL men had averaged 0.089 mg. Pb/l. of urine over the last 8-10 years of the study. Blood leads, collected mostly on individuals with higher urinary lead values, averaged 0.043 mg. Pb/100 gm. blood. A "real" group average presumably would have been lower than this.

The results of the multitude of detailed comparisons and calculations made in the study will not be presented here. They can be summarized by stating that, with one exception, the TEL and non-TEL groups (and all sub-groups) appear to have been almost identical in their health experiences, with no statistically significant or medically suggestive differences.

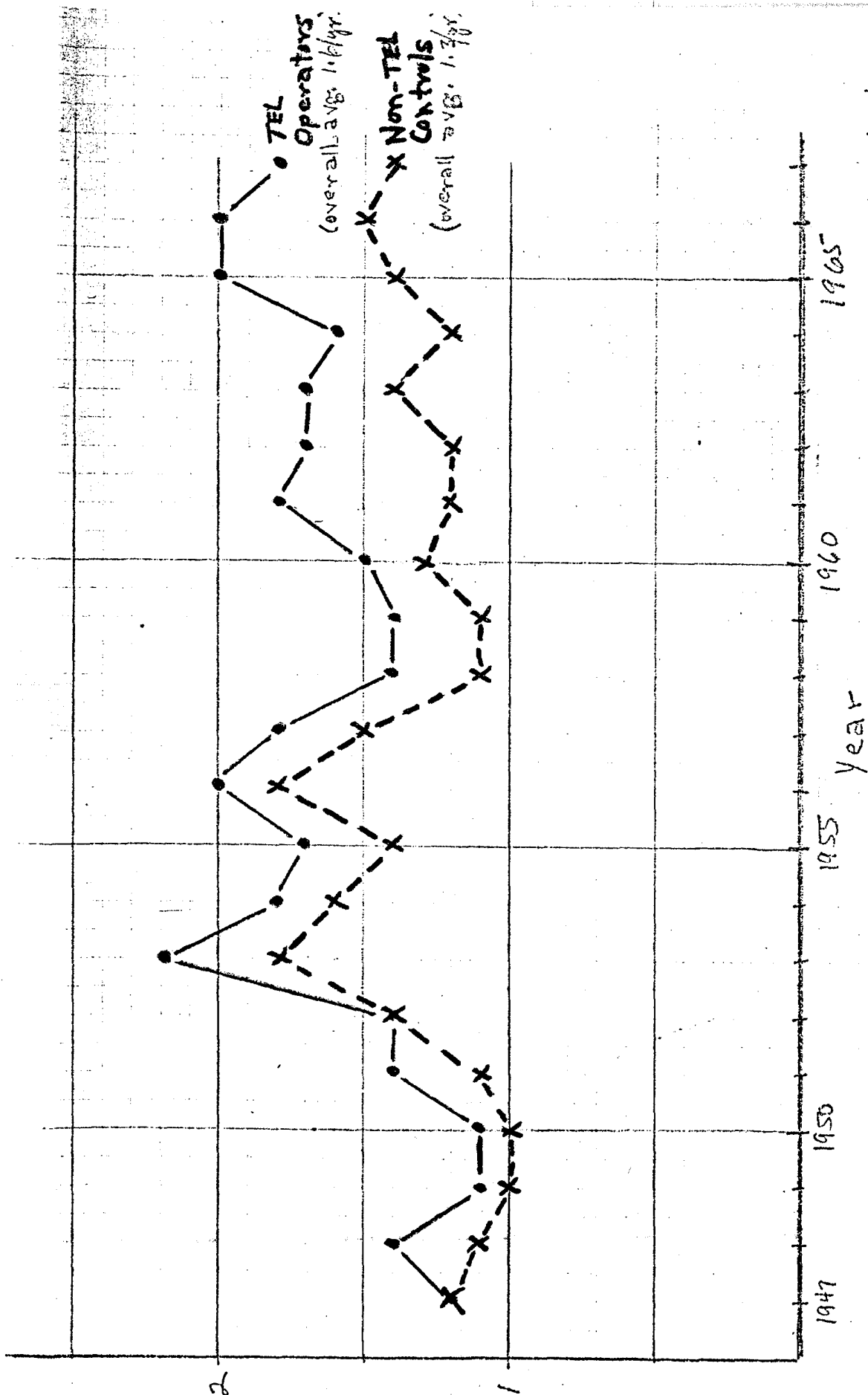
The one factor in which the TEL and non-TEL groups were found to differ is shown in Graph 8, which shows that a very small but very consistent greater number of absences per year due to personal illness for TEL workers than for non-TEL workers. As can be seen in Graph 9, the average duration of the absences for the two groups were essentially the same over the years. This same pattern was found for each of the various sub-groups ("high" and "low" urinary lead groups, "restriction" and "no restriction" groups, etc.). Analyses made for each of the various diagnostic categories (as heart disease, intestinal disorders, etc.) failed to show this difference between the TEL and non-TEL workers in any specific category.

At the present time, the reason for the observed small but consistent difference in number of absences per worker per year is not clear. The possibility that it might be due to occupational absorption of lead must be considered. The fact that those workers with the highest long term urinary lead levels and those workers who have been on restriction did not differ in this respect from those with the lowest long term urinary lead levels and those with no restrictions--or from the group as a whole--weighs somewhat against this (i.e., no progressive dose:effect relationship), but does not rule the possibility out entirely. If the observed

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Average Number of Absences Per Worker

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Graph No. 8

Average Number of Absences Per Worker Per Year (Frequency)

Due to Personal Illness and Off-Plant Injury -

TEL Operators vs. Non-TEL controls

(17)

Average Number of Working Days Lost Per Absence

15

10

5

Non-TEL Controls (overall avg. 6.6 days per absence)

TEL Operators (overall avg. 6.5 days per absence)

Graph No. 9

Average Number of Working Days Lost Per Absence Due to Personal Illness and Off-Plant Injury - TEL Operators vs. Non-TEL Controls

(18)

1965

1960

1955

1950

1947

Year

difference was due to occupational absorption of lead, the effect was present at the lowest levels of absorption covered in this study--and did not increase in magnitude up to the highest levels of absorption covered in this study. Other factors (differences in worker morale, differences in concern and caution about illness, etc.) could be involved, but no way of evaluating them has presented itself.

Summary: An exhaustive study of essentially all recorded health data on a group of TEL Operators employed for 20 or more years has shown them to be essentially identical in health experiences to a matched group of non-TEL workers. The only observed difference was a consistently slightly greater frequency of absence due to personal illness on the part of TEL workers. No specific disease, disorder or organ system could be identified as being related to this observation. The difference must be considered to be real, but the precise cause or mechanism involved is not obvious. The nature and magnitude of this finding is such that it is of academic interest to the physician, warranting further investigation when a suitable approach can be formulated. Concern or action on the part of management or workers is not indicated.

IV. Overall Commentary

An exhaustive search has been made for evidence of adverse health effects associated with work in the antiknock production area of the Baton Rouge Manufacturing facility of Ethyl Corporation. No adverse health effects that are of practical significance or concern have been found. The system of medical monitoring and control that has been in use since 1952 appears to be adequate for the protection of the health of the workers, not only against the development of acute lead intoxication, but also against any unusual incidence of other specific diseases or shortening of life span.

Theodore R. Robinson, M.D., I.M.D.

June 1, 1973

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