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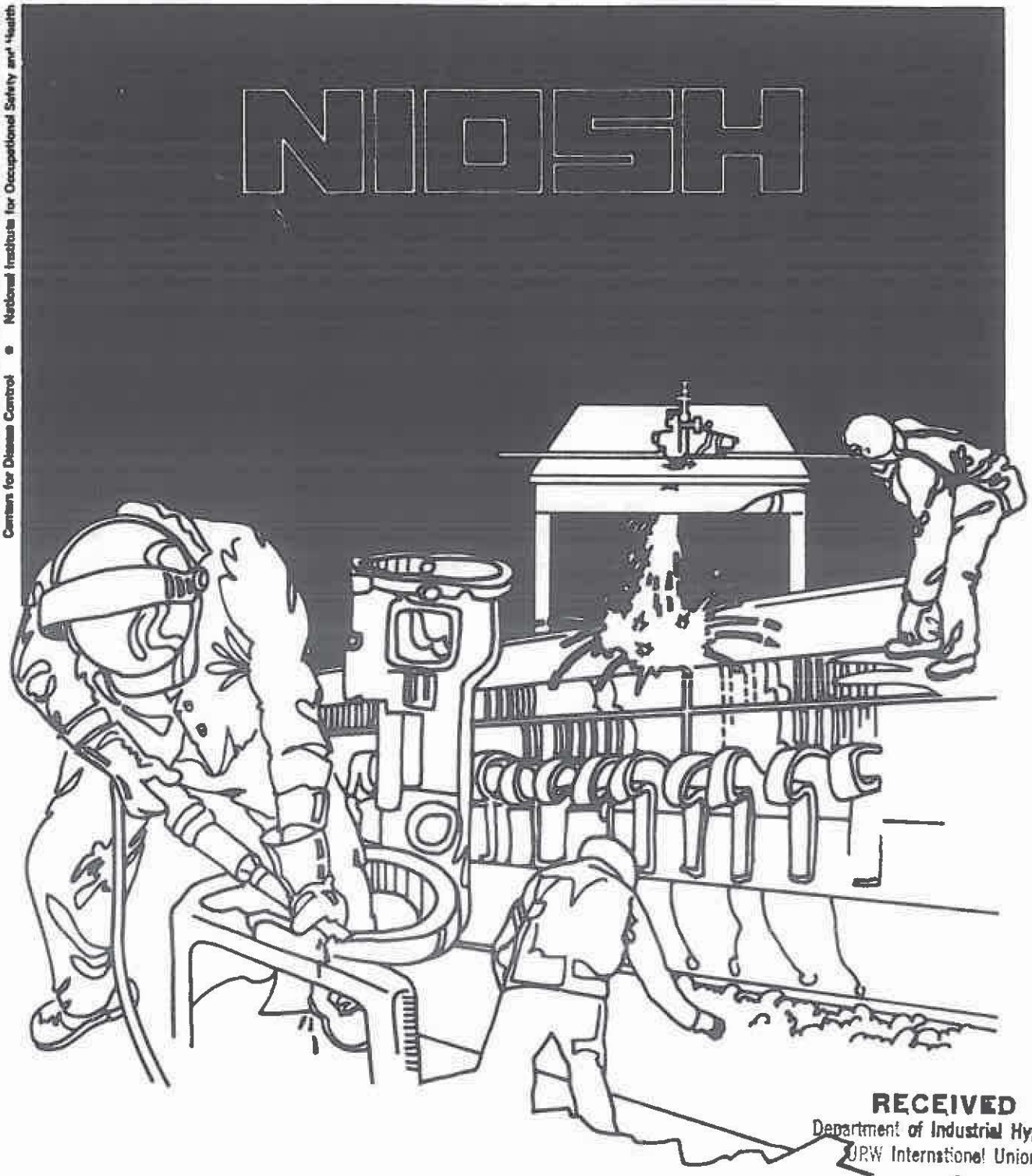

Health Hazard Evaluation Report

HETA 85-003-1834
B.F. GOODRICH
WOODBURN, INDIANA

PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to Federal, state, and local agencies; labor; industry and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

HETA 85-003-1834
SEPTEMBER 1987
B.F. GOODRICH
WOODBURN, INDIANA

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I. SUMMARY

In October 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Rubber, Cork, Linoleum and Plastic Workers of America, Local 715, to investigate a suspected excess of cancers among workers in the Milling and Tuber area of the B. F. Goodrich tire plant in Woodburn, Indiana. Specifically, "three brain cancers, one optic tumor, three lung cancers, and three leukemia cases," were reported to have occurred among people who had worked in the Milling and Tuber area.

We examined the possibility of an excess by: calculating the number of age- and sex-specific person-years at risk for the group, determining the expected number of cases by applying person-years at risk to age- and sex-specific cancer incidence rates published by the National Cancer Institute, and comparing the reported number of cases to the expected number.

Cases were verified using three sources: B.F. Goodrich's computerized corporate medical system, death certificates (obtained from the state in which death occurred), and medical records (obtained from a hospital or private physician). To be counted as a case, the diagnosis had to have been made after the person began employment in the Milling and Tuber area.

No cases of brain cancer, no cases of eye cancer, one case of leukemia, and five cases of lung cancer were verified. The one case of leukemia represents a slight, non-statistically significant, excess. The five cases of lung cancer represent a ten-fold increase over the expected cases, and is statistically significant. The imposition of minimum latencies ranging from 5-20 years, by 5-year increments, resulted in Standardized Morbidity Ratios (SMRs) of 10.36, 15.33, 14.60, and 28.57 respectively.

In December 1979, as part of a previous survey at this plant, NIOSH and the company collected a total of 21 personal breathing-zone air samples for nitrosamines. Exposures to N-nitrosomorpholine ranged from 0.5 to 1.8 micrograms per cubic meter (ug/m^3) with a mean of 0.8 ug/m^3. N-nitrosodimethylamine exposures ranged up to 0.09 ug/m^3. Due to their potential carcinogenicity, NIOSH recommends that exposure to nitrosamines be kept as low as possible. Benzene air samples collected by OSHA and the company since 1980 have shown exposures to be less than

0.1 parts per million (ppm). However, six workers sampled by the company in 1975, had air benzene concentrations ranging from 0.5 to 11.9 ppm, with a mean of 3.5 ppm. NIOSH considers benzene to be a human carcinogen, and, as such, recommends that exposures be kept to the lowest feasible level, but should never exceed 0.1 ppm as an 8-hour time weighted average (TWA) or 1 ppm as a 15-minute ceiling. Finally, prior to 1979, talc was widely used in the plant, including the department being studied. It has not been possible to determine whether some or all of the talc was asbestos-containing, but exposure to asbestos particles from this source cannot be ruled out.

On the basis of the available data, it was determined that there is evidence of an excess of lung cancer among workers who have ever been employed in the Milling and Tuber area of B.F. Goodrich's Woodburn, Indiana plant. Recommendations for medical screening and control of exposures are included in Section VIII of this report.

KEYWORDS: SIC 3011 (Tires and Inner Tubes), cancer, lung cancer, leukemia, nitrosamines, benzene, asbestos-containing talc, coal tar pitch volatiles.

II. INTRODUCTION

In October 1984, the National Institute for Occupational Safety and Health (NIOSH) received a request from the United Rubber, Cork, Linoleum and Plastic Workers of America, Local 715, to investigate a suspected excess of cancers among workers in the Milling and Tuber area of the B. F. Goodrich tire plant in Woodburn, Indiana. Specifically, "three brain cancers, one optic tumor, three lung cancers, and three leukemia cases," were reported to have occurred among people who had worked in the Milling and Tuber area.

On October 30-31, 1984, a NIOSH industrial hygienist and an epidemiologist conducted an initial visit consisting of a walk-through, and an assessment of the available personnel, medical, and industrial hygiene records. On January 22-23, 1985, we reviewed the personnel files of all current and former employees of B.F. Goodrich's Woodburn plant to obtain information for an epidemiologic study. On June 18, 1986 and again on October 8, 1986 we sent letters to the company and union informing them of the progress of the study.

III. BACKGROUND

The B. F. Goodrich plant in Woodburn, Indiana was built in 1961 and employs about 1700 workers to manufacture 27,000 tires per day. The plant covers 40 acres and has a warehouse capacity of 1 million tires.

Figure 1 shows the production stages in the manufacture of tires and tubes, and Table I describes occupational title groups in tire and tube manufacturing.[1] NIOSH publication no. 84-111, "Control of Air Contaminants in Tire Manufacturing," provides detailed descriptions of all the major processes of tire manufacturing and their potential for producing worker exposure to air contaminants.[1]

The Milling and Tuber area employs 130 workers evenly over three shifts. A mill is a machine that uses rollers to further mix rubber from the initial mixing process (Banbury) and form it into rubber sheet stock. The sheets are coated with anti-tack agents for easier handling. Tubering is an extrusion process where the milled rubber is forced through a die, forming a long, continuous strip in the shape of tread or sidewall.

Major sources of airborne contaminants are fumes emitted from the rubber as it is heated by the friction generated from the milling and extruding processes, and dust generated by the handling of anti-tack agents, such as talc. Also, the rubber solvent currently used for tire-building at the Woodburn plant contains 0.1% benzene.

IV. EVALUATION DESIGN AND METHODS

A. Medical/Epidemiologic

We were provided access to the personnel files of all current and former employees of the Woodburn B.F. Goodrich plant. The files were said to be complete by both the company and the union.

Examining each person's work history card(s), we looked for any indication that a person had ever worked in the Milling and Tuber area (designated as department 8221, 6725, or 6730). For all 336 individuals so identified, we attempted to abstract the following information from their personnel file: name, address, telephone number, social security number, gender, date of birth, date of first employment in the plant, date of last employment in the plant, date of first employment in the Milling and Tuber area, and date of last employment in the Milling and Tuber area.

Cases were identified in the following manner: the B.F. Goodrich computerized corporate medical system was searched, by plant and by International Classification of Disease (ICD) code for any cases of the diseases of interest. Any employee of the Milling and Tuber area whose name appeared on that list was considered to be a case. For additional reported cases that did not appear in the computerized corporate medical system, we obtained a death certificate from the state in which death occurred and/or medical records from a hospital or private physician. If either source confirmed the alleged diagnosis, that person was counted as a case. However, the diagnosis had to have first been made after the person began employment in the Milling and Tuber area. Because many of the people had left employment years before and would have been difficult to locate, we did not systematically obtain death information or medical histories on all of the 336 employees in the study group, only on those who had been identified as possible cases.

We used the NIOSH Life-Table Analysis System (LTAS)[2] to calculate age-specific person-years at risk (PYAR) of developing cancer among the individuals identified. Information was incomplete on two individuals, so that the PYAR reflect 334 of the 336 people. Two separate analyses were performed. The first analysis considered a worker to be at risk from the time s/he began work in the Milling and Tuber area until the study end date of January 1, 1985. No adjustment was made to stop accumulation of PYAR at date of diagnosis or death prior to the study end date.

Cancer incidence rates from 1973-1977, for whites, by five-year age groups, were obtained from the National Cancer Institute's SEER Program.[3] This program collects data, primarily from population-based tumor registries, in the following geographic areas: the states of Connecticut, Iowa, New Mexico, Utah, and Hawaii; and the metropolitan areas of Detroit, Atlanta, New Orleans, San Francisco-Oakland, and Seattle. These data and rates are then available by individual area or by all areas combined. Using the combined rates as the comparison, we calculated the number of expected cases of each cancer of interest by applying the SEER rates to the PYAR for each 5-year age group.

For each site-specific cancer, we calculated a Standardized Morbidity Ratio (SMR) (ratio of observed cases to expected cases), and, assuming a Poisson distribution, a 95% Confidence Interval (C.I.)[4] around that ratio. When the SMR was not statistically significant, we calculated the number of additional cases that would have had to have occurred in order for there to have been less than a 5% chance that the events were random.

A second similar set of analyses was then performed for lung cancer, the only site where a significant excess was identified in the original analyses. These analyses imposed minimum latencies of 5, 10, 15 and 20 years. For example, a five-year latency means that for the first five years after beginning employment in the Milling and Tuber area, we do not consider a person to be at risk of developing cancer from that job. Therefore, neither PYAR nor diagnoses of lung cancer for those five years are counted in that analysis.

B. Environmental

On December 12, 1979, as part of a previous study at this plant, NIOSH collected 10 air samples for nitrosamines in the Milling, Extruding, Curing, and Warehouse areas.[5] Samples were collected on Thermosorb tubes using battery-powered sampling pumps at a flow rate of 1.5 liters per minute (LPM). The samples were eluted with dichloromethane and methanol, and analyzed for seven volatile nitrosamines by gas chromatography-thermal energy analysis and high pressure liquid chromatography-thermal energy analysis. From 1979 to 1983, the company collected 30 air samples for nitrosamines.

Polynuclear aromatic hydrocarbons (PNAs) can also be released into the air when rubber is heated. On January 10, 1980, OSHA collected six personal breathing-zone (PBZ) samples for coal tar pitch volatiles (CTPV) among tire curing-press operators. From 1975 to 1982, twenty PBZ samples for benzene were collected by the company and OSHA.

V. EVALUATION CRITERIA

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), and 3) the U.S. Department of Labor (OSHA) occupational health standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA standards. The OSHA standards also may be required to take into account the feasibility of controlling exposures in various industries where the agents are used; the NIOSH-recommended standards, by contrast, are based primarily on concerns relating to the prevention of occupational disease. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that industry is legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from high short-term exposures.

A. Benzene

NIOSH recommends that occupational exposure to benzene be controlled to the lowest feasible level, but in no event should any worker be exposed to more than 0.1 ppm as an 8-hour time weighted average (TWA) and that short-term exposure be controlled so as not to exceed 1 ppm, as determined in any 15-minute sampling period. The OSHA permissible exposure limit (PEL) has recently been lowered to 1 ppm, with a short-term exposure limit (STEL) of 5 ppm.

The data on benzene leave no doubt regarding the human carcinogenic potential of this chemical. Rinsky et al.[6] found a significantly increased risk of developing leukemia even at long-term exposures less than 1 ppm. However, primary routes of exposure to benzene are inhalation (breathing) and skin absorption. Susten et al. [7] found that significant benzene absorption can occur among workers who use solvents that contain about 0.5% benzene. They calculated that a worker building 150 tires per day could absorb approximately 6 mg of benzene daily through intact skin. The 6 mg of benzene can be compared to the amount of benzene absorbed through inhalation of 1 ppm benzene over an 8-hour day.[7]

B. Nitrosamines

Nitrosamines are potent animal carcinogens which are readily formed by the interaction (nitrosation) of nitrites or oxides of nitrogen and amine precursors. They may be synthesized in the environment and in the body. Occupational exposures may occur, for example, to machinists from synthetic grinding fluids, and in industries such as leather tanneries and tire manufacturing plants[8, 9]. Non-occupational exposures may occur from such sources as beer, cured meats, cosmetics, and tobacco smoke.

N-nitrosodimethylamine (NDMA) has been shown to be the most potent carcinogen in the nitrosamine family. In animals, the target organs are the liver and kidney. Acute toxic effects of animal exposure to NDMA are gastrointestinal irritation, vomiting, diarrhea, and failure of the blood to coagulate[10]. A study by Moiseev and Benemanskii[11] found that rats exposed daily by inhalation to 0.2 mg/M^3 NDMA for 25 months had tumors of the lung, kidney, and liver earlier and at greater rates than controls who were exposed to 0.005 mg/M^3 NDMA.

Due to their carcinogenic potential, NIOSH recommends that exposure to nitrosamines be reduced to the lowest feasible level. OSHA regulates NDMA as a cancer-suspect agent, though there currently is no permissible exposure limit (PEL).

C. Coal Tar Pitch Volatiles (CTPV)

NIOSH considers CTPV to be potential carcinogens, with the lung and skin as target organs. NIOSH's recommended exposure limit (REL) is 0.1 mg/M^3 as an 8-hour time weighted average (TWA). OSHA also considers CTPV potential carcinogens, and has established a standard of 0.2 mg/M^3 TWA.

D. Talc

In evaluating the toxicity of talc, it is important to determine whether the material also contains asbestos particles. Aside from any asbestos exposure, talc can cause fibrotic pneumoconiosis (a dust disease of the lungs). The OSHA standard is 20 mppcf (million particles per cubic foot of air). The ACGIH recommendation is 2 mg/M^3, measured as respirable dust.

Studies of workers exposed to asbestos-containing talc have found similar health effects to those found in workers exposed to other asbestos products. These health effects include increased mortality due to both malignant (cancer) and non-malignant

respiratory diseases[12, 13]. Other studies have found symptoms and X ray and lung function changes consistent with asbestosis[14-19].

VI. RESULTS AND DISCUSSION

A. Medical/Epidemiologic

Tables II through V depict the number of person-years at risk (with no minimum latency), cancer incidence rates, and expected cases by five-year age group for each of the cancers reported to be of concern. Table VI is a summary of the verified cases of cancer, grouped by site.

No cases of brain cancer were verified among Milling and Tuber area employees, nor were any cases of cancer of the eye.

One case of leukemia was verified, compared with an expectation of 0.13 case. The case was first diagnosed 13 years after the worker began employment in the Milling and Tuber area. The standardized morbidity ratio (SMR) was 7.75 (95% C.I.: 0.10 - 43.13), not statistically significant.

Five cases of lung cancer were verified, compared with an expectation of 0.50 case. The cases were first diagnosed one month, 14, 15, 20, and 21 years after the workers began employment in the Milling and Tuber area. The SMR was 10.08 (95% C.I.: 3.25 - 23.52). This finding is statistically significant (not likely due to chance).

Our second set of analyses was performed only for lung cancer. Imposed minimum latencies of 5, 10, 15 and 20 years resulted in SMRs (with 95% C.I.) of 10.36 (2.79 - 26.53), 15.33 (4.12 - 39.24), 14.60 (1.64 - 52.71), and 28.57 (0.37 - 158.97), respectively (Table VII).

As described in Section IV of this report, NIOSH did not conduct an exhaustive follow-up of the vital status/existence of cancer among all employees of the Milling and Tuber area. It is believed that combining the company's medical data base with union reports of cancer cases (which were later verified) allowed us to identify most of the cancer cases among the workers in question. Still, our estimates of cancer risks must be considered to be minimum estimates because there could be additional cases.

Our estimates of cancer risk are conservative in other ways, as well. Because we did not ascertain the vital status of group members, undoubtedly some people who died prior to the study end date (January 1, 1985) were incorrectly assumed to be at risk of being diagnosed with cancer until that date. Additionally, those people who were diagnosed with cancer prior to the study end date incorrectly continue to accumulate PYAR until the study end date.

A potential concern was that lung cancer rates in the U.S. are increasing over time (particularly for women). We accounted for that by selecting as referents SEER rates which are approximately from the middle of the time period during which this group of workers was at risk.

We did not impose minimum exposure durations as well as latencies because the small numbers which would have resulted would not have been meaningful. However, it is noteworthy that the four cases of lung cancer which had latencies of 14, 15, 20, and 21 years had worked 13, 15, 20, and 21 years, respectively, in the Milling and Tuber area prior to diagnosis. They were all males, and their ages at diagnosis were 62, 49, 53, and 47, respectively. The latency of each of these cases is not incompatible with asbestos-induced lung cancer. In fact, if significant exposure to asbestos-containing talc did occur, it is reasonable to expect those exposed to be at increasing risk of lung cancer until approximately 30-34 years after first exposure.[20, 21]

B. Environmental

All ten of the air samples collected by NIOSH in 1979 contained N-nitrosomorpholine (NMOR), and five of them also contained N-nitrosodimethylamine (NDMA) (Table VIII).[5] Worker exposure to NMOR ranged from 0.6 to 1.8 micrograms per cubic meter (ug/m^3), and exposure to NDMA ranged up to 0.09 ug/m^3. Fifteen personal breathing-zone samples for NMOR collected by the company on December 11-13, 1979, had concentrations ranging from 0.31 to 1.0 ug/m^3, with a mean of 0.66 ug/m^3. In 1982, the company collected two area samples for NMOR near the No. 2 Tread Tuber that showed air levels of 0.42 and 0.71 ug/m^3. In 1983, an area sample near the No. 2 Tread Tuber showed 0.3 ug/m^3 NMOR and 0.04 ug/m^3 NDMA. At that time three area samples collected in the warehouse found NMOR levels ranging from 1.2 to 1.4 ug/m^3 and a NDMA level of 0.05 ug/m^3.

In 1980, six curing-press operators were found to have CTPV exposures ranging up to 110 ug/m^3, with a mean of 43 ug/m^3. No samples have been collected in the Milling and Tuber area.

In 1979, the company switched to kaolin as an anti-tack agent for milled rubber. Talc was used prior to 1979. No historical sampling results exist to determine the presence or absence of asbestos fibers in the talc. The company maintains that non-asbestos containing talc was always used, but no proof was provided and it is not possible to verify that at this time.

None of the 14 PBZ samples for benzene collected by OSHA or the company since 1980 have had a concentration that exceeded 0.1 parts per million (ppm). However, six workers sampled by the company in February 1975, had air benzene exposures ranging from 0.5 to 11.9 ppm, with a mean of 3.5 ppm.

VII. CONCLUSIONS

The results of our study show a significant excess of lung cancer among current and former employees of the Milling and Tuber area. Four cases were diagnosed 14-21 years after the individual began employment in the area. This latency is compatible with (though not proof of) the etiologic agent being exposure to some material in the Milling and Tuber area. No smoking history was obtained from the cases or their next of kin. As smoking is a known powerful lung carcinogen, smoking habits may have influenced these results. However, the cancer incidence rates used for comparison are based upon populations which include both smokers and non-smokers. Well documented exposures to nitrosamines, possible exposures to PNAs, and -- if it was present -- exposure to asbestos-containing talc are possible explanations for the lung cancer excess. However, nitrosamine and PNA exposures were not limited to the Milling and Tuber area. Emissions from hot rubber continue throughout the rest of the tire-making process. In fact, some of the highest nitrosamine levels at the Woodburn plant have been found in the warehouse. Past exposure to talc, however, is unique to the Milling and Tuber area.

The one case of leukemia was more than expected, though it is inconclusive whether an increased leukemia risk exists for the current employees of the Milling and Tuber area. The 13 year latency from time of first employment in the area until time of diagnosis is not inconsistent with such an etiology.

VIII. RECOMMENDATIONS

1. NIOSH Publication No. 84-111, "Control of Air Contaminants in Tire Manufacturing"[1], includes many recommendations for controlling exposures in the industry. Those recommendations, where applicable, should be followed.

2. Additionally, a medical surveillance program should be implemented. Given the documented excess risk of lung cancer, this program should be implemented for all employees who have worked at least five years in the Milling and Tuber area or any other area of the plant where potential exposure to a carcinogen exists. The program should minimally include an annual physical exam, chest x-ray, and pulmonary function testing, with the results to be discussed with the employee. Upon termination of employment, those employees should be advised to continue receiving annual screening.

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XI. 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 Service (NTIS), 5285 Port Royal, Springfield, Virginia 22161. Information regarding its availability through NTIS can be obtained from NIOSH Publications Office at the Cincinnati address. Copies of this report have been sent to:

1. B. F. Goodrich, Woodburn, Indiana
2. United Rubber, Cork, Linoleum and Plastic Workers of America, Local 715
3. United Rubber, Cork, Linoleum and Plastic Workers of America
4. OSHA, Region V

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.

TABLE I

Description of Occupational Title Groups in Tire and Tube Manufacturing[1]

Occupational Title Group	Description of Process
Compounding	Batch lots of rubber stock ingredients are weighed and prepared for subsequent mixing in Banburys; solvents and cements are prepared for process use.
Banbury Mixing	Raw ingredients (rubber, filler, extender oils, accelerators, antioxidants) are mixed together in a Banbury mixer. This internal mixer breaks down rubber for thorough and uniform dispersion of the other ingredients.
Milling	The batches from the Banbury are further mixed on a mill, cooled, and the sheets or slabs coated with talc so they are not tacky. The stock may return to the Banbury for additional ingredients, or go on to breakdown or feed mills prior to extrusion or calendaring.
Extrusion	The softened rubber is forced through a die forming a long, continuous strip in the shape of tread or tube stock. This strip is cut in appropriate lengths, and the cut ends are cemented so as to be tacky.
Calendaring	The softened rubber from the feed mill is applied to fabric, forming continuous sheets of plystock by the calendar (a mill with three or more vertical rolls and much greater accuracy and control of thickness.
Plystock Preparation	The plystock from the calendar is cut and applied to the correct size for tire building, and so the strands in the fabric have the proper orientation.
Bead Building	Parallel steel wire is insulated with rubber vulcanizable into a semi-hard condition and covered with a special rubberized fabric. The beads maintain the shape of the tire and hold it on the steel rim in use.
Tire Building	The tire is built from several sheets of calendared plystock, treads, and beads.

TABLE I
(Continued)

Description of Occupational Title Groups in Tire and Tube Manufacturing[1]

Occupational Title Group	Description of Process
Curing Preparation	The assembled green or uncured tire is inspected, repaired, and coated with agents to keep it from sticking to the mold in vulcanization.
Tube Splicing	Assembly of tube stock; i.e., tube building.
Curing	The green tire or tube is placed in a mold and vulcanized under heat and pressure.
Final Inspection and Repair	The cured tire is trimmed, inspected, and labeled; repairable tires or tubes which do not pass initial inspection are repaired.

TABLE III

Expected Cancers of the Eye

No Minimum Latency

B.F. Goodrich
Milling and Tuber Area
Woodburn, Indiana
HETA 85-003

Age	Person-Years at Risk	Incidence/100,000	Expected Cases
15-19 (Males)	37	0.1	0.000
20-24	313	0.1	0.000
25-29	602	0.2	0.001
30-34	671	0.4	0.003
35-39	638	0.3	0.002
40-44	510	0.7	0.004
45-49	232	1.2	0.003
50-54	88	1.6	0.001
55-59	28	2.0	0.001
60-64	10	2.3	0.000
			= 0.015
15-19 (Females)	4	0.1	0.000
20-24	32	0.1	0.000
25-29	50	0.1	0.000
30-34	42	0.2	0.001
35-39	33	0.5	0.002
40-44	11	0.4	0.002
			= 0.001

Total Number of Expected Cases = 0.016
Minimum Number of Cases Necessary for a Statistically Significant Excess* = 1
Number of Cases Verified = 0

*Upper boundary of the 95% Confidence Interval for the Poisson Distribution.

TABLE IV

Expected Cancers of the Brain

No Minimum Latency

B.F. Goodrich
Milling and Tuber Area
Woodburn, Indiana
HETA 85-003

Age	Person-Years at Risk	Incidence/100,000	Expected
15-19 (Males)	37	1.9	0.001
20-24	313	2.1	0.007
25-29	602	2.4	0.014
30-34	671	2.8	0.019
35-39	638	4.4	0.028
40-44	510	5.6	0.029
45-49	232	8.3	0.019
50-54	88	11.2	0.010
55-59	28	14.6	0.004
60-64	10	17.8	0.002
			= 0.133
15-19 (Females)	4	1.6	0.000
20-24	32	1.6	0.001
25-29	50	1.9	0.001
30-34	42	1.9	0.001
35-39	33	2.6	0.001
40-44	11	3.6	0.000
			= 0.004

Total Number of Expected Cases = 0.137
Minimum Number of Cases Necessary for a Statistically Significant Excess* = 2
Number of Cases Verified = 0

* Upper boundary of the 95% Confidence Interval for the Poisson Distribution.

TABLE V

Expected Cases of Leukemia

No Minimum Latency

B.F. Goodrich
Milling and Tuber Area
Woodburn, Indiana
HETA 85-003

Age	Person-Years at Risk	Incidence/100,000	Expected
15-19 (Males)	37	3.0	0.001
20-24	313	1.8	0.006
25-29	602	2.8	0.017
30-34	671	2.9	0.019
35-39	638	4.0	0.026
40-44	510	4.5	0.023
45-49	232	7.1	0.016
50-54	88	10.6	0.009
55-59	28	17.6	0.005
60-64	10	30.2	0.003
			= 0.125
15-19 (Females)	4	1.7	0.000
20-24	32	1.9	0.001
25-29	50	2.1	0.001
30-34	42	1.9	0.001
35-39	33	2.7	0.001
40-44	11	3.8	0.000
			= 0.004

Total Number of Expected Cases = 0.129
Minimum Number of Cases Necessary for a Statistically Significant Excess* = 2
Number of Cases Verified = 1
Standardized Morbidity Ratio (SMR) = 7.75
95% Confidence Interval for the SMR: 0.10 - 43.13

* Upper boundary of the 95% Confidence Interval for the Poisson Distribution.

TABLE VI

Verified Cases of Cancer

No Minimum Latency

B.F. Goodrich
Milling and Tuber Area
Woodburn, Indiana
HETA 85-003

Cancer	# Verified	# Expected	Standardized Morbidity Ratio (SMR)	95% Confidence Interval
Brain	0	0.137	0	-
Eye	0	0.016	0	-
Leukemia	1	0.129	7.75	0.10 - 43.13
Lung and Bronchus	5	0.496	10.08	3.25 - 23.52

TABLE VII

Cancers of the Lung and Bronchus

Minimum Latencies of 0-20 Years, by 5-year Increments

B.F. Goodrich
Milling and Tuber Area
Woodburn, Indiana
HETA 85-003

Minimum Latency	Observed/Expected	= SMR	95% Confidence Interval
0 Years	5 / 0.496	10.08	3.25 - 23.52
5 Years	4 / 0.386	10.36	2.79 - 26.53
10 Years	4 / 0.261	15.33	4.12 - 39.24
15 Years	2 / 0.137	14.60	1.64 - 52.71
20 Years	1 / 0.035	28.57	0.37 - 158.97

These categories are not mutually exclusive. For example, the case which had more than 20 years of latency was counted in each of the other categories (in other words, it had more than zero, 5, 10, and 15 years of latency. Each SMR, with the exception of that for more than 20 years of latency, represented a statistically significant excess.

TABLE VIII

Air Concentrations of Nitrosamines
B. F. Goodrich
Woodburn, Indiara
December 12, 1979[5]

Sample Type	Location	Sampling Volume (Liters)	NDMA ng/ThermoSorb	NDMA ug/m3	NMOR ng/ThermoSorb	NMOR ug/m^3
PBZ*	#101 Rubber Mill	155	N.D.**		138	0.90
PBZ	Four Roll Calendar	147	N.D.		125	0.85
PBZ	Tread tuber operator #2 Extruder	210	33	0.09	486	1.2
PBZ	Spacesaver Spares Curing Area	243***	N.D.		608	1.8
Area	Spacesaver Curing Area	293	24	0.08	429	1.5
Area	Spacesaver Tire Warehouse	324	123	0.38	1194	3.7
HPLC-TEA	Confirmation	324	125	0.39	1227	(3.7)
PBZ	Mill Operator in tubing operation	372	15	0.04	506	1.4
Area	Near #2 Extruder	375	660	1.8	1170	3.1
HPLC-TEA	Confirmation	375	531	1.4	1079	2.9
Area	Four Roll Calendar	390	N.D.		330	0.85
PBZ	Heavy duty curing presses	326	N.D.		205	0.63

*PBZ = personal breathing-zone

**N.D. = None detected - detection limit 10 ng/ThermoSorb

***Shift change after 107 minutes

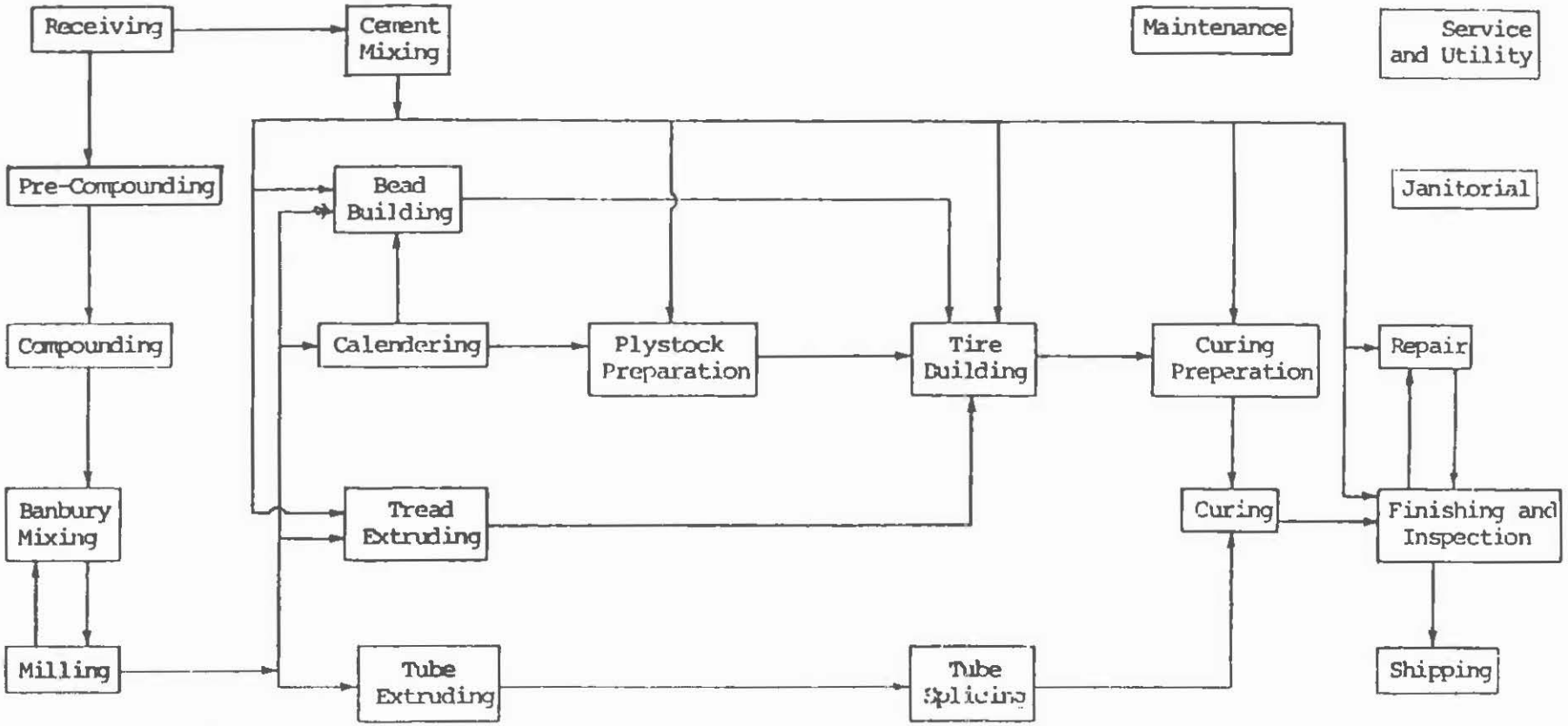

Figure 1. Production Stages in the Manufacture of Tires and Tubes.