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I. SUMMARY

In October 1986, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH) received a request from the United Rubber Workers' International Union (URW) to evaluate exposure to fibrogenic dust and the occurence of pneumoconioses among tire workers. NIOSH evaluated a series of chest radiographs from the URW/tire industry-sponsored Personal Health Surveillance Program (PHSP), reviewed Occupational Safety and Health Administration (OSHA) environmental exposure data, and conducted limited environmental surveys at three plants.

The final sample of radiographs included 987 chest films from examinees $\geq$40 years of age who worked at nine plant locations (4 companies). Three board-certified radiologists who were also NIOSH 'B' readers independently interpreted the films according to the rules and criteria contained in the l980 International Labour Office (ILO) classification system for the pneumoconioses.

Two films with minor parenchymal change consistent with pneumoconiosis were identified. In addition, 22 other casess pleural abnormalities were found. Almost half (l0) of the films identified with pleural abnormalities were from employees at one plant.

A review of the OSHA environmental exposure data collected from 1979 through 1985 in the rubber manufacturing industry revealed that 3% of the exposure data exceeded 2 fibers per cubic centimeter (f/cc), the OSHA permissible exposure limit in effect (PEL) at the time. When compared to the current PEL of 0.2 f/cc, 28% were in excess of the standard, and when compared to the NIOSH recommended exposure limit of 0.1 f/cc, 33% were in excess.

Our surveys at the three tire plants failed to document any overexposures to fibrous minerals or other known pneumoconiosis producing dusts.

Pleural abnormalities, consistent with exposure to asbestos, were identified on 2.2% of 987 chest radiographs. Nearly one-half of these abnormalities were in workers from one plant. OSHA compliance data for the industry indicate overexposures to asbestos.

Keywords: SIC 3011 (tires and inner tubes), Coal Tar Pitch Volatiles, asbestos, talc, rubber manufacturing, pneumoconiosis

II. INTRODUCTION

In October 1986, the Division of Respiratory Disease Studies, National Institute for Occupational Safety and Health (NIOSH) received a request from the United Rubber Workers' International Union (URW) to evaluate exposure to fibrogenic dust and the occurence of pneumoconioses among tire workers. NIOSH evaluated a series of chest radiographs from the URW/tire industry-sponsored Personal Health Surveillance Program (PHSP), reviewed Occupational Safety and Health Administration (OSHA) environmental exposure data, and conducted limited environmental surveys at three plants.

In l982, collective bargaining agreements between the URW and selected companies set in motion a multiphasic screening activity--the Personal Health Surveillance Program (PHSP). Through one provider, mobile health testing vans visit local union and/or plant sites on an annual basis. Test procedures include chest x-rays. The PHSP is a "stay healthy" or wellness program[1] covering an estimated 30,000 workers. Although workers contribute financially to the PHSP, their participation in the testing is voluntary.

At the time of our survey, PHSP was in its fifth annual cycle of examinations. Twenty one plants owned by four companies have participated in the program; l5 of them manufactured tires and/or tubes. Locations of participating plants were:

<u>Armstrong</u>

*Des Moines, Iowa
*Natchez, Mississippi
*Madison, Tennessee
*Hanford, California

<u>B.F. Goodrich</u>

Akron, Ohio
*Oaks, Pennsylvania
*Miami, Oklahoma
*Woodburn, Indiana
*Tuscaloosa, Alabama

<u>Uniroyal</u>

*Eau Claire, Wisconsin
Mishawaka, Indiana
Painesville, Ohio
*Opelika, Alabama
Port Clinton, Ohio
Naugatuck, Connecticut

<u>Firestone</u>

Akron, Ohio
*Des Moines, Iowa
*Decatur, Illinois
*Bloomington, Illinois
*Albany, Georgia
*Oklahoma City, Oklahoma

*tire and/or tube manufacturing

In February l987, NIOSH issued an interim report of the survey's findings. This current report is an update of that interim report and includes additional radiological evaluations of l92 workers from 2 plants which were not previously included.

III. METHODS

A. Medical

In an attempt to focus on the population with greatest potential for disease, we limited our evaluation to employees with ≥40 years of age. In order to reach a sample size of approximately 1000, we used radiographs from nine plants. Chest films from the second annual PHSP survey period (l983-84) were utilized. In these nine facilities, participation in the PHSP by plant ranged from a high of 26% to a low of only 9%. Some examinations performed during that time frame involved individuals working at plants which are now closed.

The nine tire/tube manufacturing plants were:

Goodrich	Number >40 Yrs Age
Oaks, Pennsylvania	86
Miami, Oklahoma	302
Armstrong	
Des Moines, Iowa	163
Natchez, Mississippi	29
Firestone	
Des Moines, Iowa	261
Bloomington, Illinois	21
Decatur, Illinois	48
Albany, Georgia	50
Uniroyal	
Opelika, Alabama	27
Total	987

Initially, the chest films from the two Armstrong plants were removed from the study at the request of the URW and Armstrong. Subsequently, these parties agree to have the radiographs included and the results are part of this report.

To use more than a single interpreter for x-ray readings is beneficial, as variability is well documented.[2-6] We chose to use three experts; an odd number is preferable to resolve discrepancies in reading.[7] For profusion of small lesions, a median determination became the final reading. For all other findings, the majority opinion was utilized.

Four criteria were used in the selection of readers:

1) Board certified in radiology.
2) NIOSH 'B' reader certification.[8]
3) Detailed knowledge of the l980 International Labour Office (ILO) radiographic classification system for the pneumoconioses.[9]
4) Known experience involving a large volume of cases with dust induced diseases, especially resulting from exposure to asbestiform materials.

Except for the interpretation of the Armstrong films, each radiologist was assigned an assistant to record observations; the assistant being specially trained in the use of a standardized reporting form and having general familiarity with the ILO classification system.

All films were interpreted by all readers independently according to the provisions and criteria specified in the l980 revision of the ILO classification system for the pneumoconioses. All readings were performed without knowledge relating to the purpose of the trials or the source of the films. The Armstrong films were read at a later date. The same radiologists were used, and readings were preformed in an independent manner. The exact design used in the trials was as follows:

Reading Order
Reader by Batch (A-F)

	Reader l	Reader 2	Reader 3
	A	B	C
	D	E	F
INITIAL TRIALS	B	C	A
	E	F	D
	C	A	B
	F	D	E
ARMSTRONG FILMS	X	X	X

B. Environmental

We determined that a plant-by-plant examination across the rubber manufacturing industry would be beyond the scope of the health hazard evaluation program. To address exposures we began by reviewing the materials found in the National Occupational Hazard Survey (NOHS). A group of commonly utilized minerals and other finely divided solid materials was selected from NOHS and utilized to cross search the Occupational Safety and Health Administration's (OSHA) exposure data records (SASDATA.OSHA) in the SIC Codes listed below, for the period 1979 through 1985:

SIC 3011 - Tires and Inner Tubes
SIC 3021 - Rubber and Plastics Footwear
SIC 3031 - Reclaimed Rubber
SIC 3041 - Rubber and Plastic Hose and Belting
SIC 3069 - Fabricated Rubber Products, Not Otherwise Classified

The materials for which OSHA had exposure records during that time period included asbestos, talc, coal tar pitch volatiles, quartz, respirable dust and total dust.

The plants from which worker x-rays were selected were all in SIC code 3011 and were involved in tire manufacturing. Of the nine plants in the film-reading survey, site evaluations were conducted at three. During these evaluations air sampling for respirable dust, quartz, and asbestos was performed. Respirable dust was sampled at 1.7 liters per minute onto 5-micrometer pore size polyvinyl chloride filters preceded by 10-millimeter cyclones and analyzed gravimetrically. Quartz was determined from the same samples utilizing NIOSH method no. 7500. Fibers were sampled at 2 liters per minute on 0.8 micrometer pore size 25-millimeter cellulose ester filters in open-faced cassettes. Filters were analyzed both by phase contrast microscopy (NIOSH method 7400), and transmission electron microscopy (NIOSH method 7402). Bulk samples of mineral product ingredients and settled dust samples were collected for subsequent analysis by polarized light microscopy. Observations of asbestos insulation and friction materials and their state of repair were noted as part of each plant evaluation.

Each of the three plants employed from 1500 to 2000 workers, and had been in operation for more than 20 years. The tire manufacturing techniques were standard and have remained unchanged except for variations in raw materials. The various processes are well described in Recognition of Health Hazards in Industry by William A. Burgess, John Wiley & Sons, 1981 with one exception, the creel room. This process involves the feeding of brass clad steel wire, from hundreds of spools, to be fashioned into steel belts. Each of these spools contains two brake pads to prevent overspin. Each plant employed some hand mixing of raw materials, but this involved very few workers. Only one of the three plants reported using talc. However, all three plants contained asbestos materials in the form of thermal insulation or friction materials. The other naturally occurring minerals found included bentonite and kaolin clays containing some small amounts of silica.

IV. RESULTS

A. Environmental

OSHA DATA

We examined the OSHA occupational exposure data for the years 1979 through 1985. Table I summarizes the OSHA particulate exposure data by agent collected. The data are presented as a percentage of exposure measurements exceeding OSHA's permissible exposure limit (PEL), NIOSH's recommended exposure limit (NIOSH REL) and the average of all exposures.

TABLE I
OSHA PARTICULATE EXPOSURE DATA
BY AGENT
1979 THROUGH 1985

AGENT	%> OSHA PEL	% >NIOSH REL	MEAN CONCENTRATION	STANDARD DEVIATION	NUMBER OF SAMPLES
COAL TAR PITCH VOLATILES (CTPV)	51	64	0.4 mg/m^3	0.6 mg/m^3	55
KAOLIN	0	--	0.4 mg/m^3	--	3
QUARTZ	7	11	12 mg/m^3	29 mg/m^3	55
ASBESTOS	3	33	0.4 f/cc	0.9 f/cc	39
TALC --	--	--	--	1	
RESP. DUST	3	--	1mg/m^3	2mg/m^3	101
TOTAL DUST	20	--	9 mg/m^3	10 mg/m^3	99

Considering the NIOSH exposure criteria, significant overexposures from CTPVs, quartz and asbestos occurred in the rubber industry during the 1979 through 1985 time interval. Table II presents OSHA measured overexposures as a percentage of samples by agent within each standard industrial classification (SIC).

TABLE II
OVEREXPOSURES AS A PERCENTAGE OF SAMPLES
AGENT BY SIC CODE (SASDATA.OSHA 1979 THROUGH 1985)

AGENT	SIC CODE				
	3011	3021	3031	3041	3069
CTPV*	36	0	0	0	29
ASBESTOS*	3	0	0	0	51
QUARTZ*	0	0	1	0	12
RESP. DUST	0	0	0	0	3
TOTAL DUST	3	2	0	0	15

*Overexposure Determination Based on NIOSH Criteria

For the time interval 1979 to 1985, two SIC codes stand out with regard to the high percentage of overexposures; SIC 3011 (tires and inner tubes) with overexposures to coal tar pitch volatiles, and SIC 3069 (fabricated rubber products not otherwise classified) with exposures to coal tar pitch volatiles, asbestos, quartz and total dust.

The inferences that can be drawn from the OSHA data summarized in these tables include:

(1) There was a number of exposures to CTPVs above the REL. If the components in these CTPV's include large molecular weight polycyclic hydrocarbons as is found in coke oven emission, there could be significant exposures to carcinogens. However, a previous NIOSH tire plant study found compounds such as benzo-a-pyrene to be well below the value recommended by the Standard Advisory Committee on Coke Oven Emissions and within the range of ambient levels.[10]

(2) If current fiber exposures represent asbestos exposures and they remain at the pre-1986 levels, then these exposures are excessive by todays standards.

(3) Essentially no talc and no vermiculite exposure information is available.

(4) The greatest percentages of samples indicating overexposures, asbestos in particular, are occurring mostly in SIC code 3069. This category includes flooring, automotive brakes, insulated wire and cable, insulation and other products with the potential for utilizing asbestos as a product ingredient.

SITE SURVEYS

Site visits were conducted at three tire plants represented in the x-ray survey. Of these three plants only one utilized talc minerals in compounding. Additionally, the only other naturally occurring minerals employed as compounding agents were clays and limestone. None of the plants employed talc as a detackifier. Figure 1 is a photomicrograph of a sample of the talc from plant #3 under plane polarized light at 400x magnification. This product is labeled "asbestos free" by the producer, and this is confirmed in this sample by the absence of any discernable fibers. Detackifier slurries typically consisted of clay, soap and sometimes limestone, as well as some chemically produced materials such as precipitated silica. Figure 2 is a photomicrograph of bentonite clay from plant #2 under plane polarized light at 100x magnification. No fibrous minerals are present. The bentonite is typified as the more rounded granular-like particles, while the large equant particles include silica (quantitated by XRD), limestone and orthoclase among the more predominant. Figure 3 is a photomicrograph of settled dust collected from a rafter in plant # 2 above a detackifier mixing area. Again the magnification is 100x and the light is plane polarized. No asbestos is present although the dark particles, which are rubber, may contain some particle forms which would fit a 3 to 1 length to width aspect ratio, a criteria which is utilized in designating fibers for purposes of counting in a sample from an environment known to contain asbestos. The lighter, more rounded particles are clay. Figure 4, at 40x, is sandblasting material from plant #1 where it was labeled in company air sampling records as silica sand. However, these round glassy spheres and fragments were determined to be amorphous rather than crystalline when examined under crossed polars of the microscope. The crossed polars view is not shown here, as amorphous materials appear black against a black background. All three plants contained asbestos materials, either friction products (as in the case of brake linings in the creel rooms) or thermal insulation on various pipes, boilers, and other vessels. Dust near the brakes in the creel room of plant # 1 was found to contain chrysotile asbestos as demonstrated in Figure 5. In this photomicrograph at 100x magnification and 15 degree offset polars the chrysotile appears as the long thin fiber bundles on the right. Figure 6 is the same field of view with the polars uncrossed. Since the material is mounted in a liquid with a refractive index matching that of chrysotile (1.55), the fibers on the right disappear while the cellulose fibers present remain in good contrast. This refractive index matching, plus particle morphology, demonstrate the presence of chrysotile asbestos fibers in this sample. The area where the samples were obtained is cleaned by blowing the dust loose with pressurized air prior to sweeping.

Figures 7 and 8 show the same refractive index matching as Figure 6, only this time the sample contains amosite asbestos mounted in a liquid with a refractive index of 1.68. This material was found in floor debris near the asbestos-insulated piping of a contact heater in plant # 3. Recently, an asbestos removal project had taken place in this area. This sample certainly points out the need for more thorough containment during asbestos removal and more care in accepting the area as clean before terminating the abatement project.

Incidental damage to asbestos insulation producing asbestos containing debris was also observed, particularly in the power plants where much asbestos still remains. This type of damage and the debris produced should be taken care of as soon as it is noted. Allowing this material to be trod upon may widely disperse asbestos contamination and contribute to a background level of asbestos fibers in the plant air.

Tables III and IV present the results of the area air sampling conducted at the three plants for airborne fibers, respirable dust and silica.

TABLE III
FIBER CONCENTRATIONS BY
PLANT AND OPERATION

Plant #	Operation	f/cc PCM (7400 A Rules)	f/cc TEM (7402)	Fiber Type
1	Hand Mix	<.006	.003	cellulose
1	Master Batch	<.006	-	
1	Pallet Lube Mix	<.006	-	
1	Banbury	<.007	.011	cellulose
1	Creel Room	<.005	-	
2	Banbury	.052	-	
2	Banbury	.050	-	
2	Milling	.050	.004	cellulose
2	Fabric Calendar Drying Oven	.050	-	
2	Creel Room	.190	-	
2	Creel Room	.280	.017	cellulose
3	Creel Room	-	.014	cellulose
3	Detackifier Mixing	-	.006	cellulose
3	Banbury	-	.019	cellulose
3	Master Banbury	-	.015	cellulose
3	Pigment Compounding	-	.031	cellulose
3	Power House	-	.023	cellulose
3	#85 Contact Heater	-	.013	cellulose

TABLE IV
RESPIRABLE DUST AND QUARTZ BY
PlANT AND OPERATION

Plant #	Operation	mg/m^3 Respirable Dust (gravimetric)*	mg/m^3 Quartz (7500)**
1	Banbury	0.12	ND
1	Banbury	0.07	ND
1	Milling	0.15	ND
1	Creel Room	ND	ND
2	Hand Mixing	0.17	ND
2	Master Batch	0.40	ND
2	Pallet Lube Mix	0.16	ND
2	Banbury	0.34	ND
2	Daywork Banbury	1.07	ND
3	Banbury	0.11	0.06
3	Master Banbury	0.11	ND
3	Pigment Compounding	0.18	ND
3	Detackifier Mixing	0.14	ND

* Lowest Limit of Detection - .0lmg/filter
** Lowest Limit of Detection - .03mg/m^3
ND - Not Detected

The average transmission electron microscope fiber count in the 11 samples was 0.014 fibers per cubic centimeter of air (0.003 to 0.031 f/cc). No asbestos fibers were found in any of the air samples. Respirable dust exposures averaged 0.28 milligrams per cubic meter of air. Quartz was detected in only 1 of 13 samples, at a concentration of 0.06 mg/m^3, above the NIOSH REL of 0.05 mg/M^3.

The results of the three tire plant visits are summarized as follows:

1. The only asbestos identified was in the form of friction products, pipe and boiler insulation.

2. Only one of the three plants used talc, and asbestos was not detected in this material.

3. Two of the three plants had active asbestos identification and abatement activities carried out by outside contractors.

4. Workers with the greatest potential for exposure to asbestos would be the power plant personnel, maintenance workers required to make repairs in and around insulation, and custodial staff encountering asbestos containing debris. Blow-down dust cleaning in areas like the creel rooms, where asbestos friction products may be utilized, also contributes to intermittent exposure.

B. MEDICAL

As the technical quality of radiographs can influence the interpretation more than any other single factor,[11,12] an assessment of quality was given high priority. These data are shown in Table V:

Table V
Film Quality Assessment

Film Quality	No. and % by Reader					
	A		B		C	
	No.	%	No.	%	No.	%
Good	709	7l.8	879	89.l	509	5l.6
Acceptable, no technical defect impairing classification	239	24.2	l08	l0.9	352	35.7
Poor, with technical defect, but readable	39	4.0	0	0.0	74	7.5
Unacceptable	0	0.0	0	0.0	52	5.3
Total	987	l00.0	987	l00.0	987	l00.0

On balance, the quality of the radiographs evaluated was good. One radiologist indicated that around nine of every l0 radiographs were of good quality with no technical defects, and found none which were unreadable. On the other hand, another radiologist found over 5% of the films unreadable and only about half of the films to be good quality. Two of 987 films (0.2%) were designated as having parenchymal changes consistent with the pneumoconiosis. The profusion for these two cases was l/0. In both cases, small opacities were described as irregular in shape and were predominant in the lower lung zones, a pattern typical of early asbestosis. In addition to these two films, five others were classified as 0/l; i.e. they were ultimately classed as category zero but category l was given some consideration. No cases of progressive massive fibrosis were noted. The two films with minimal parenchymal disease had no pleural abnormalities. Data regarding profusion of small lesions are shown in Table VI:

Table VI
Parenchymal Abnormalities
Median Profusion of Small Opacities

Profusion	No. of Cases	%
O (O/1)	985 (5)	99.8
1 (1/0)	2 (2)	0.2
2	0	-
3	0	-
PMF	o	-
Total	987	100

Aside from parenchymal abnormalities, emphasis was given to determining the extent of pleural changes; i.e. basically the presence of diaphragmatic and chest wall plaques, and diffuse chest wall thickening. Thirteen radiographs (l.3%) were noted as having developed diaphragmatic plaques. These l3 were from workers at four plants; six were from workers at one plant. While the number and proportion of cases with diaphragmatic plaques is small, it is noted that nearly one-half of the cases identified worked at one location. The overall consensus data regarding diaphragmatic plaques are shown in Table VII:

Table VII
Consensus Interpretation
of Diaphragmatic Plaques

Item	No. of cases	%
None	969	98.7
Agreement that Diaphragmatic Plaques Exist	13	l.3
Total	982	l00.0
No Consensus*	5	

*Exists because one interpreter judged the films as unreadable and the other 2 interpreters differed.

The radiologists agreed that 2l films (2.l%) had chest wall plaques. Twelve of these 2l also had diaphragmatic plaques. For l4 of the 2l, the plaque formations were bilateral. These 2l films were from workers at four plants, and l0 of the 2l were from workers at a single plant; the same one where the 6 workers with diaphragmatic plaques was identified. Ten (12%) of the 86 films from workers at this plant had chest wall plaques. No cases of diffuse chest wall thickening were identified in the sample. (Table VIII)

Table VIII
Consensus Interpretation
of Chest Wall Plaques

Item	No. of Cases	%
None	962	97.9
Agreement that Chest Wall Plaques Exist	21	2.1
Total	983	l00.0
No Consensus*	4	

*Exists because one interpreter judged the films as unreadable and the other 2 interpreters differed.

In summary 24 (2.4%) of 987 films had findings consistent with an asbestos exposure. Below are these summary results:

X-ray Finding	Summary of Cases No. of Cases
Parenchymal abnormality; category l/0, with no evidence of pleural changes	2
Pleural abnormality; chest wall and diaphragmatic plaques	12
Pleural abnormality; chest wall plaques	9
Pleural abnormality; diaphragmatic plaques	1

V. DISCUSSION

The technical quality of most chest films reviewed was acceptable to good. No consistent technical artifacts were noted. That the PHSP uses a standard PA film in screening, without additional lateral or oblique views, fits well with recommendations from the literature.[l3] Although about 30,000 workers contribute financially to the PHSP and are thus eligible for testing, only approximately 5,000 per year participate in the radiographic surveillance. In our sample, participation by plant ranged from a high of 26% to a low of only 9%. Since we have no data on the non-participants in the PHSP, we could not determine if participants were representative of the total work force of these plants or of the tire industry.

The parenchymal changes identified were minor; only two cases both having ILO category l/0 profusion. Such borderline profusion is often confused with increased vascularity and also considered (by some) to be consistent with linear markings seen in the lungs of some cigarette smokers.[l4] However, both cases identified had irregular shaped lesions with basal involvement, consistent with an asbestos exposure.

Pleural abnormalities were identified in 22 (2.2%) of the 987 films. The expected prevalence of such abnormalities is not known. A study of "unexposed" blue collar workers found only 3 pleural abnormalities among 1422 films, but this population had a mean age of 33.8 years and x-rays from 880 potential participants were not included among the 1422 because these persons had a history of past exposure to "dusts or other repiratory hazards".[15] The workers whose x-rays were read as part of our survey were all over 40 years of age and were not excluded from the survey on the basis of exposures outside the tire industry. Finally, neither group consisted of a sample known to be representative of its population; the tire workers were a self-selected minority and only 55% of the targeted population participated in the blue-collar study.

While fat and muscle shadows, scarring adjacent to old disease, and trauma can mimic plaque,[16] four of the films involved calcification typical of asbestos-induced plaques. Furthermore, several more of the cases with pleural plaques were of 'textbook' quality, with small likelihood of misclassification. Of potential importance is the fact that a seemingly high number of pleural abnormalities occurred in a single plant. Ten (12%) of 86 x-rays from workers (≥40 years of age) at this one plant had evidence of pleural changes. This plant is now closed, so we could not conduct an environmental evaluation.
Comparison of original readings (from the PHSP contractor) with cases identified in our survey is difficult due to the differences in classification systems used. In our work, the l980 ILO classification system was used whereas (in l983) the contractor used a single clinical interpretation. Nonetheless, both films we identified as having parenchymal changes (category l/0) were originally diagnosed as having increased lung markings suggestive of pulmonary fibrosis. On the other hand, while we identified 22 films with pleural abnormalities, the original clinical interpretations mentioned pleural involvement in only about half of these. At least two reasons might be advanced regarding this difference. First, the interpreters we selected were known for their experience in reading large numbers of radiographs of workers with asbestiform mineral exposure; thus, their sensitivity in the area of diagnosing pleural abnormalities might have been enhanced. Second, the initial readings and our survey were performed three years apart; general emphasis regarding the diagnosis of pleural changes has increased in recent years.

This evaluation of a non-random sample of rubber workers chest X-rays in selected plants served by the PHSP indicates the presence of some radiographic changes consistent with asbestos exposure. Sources of exposures potentially responsible are not determined at this time, although the environmental survey found

asbestos-containing materials in all 3 plants. Inferences directed at or implicating specific industry operations and/or materials are not possible on the basis of the findings of this study..

VI. REFERENCES

1. Beliczky, L.S., A fifteen year overview and update of the URW's activities in Occupational Health and Safety, Joint URW/JRW Conference, Seattle, June, l986.

2. Reger, R.B., and Morgan, W.K.C., On factors influencing consistency in the radiologic diagnosis of pneumoconiosis, ARRD, Vol. l02, l970.

3. Reger, R.B., Amandus, H., and Morgan, W.K.C., On the diagnosis of coalworkers' pneumoconiosis: Anglo-American disharmony, ARRD, Vol. l08, l973.

4. Yerushalmy, J., Reliability of chest radiography in the diagnosis of pulmonary lesions, Amer. J. Surg., Vol. 89, l955.

5. Garland, L.H., On the reliability of roentgen survey procedures, AJR, Vol. 64, l950.
6. Reger, R.B., Petersen, M., and Morgan, W.K.C., Variation in the interpretation of radiographic change in pulmonary disease, The Lancet, January, l974.

7. Felson, B. et al., Observations on the results of multiple readings of chest films in coalworkers' pneumoconiosis, Radiology, Vol. l09, l973.

8. Morgan, R.H., Proficiency examination of physicians for classifying pneumoconiosis chest films, AJR, Vol. l32, l979.

9. Occupational Safety and Health Series No. 22, Guidelines for the use of ILO international classification of radiographs of pneumoconioses, International Labour Office, Geneva, revised edition l980.

10. Control of air contaminants in tire manufacturing. DHHS (NIOSH) Publication No. 84-111, 1984.

11. Reger, R.B. et al., The effect of film quality and other factors on the roentgenographic categorization of coalworkers' pneumoconiosis, AJR/RT/NM, Vol. CXV, l972.

12. Liddell, F.D.K., The effect of film quality on reading radiographs of simple pneumoconiosis in a trial of x-ray sets, BJIM, Vol. l8, l96l.

13. Reger, R.B. et al., The detection of thoracic abnormalities using posterior-anterior (PA) vs. PA and oblique roentgenograms, Chest, Vol. 8l, l982.

14. Amandus, H.E. et al., Significance of irregular small opacities in the radiographs of coal miners, BJIM, Vol. 33, l976.

15. Castellan, R.M., Sanderson, W.T., and Petersen, M.R. Prevalence of radiographic appearance of pneumoconiosis in an unexposed blue collar population, ARRD, Vol. l3l, l985.

16. Sargent, E.N., et al. Sub pleural fat pads in patients exposed to asbestos: distinction from non calcified pleural plaques, Radiology, Vol. l52, l984.

VII. AUTHORSHIP AND ACKNOWLEDGMENTS

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VIII. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report are temporarily available upon request from NIOSH, Hazard Evaluations and Technical Assistance Branch, 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. United Rubber Workers of America
2. The Firestone Tire & Rubber Company
3. The Uniroyal Goodrich Tire Company
4. The Armstrong Tire & Rubber Company
5. OSHA
6. NIOSH Regional Office

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

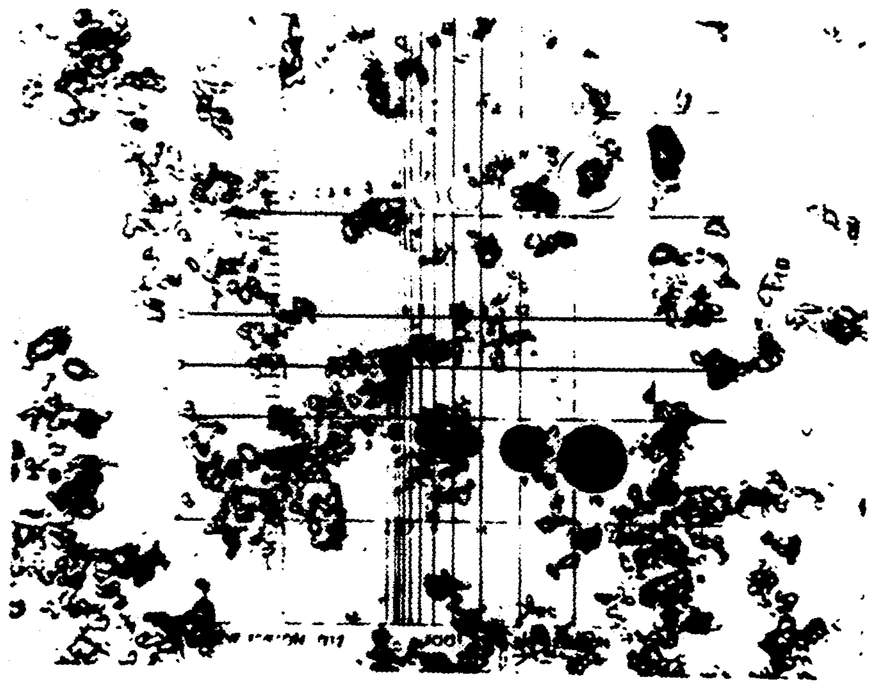

FIGURE 1 TALC USED IN WHITE SIDEWALL TIRE PRODUCTION
PLANE POLARIZED LIGHT 400x
CIRCLE # 10 DIAMETER IS 20 MICROMETERS

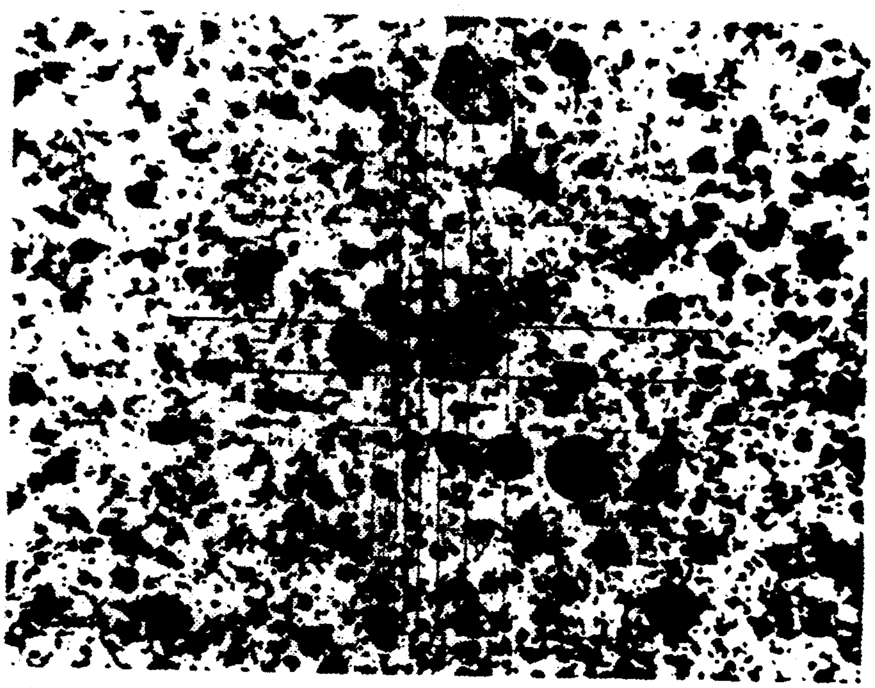

FIGURE 2 BENTONITE CLAY DETACKIFIER
PLANE POLARIZED LIGHT 100x
CIRCLE #10 DIAMETER IS 80 MICRONS

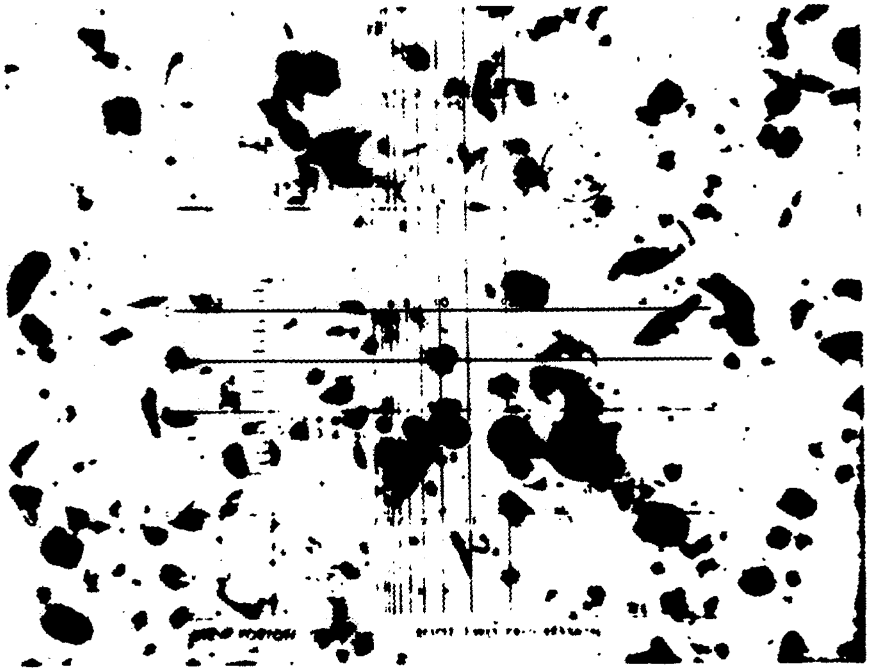

FIGURE 3 RUBBER AND CLAY DUST FROM RAFTER SAMPLE
PLANE POLARIZED LIGHT 40x
CIRCLE #8 DIAMETER IS 100 MICROMETERS

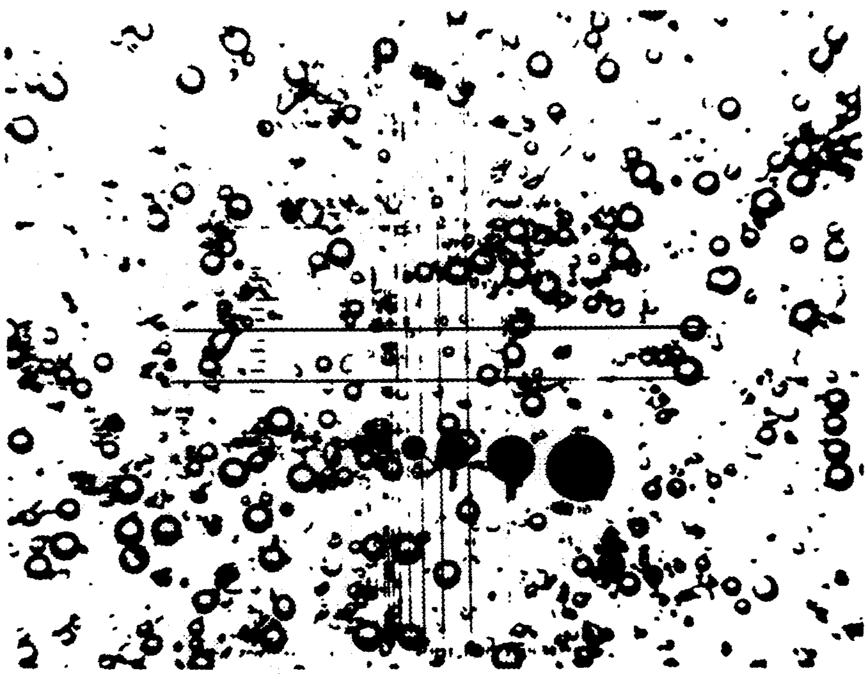

FIGURE 4 GLASS SPHERES USED IN SAND BLASTING
PLANE POLARIZED LIGHT 40x
CIRCLE #8 DIAMETER IS 100 MICRONS

FIGURE 5 CHRYSOTILE ASBESTOS IN BREAK DUST
SLIGHTLY UNCROSSED POLARS 100x
——— 80 MICROMETERS

FIGURE 6 CHRYSOTILE ASBESTOS IN BREAK DUST
PLANE POLARIZED LIGHT 100x
CIRCLE #10 DIAMETER IS 80 MICROMETERS

FIGURE 7 AMOSITE ASBESTOS IN FLOOR DEBRIS
SLIGHTLY UNCROSSED POLARS 100x
—— 80 MICROMETERS

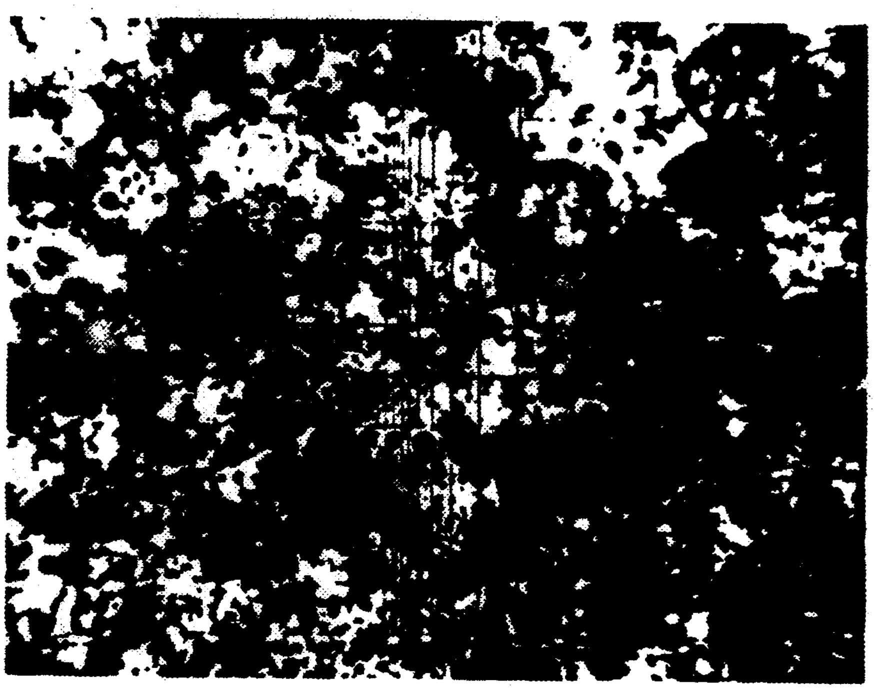

FIGURE 8 AMOSITE ASBESTOS IN FLOOR DEBRIS
PLANE POLARIZED LIGHT 100x
—— 80 MICROMETERS