HAZARD EVALUATION AND TECHNICAL ASSISTANCE REPORT
HETA 85-098-L1959
TEEPAK, INC.
Danville, Illinois
APRIL 1989

Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations and Field Studies
National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, Ohio 45226

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Background

On December 11, 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Food and Commercial Workers Local 686 for a health hazard evaluation at Teepak, Inc., in Danville, Illinois. The company, which began operation in 1957, employs approximately 650 workers in the manufacture of sausage casings. Of primary concern in this operation is the potential for exposure to carbon disulfide. The request stated concern about a possible excess of heart disease and cancer related to this exposure.

Among the products manufactured at the Danville Teepak plant is Wienie-Pak[R], used in the processing of skinless wieners. It is produced in a xanthating process, whereby wood pulp is broken down and converted into long-chain cellulose molecules. The cellulose, dissolved with caustic, is squeezed and dropped into shredders. The resulting "crumb" is put into aging cans, then dropped into barattes, which are rotating drums. It is at this point that carbon disulfide is introduced into the process to promote the lengthening of the cellulose chains. The resulting "orange crumb" (cellulose xanthate) goes through a series of slurry and holding tanks, filter presses, extrusion, coagulating and wash tanks to yield a very thin film. This "wet end" process is followed by the "dry end," which entails the rolling up, converting, storage, packaging, and shipping of the Wienie-Pak[R].

On January 31, 1985, an initial site visit was made by NIOSH investigators Peter Orris, M.D., then the project officer, and Richard Kramkowski, industrial hygienist. Following that visit, and after several subsequent discussions between NIOSH investigators and representatives of the company and the union, NIOSH decided to proceed with an evaluation of the mortality experience of Teepak workers.

Exposure to Carbon Disulfide

Carbon disulfide (CS_2) is a colorless, volatile, extremely flammable liquid used as a solvent in a variety of industrial processes, most notably the manufacture of viscose rayon. Acute exposures to high concentrations have historically been associated with severe psychologic and behavioral abnormalities. Chronic exposure to CS_2 has been associated with diseases of the nervous and cardiovascular systems. A number of studies have demonstrated a relationship between exposure to CS_2 and mortality from coronary heart disease.[1-4]

Many of these studies, though persuasive in documenting such an association, lack sufficient data to provide an estimate of a possible safe exposure threshold. Evidence of an increased risk of coronary heart disease at exposures of approximately 20 parts per million (ppm) has been seen.[3] A Finnish mortality study of a cohort of rayon workers monitored from 1967 to 1982 documented excess mortality from heart disease (relative risk = 4.7) among CS_2-exposed workers at levels of 10-30 ppm. However, this excess disappeared after engineering controls were introduced in 1972, which lowered exposure levels to less than 10 ppm.[4] The authors postulated that this apparent reversibility may have been caused by direct toxic action on the myocardium rather than an acceleration of the atherosclerotic process. However, another study found elevated atherosclerosis and hypertension among workers exposed to levels as low as 7 ppm.[5]

The current OSHA Permissible Exposure Level (PEL) is 20 ppm, with a ceiling of 30 ppm. NIOSH reports that "chronic exposure to carbon disulfide at airborne concentrations greater than 30 mg/cu (10 ppm) has been associated with diseases of the cardiovascular and nervous systems. Effects on the reproductive system have been reported at lower concentrations."[6] In order to provide a margin of safety, NIOSH's recommended exposure limit is 3 mg/cu (1 ppm), with a ceiling of 30 mg/cu (10 ppm) during any 15-minute period.

Few historical exposure data, particularly from the early years of Teepak's operation, were available from company records. However, some personal monitoring results from 1980 through 1986 were provided. Some of these measurements were 8-hour time-weighted averages (TWA's); however, many were short-term samples, and inferences must be made carefully. Of the 257 readings available, the mean CS_2 level was 4.9 ppm ($\pm$ 7.7), with a median of 2.2 ppm and a range from 0.1 to 53 ppm. The majority of readings were below 10 ppm (87%), with 7% between 10 and 19.9 ppm, and approximately 6% at or above the OSHA PEL of 20 ppm. These highest readings were found among the baratte operators in the chemical department. It should be noted that no industrial hygiene monitoring data are available for the years 1957 to 1980, when exposures to CS_2 may have been considerably higher than in the later years of the plant's operation.

Mortality Evaluation

In order to assess the mortality of former Teepak employees from heart disease and cancer, NIOSH investigators selected, at random, 10 percent of the population of current and former employees. The personnel records of these individuals would yield information to be used to estimate the number of person-years experienced by workers at the plant. An estimate could then be made of the expected numbers of deaths among Teepak employees from a variety of causes. These expected numbers could then be compared with the actual number of deaths observed among these workers, to determine if an excess might exist. This approach was chosen because it would provide an estimate of the standardized mortality ratio (SMR) in a time-efficient manner. If a possible excess were seen, then a full-scale SMR study would be recommended. Such a study would entail a review of 100 percent of the personnel records, as well as a systematic determination of the vital status (alive or dead) of all former Teepak employees, and obtaining death certificates of all deceased employees. In addition, this 10 percent sample would allow a review of the personnel records to determine their usefulness should a full-scale SMR study be warranted.

A. Methods

The names of deceased persons were obtained from company and union records. The company maintains files on all retired and vested (employed ten years or more) workers after their deaths. In addition, a notation is made in the record of any other former employee if the person's death becomes known to the company. Obviously, this results in an incomplete ascertainment of deaths of persons employed at Teepak less than 10 years. Union representatives also provided a list of former employees thought to be deceased, identified either from the union's records or the recollection of union members. Death certificates were sought for all individuals named by the company and/or the union. A certified nosologist coded the underlying cause of death for each certificate obtained.

In order to estimate the number of person-years experienced by workers at Teepak since it began production in 1957, a 10 percent sample of personnel records of all current and former workers was selected. Personnel records at Teepak are maintained in such a way that there are separate areas for current, retired/vested, former (pre-1977), former (since 1977), and deceased workers. The records are filed by employee clock number, which is ordered by date of hire. Every tenth record was abstracted from each group of employee records, thus assuring a representative distribution by time of hire. The following information was obtained from each record included in the sample: name, clock number, social security number, sex, date of birth, and complete job history, including starting and ending dates by each department and class (Appendix). In addition, if a notation was made in the record of the employee's death, it was also recorded. The same information listed above was also recorded for each worker known to be deceased.

Data from personnel records were entered into the NIOSH Life Table Analysis System for tabulation of the 10-percent estimate of the number of person-years-at-risk (PYAR) experienced by workers at the plant. Person-years were then stratified by race, gender, age, duration of employment, and time from first employment to the study end date. The expected numbers of deaths from a variety of causes were estimated by applying national death rates to the number of person-years in this population.

An individual's person-years begin on the date of hire and accumulate through the end of the study period (12/8/86). In a full mortality study, the end of accrual of person-years is either the date of death or the end of the study date. However, only in rare cases were persons known to be deceased included in the 10-percent sample. Therefore, the number of person-years is known to be over-estimated, and the expected number of deaths is therefore, a conservative (that is, high) estimate.

Estimates of the standardized mortality ratios from arteriosclerotic heart disease and other causes of death were calculated by dividing the number of observed deaths from a particular cause by the number of expected deaths and multiplying by 100. Therefore, an SMR of 100 would reflect no difference in the number of observed and expected deaths. Because the denominator of the rates used (person-years) is an estimated number, it is not possible to perform meaningful statistical tests to determine the statistical significance of resulting SMRs.

B. Results

The 10 percent sample record review resulted in the selection of the records of 224 employees (Table 1), who contributed a total of 3755.8 person-years. Therefore, the estimated total amount of person-time for the entire workforce is 37,558 person-years.

Of the total 82 deaths reported either by the company, the union, or both, the death certificates of 77 (94%) were located (Table 2). Names of deceased persons were obtained from two sources: company management and union officials. In order to assess any potential bias, the percent of deaths from heart disease was compared from each list. Of the total 77 deaths, the company provided the names of 54. Of these, 25 (46%) died of heart disease. Of the 52 names provided by the union, 23 (44%) died of heart disease (Table 3). It can be seen that the deaths from heart disease were identified equally by both sources of information.

Of the 77 deceased individuals, complete work histories were obtained for 54 (72%) from company personnel records at the time of the NIOSH site visit in December 1986. These 54 were limited to individuals made known through company records. The reason for this systematic selection is that names of deceased individuals were obtained from company records during the NIOSH site visit. The names from union records were not provided until after the visit.

From the amount of person-time estimated to have been experienced by this workforce, the total number of expected deaths is 105 (Table 4). This is compared with 77 deaths observed, for a standardized mortality ratio (SMR) of 74. The number of deaths observed from diseases of the circulatory system is 35, compared with 30.2 expected (SMR = 116). Of primary interest in the investigation of health effects of carbon disulfide is arteriosclerotic heart disease. It can be seen that 27 such deaths were observed and 24.3 were expected, based on national death rates. The resulting SMR is 111.

Further stratification of this life-table analysis by exposure variables (duration, job classification) was not performed because the small numbers would not yield meaningful results. However, in order to address the questions of possible associations between heart disease and exposure to carbon disulfide, a "case-control" analysis was performed, in which the work histories of the persons having died of heart disease were compared with those of persons having died from other causes. This analysis was performed on the 55 persons for whom a work history was obtained. Workers in the chemical and process departments (except coating tower operators) were considered to have potential exposure to carbon disulfide.

Overall, the odds of an individual who died of heart disease to have ever worked in a job with potential CS_2 is slightly higher than the odds of an individual who died from another cause never to have worked in a CS_2-exposed job [odds ratio (OR) = 1.6], though this difference is not statistically significant ($p = .35$) (Table 5). However, among younger workers (50 years old or younger), there appears to be an association between dying of heart disease and ever working in a CS_2-exposed job (OR = 12.6; $p = 0.03$, Fisher's 2-tailed test).

In order to assess the association between heart disease and duration of exposure, the death certificate data were stratified by years worked in CS_2-exposed jobs (Table 6). There is no overall association between heart disease mortality and duration of CS_2 exposure (X^2 for linear trend: $p = 0.15$), though the numbers of deaths in the various categories are relatively small. However, as was observed with the association between heart disease and ever having worked in a CS_2 job, the association with duration was statistically significant for workers at or below the age of 50 ($p = 0.02$), while there was no association among workers over the age of 50 ($p = 0.48$).

Conclusion

This 10-percent sample mortality investigation showed no elevation in overall mortality (SMR=74). However, the death rate from arteriosclerotic heart disease was marginally elevated (SMR=111), particularly in light of the probable incomplete ascertainment of deaths in this study. It should be noted as well, however, that the death rates from cancer (overall and several site-specific cancers) were also similarly elevated. There is no good a priori evidence to suggest that work in this plant or exposure to carbon disulfide would result in higher than expected rates of cancer. A follow-up of the cohort of rayon workers that provided evidence of a strong association between exposure to CS_2 and heart disease mortality showed no elevation in the death rates from cancer among that study population.[7] The authors concluded that this supported the tentative conclusion that carbon disulfide "is not carcinogenic, at least not under moderate conditions of exposure."

Overall, there is no evidence of an association between mortality from heart disease and either ever having worked in a CS_2-exposed job or duration of work in such a job. However, among workers 50 years old or less, these associations are seen despite possibly incomplete case ascertainment. The levels of exposure in this plant are, for the most part, within the OSHA permissible exposure level of 20 ppm. There is no documentation of air levels prior to 1980; however, it is likely that they were higher than the levels recorded during the 1980's. There are no data to point to a definitive level of effect, but there is evidence of increased mortality from heart disease at exposure levels as low as 10 ppm.

The results of the 10-percent sample mortality evaluation are not conclusive of either an association or a lack of association between exposure to CS_2 and heart disease at the Teepak plant. Only a full-scale standardized mortality ratio study, with complete ascertainment of deaths and person-years experienced by the entire workforce would provide a definitive assessment of the mortality experience at Teepak.

A research question that is as yet largely unanswered is at what level of exposure to CS_2 are adverse effects on the heart observed. Although there have been some studies suggesting that increased mortality from heart disease may be seen at levels at or below the OSHA standard of 20 ppm, definitive evidence of this is lacking. As stated previously, historical records of CS_2 exposure at the Teepak plant are severely limited. However, if it were possible to characterize more accurately the exposure history of the plant, a mortality study of Teepak workers might provide insight into this important research question. Such a study is beyond the scope of the health hazard evaluation program; however, we have sent a copy of this report to the appropriate NIOSH research branch for consideration.

Distribution and Availability of Report

Copies of this report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Publications Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days, the report will be available through the National Technical Information Services (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from the NIOSH Publications Office at the Cincinnati address.

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

REFERENCES

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Table 1

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Employment Status of Ten-Percent Sample of Personnel Records

STATUS	NUMBER (%)
Current	63 (28%)
Former	
(1977-1986)	25 (11%)
(1957-1977)	128 (57%)
Vested/Retired	4 (2%)
Deceased	4 (2%)
TOTAL	224 (100%)

Table 2

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Source of Information About
Deaths Occurring Among Former Employees of Teepak

	Company Only	Union Only	Both	TOTAL
Informed of Death	28	25	29	82
Death Certificate Obtained	25 (89%)	23 (92%)	29 (100%)	77 (94%)
Work History Obtained	25 (100%)	0 *	29 (100%)	54 (72%)

* See text for explanation

Table 3

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Cause of Death by Source of Information Regarding Decedent

SOURCE	HEART DISEASE	NON-HEART DISEASE	TOTAL
Company only	12 (48%)	13 (52%)	25
Union only	10 (43%)	13 (57%)	23
Both company & union	13 (45%)	16 (55%)	29
TOTAL	35 (45%)	42 (55%)	77

Table 4

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Causes of Deaths Among Teepak Employees
(NIOSH Classification Based on ICD 8)

CAUSE OF DEATH	# Observed	# Expected *	SMR **
Neoplasms	22	21.2	104
MN@-Digestive organs/peritoneum	3	4.3	70
MN-Respiratory system	6	6.2	97
MN-Breast	1	1.6	63
MN-Female genital organs	2	0.9	222
MN-Male genital organs	2	0.6	333
MN-Other/unspecified	4	3.5	114
Lymphatic/hematopoietic	3	2.7	111
Benign/unspecified of brain	1	0.3	333
Nervous System			
Vascular lesions of CNS	1	3.9	26
Circulatory System	35	30.2	116
Arteriosclerotic HD	27	24.3	111
Chronic endocarditis (not rheumatic)	1	0.2	500
Other HD	4	2.3	174
Diseases of arteries/veins	3	1.9	158
Respiratory system	1	3.7	27
Skin/subcutaneous tissue	1	0.1	1000
Accidents	11	19.1	58
Violence	4	10.0	40
Suicide	4	6.7	60
Homicide	0	3.4	0
Other causes	2	5.8	34
ALL CAUSES	77	105	74

* Number of deaths expected, based on person-year experience of plant from 10-percent record review, applying rates of U.S. population

** Estimate of standardized mortality ratio:
SMR = (observed deaths/expected deaths) X 100

@ Malignant neoplasm

Table 5

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Case-Control Analysis of Deaths
for Whom a Work History Was Available

		Heart Disease * YES	Heart Disease * NO
CS_2**	YES	14	12
	NO	12	17

Odds Ratio = 1.6 (95% Confidence Interval = 0.5, 5.5)

< = 50 YEARS OLD

		Heart Disease YES	Heart Disease NO
CS_2	YES	7	5
	NO	1	9

OR = 12.6 (95% CI: 1.0, 629.2)

> 50 YEARS OLD

		Heart Disease YES	Heart Disease NO
CS_2	YES	7	7
	NO	11	8

OR = 0.7 (95% CI: 0.1, 3.6)

* Diseases of the heart, as defined in NIOSH death categories (International Classification of Disease groupings) include:
rheumatic heart disease (including fever), ischemic heart disease, chronic diseases of endocardium, other myocardial degeneration, hypertension with heart disease, other diseases of the heart

** CS_2: ever vs. never having worked in a department and job that is reported to experience exposure to CS_2

Table 6

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Case-Control Analysis of Deaths
for Whom a Work History Was Available

		Heart Disease		
		YES	NO	(% H.D.)
Yrs. in CS_2 Job	0	12	17	(41%)
	1-10	5	7	(42%)
	10+	9	5	(64%)

X^2 linear trend = 1.08; p=0.15 (1-tailed)

		≤ 50 YEARS OLD			> 50 YEARS OLD		
		Heart Disease			Heart Disease		
		YES	NO	(% H.D.)	YES	NO	(% H.D.)
Yrs. in CS_2 Job	0	1	9	(10%)	11	8	(58%)
	1-10	3	4	(43%)	2	3	(40%)
	10+	4	1	(80%)	5	4	(55%)
		X^2 trend = 4.4; p=0.02			X^2 trend = 0.004; p=0.48		

APPENDIX

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Department and Job Classifications

Chemical Department *
- chemical control operator
- day relief man
- spin operator
- chemical operator
- filter pressman/utility man
- vacation relief man
- recovery operator

Laboratory
- laboratory technician

General Service
- warehouseman
- general serviceman
- warehouseman/truck driver

Stores
- stores serviceman

Maintenance Department
- electronic technician
- electrician
- instrument mechanic
- machinist
- mechanic
- shift mechanic
- stationary engineer
- pipefitter/welder
- building maintenance man
- shirring mechanic
- maintenance utility man
- oiler
- belt and wheel grinder
- tool room man
- instrumentation specialist
- HVAC mechanic

Process Department *
- die and mandrel technician
- dye man
- extrusion operator
- reelman
- day relief man
- die and mandrel utility man
- process control operator
- coating tower operator

Shirring Department
- packer/sealer
- shirring serviceman/utility
- shirring machine operator
- saturator operator
- water tester

Office Work
- office work

Converting Department
- platemaker
- flexographic pressman
- trainee qual. flexo pressman
- flexo pre-make-ready man
- chief set-up man
- young pressman
- converting machine operator & set-up (slitter-extruder)
- packer/shipper
- converting area serviceman
- sealing machine operator
- stock clerk
- catcher-inspector
- inkman
- warehouseman
- lab technician

* Workers in Chemical and Process Departments (except coating tower operator) have potential exposure to carbon disulfide