PLAINTIFF'S EXHIBIT

G-522

THE ACTUAL RELEASE OF ASBESTOS FIBERS

FROM NEW, USED AND FLANGED GARLOCK INC.

ASBESTOS GASKET MATERIALS

CARL A. MANGOLD, CIH

SEPTEMBER 1985
BELLEVUE, WASHINGTON

Mangold
EXHIBIT NO. 13
4-29-98
H. Thuman, CSR

ABSTRACT

An experimental design was developed to determine the actual release if any, of asbestos fibers from GARLOCK, INC. encapsulated gasket materials for 1. New Gasket Materials, 2. Used Gasket Materials Removed From Flanges, and 3. Gaskets In Place Inside Flanges. The 8 hour time weighted average of the results revealed that gaskets sealed inside flanges did not exceed the ambient background levels in a residential environment of .002 fibers/cc, greater than 5 micrometers in length. The release from newly cut gasket averaged .005 fibers/cc, while used gaskets removed from flanges averaged .006 fibers/cc. The tests were conducted in separate asbestos-free sealed enclosures where moderate air currents passed over the gasket materials. The Federal standard, 29 CFR 1910.1001-Asbestos allows an 8 hour time weighted average exposure to unprotected workers of 2 fibers/cc, greater than 5 micrometers in length. By comparison, the gasket materials present a negligible risk to anyone in the vicinity even for extended periods of time.

DISCLAIMER

The author is solely responsible for the contents and conclusions in this report which may not necessarily reflect the official opinion of the contributors, the U.S. Department of the Navy, or the U.S. Department of Labor.

ACKNOWLEGEMENTS AND CONTRIBUTORS

1. J. D. WENDLICK, Corporate Industrial Hygienist, The Weyerhaeuser Company, Tacoma, Washington

2. NORTHWEST HEALTH SERVICES, Richland, Washington

3. DEVINE DIVING AND SALVAGE, Portland, Oregon

4. MINE SAFETY AND APPLIANCE COMPANY, Seattle, Washington

5. GELMAN SCIENCES, Ann Arbor, Michigan

TABLE OF CONTENTS

I

HISTORY

Asbestos is one of the most plentiful, useful, cheap, and strong industrial minerals. Consequently, because of its high thermal stability and resistance to corrosion it appears in more than 3000 manufactured goods in the United States. At least 30 million tons have been used in construction and manufacturing since the year 1900, exposing millions of Americans to asbestos in industry, non-occupationally in cities, near industrial complexes, or in offices and schools containing asbestos insulation. Even today, large numbers of the population are exposed to substantial asbestos fiber levels in the air in cities, near industial complexes, from soil high in asbestos content, and from drinking water (1,2,3,4,5,6,7). The exposures from natural asbestos sources from basic rock formations in the United States is substantial. Twenty-two states contain asbestos-bearing rock formations that contribute to ambient levels of airborne asbestos (8). The ground waters from these sources often contain high levels of tiny asbestos fibers adding to the overall exposure to the general population (9). Lanting and den Boeft (10) calculated that the total atmospheric release from its technical use in the United States is 2,093 metric tons per year, but this is only four thousandths of one percent (.004%) of all asbestos released to the environment by air, water, or land erosion. This continues to be a major source of asbestos exposure to the general population.

Besides the exposure for the ambient air and drinking water, occupational and non-occupational sources add to the exposure burden of those who work in cities, and in buildings insulated with asbestos, or who are workers in industry where asbestos is used directly or in nearby operations. Nicholson and Pundsack (11) reported in 1973 at the International Agency for Research on Cancer that asbestos fibers escaping from the manufacture of asbestos products, vehicle clutches and brakes, and spraying of asbestos in buildings is a substantial source of continual exposure from the atmosphere. From 1958 to 1973 they estimated that 500,000 toms of asbestos was used in the United States to spray the inside of buildings for insulation and fireproofing. Since then the demolition of buildings continue to provide a major source of exposure in cities.

The Environmental Protection Agency (7) estimated that in 1978 the worldwide production of asbestos approached 5 million tons annually, and that United States consumption reached 900,000 tons of which 70% was used in industry. Therefore, the contributions to the ambient air of workers and those non-occupationally exposed city dwellers will likely occur for many years from this source.

Most Americans receive at least some regular low-level exposure to asbestos over their lifetime (12,13,14). Of particular interest since 1978 is the additional exposure of children to asbestos, and the employees in schools that have been treated with spray insulation containing asbestos. Although the spraying of asbestos containing materials has all but ceased, the sprayed on asbestos insulation remains a potential widespread source of asbestos fiber exposure (7). Because of the nature of the unprotected sprayed asbestos insulation commonly used in schools and other buildings it is particularly vulnerable to contact damage or vibration that may release intermittent peak exposures. Redispersion of fibers already fallen onto interior surfaces will add to such exposures. Since 1978 the EPA has developed Federal regulations and rational alternatives for exposure reduction in schools (7).

The asbestos fiber exposures in schools generally are of a low order, but may exceed that expected from exposures in city streets. Occassional exposures of significance are caused by damage to theinsulation, maintenance and repair, activities that vibrate the whole building, and redispersion of fallen asbestos fibers. Some of the levels reported by the EPA approach those expected to be found in industrial settings (7). Regardless, there is little eveidence that continuing exposures to ambient asbestos fiber exposures to the general population gives rise to significant identified asbestos related disease (15,16, 17,18).

Until about 1964 when Selikoff and others (19,20) presented real evidence to shape thinking about occupational exposure to asbestos, high level exposures were allowed because standards were based on the etiology of asbestosis, a lung disease; not cancer. Many of the exposures were excessive and uncontrolled based on known practices at that time. However, little attention was given to the actual exposure of the general population in cities, nearby industrial complexes, or public buildings or schools. There is current evidence to show that some ambient contamination levels in cities may exceed those found in some industrial applications (21,22, 23,24).

The long lapse time from exposure to the onset of asbestosis, or asbestos-related cancers creates significant difficulty in attempting to establish a dose-response relationship (25,26). The disease incidence today is likely from decades past when few measurements of asbestos exposure were made, exposures were high, and controls were few (27,28, 29,30,31).

Churg and Warnock (13) described the relatively high level of asbestos fibers in the lungs of city dwellers not occupationally exposed. This suggests a lower no-effect level at which there is no measureable effect on the health of city dwellers from this substantial exposure to airborne asbestos fibers in the ambient air.

II

BACKGROUND

In 1976, the Federal standard, 29 CFR 1910.1001-Asbestos, limited the occupational exposure to an airborne concentration of asbestos fibers in the breathing zone of 2 fibers greater than 5 micrometers in length per cubic centimeter of air sampled as collected on a mixed cellulose ester membrane filter at 2 liters per minute and counted by Phase Contrast Microscopy at 400 X power, for any eight hour time-weighted average work day (32,33,34). The standard allows excursions of 10 fibers/cc for any 15 minute period in the same work day. Interpretations of paragraph (j) of the Federal standard requires medical examination and surviellance of workers when the 8 hour TWA exposures reach 0.1 fibers/cc (32).

The current Federal standard is a marked reduction over the Threshold Limit Value (TLV) of 5 million particles per cubic foot (mppcf) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). The standard existed from 1946 until 1969, when it was reduced to 2 mmpcf or 12 fibers/cc. In 1972, the Federal standard became 5 fibers/cc, reducing to 2 fibers/cc in 1976.

As the allowable level of exposure to unprotected workers was reduced more attention was given to other sources of asbestos exposure such as natural ambient levels, and inside buildings like offices and schools. The National Institute for

Occupational Safety and Health (NIOSH) reported in its "Revised Recommended Asbestos Standard of 1976", that only a few studies of ambient levels or other low level exposures have been performed using phase contrast microscopy to relate to the current standard. The limited studies indicated ambient levels to be generally less than .01 fibers/cc, greater than 5 micrometers in length, but some peak values are as high as .03 fibers/cc (35).

In 1981, Le Moine reported ambient asbestos fiber levels using the phase contrast microscopy method in the City of Seattle as high as .03 fibers/cc (36). The work of Mangold (37) revealed ambient asbestos levels ranging from .01 to .02 fibers/cc during dry summer days in July and August 1982 in Seattle, WA, Portland, OR, and Bremerton, WA. In a similar study, Mangold (38) found that ambient levels in Vallejo, Oakland, and San Francisco, CA, averaged .02 fibers/cc as well during 8 hour work days when commercial activity and road traffic were at their greatest. Wendlick (39) reported ambient asbestos levels ranging .01 to .02 fibers/cc for downtown and industrial sites of the Norfolk-Portsmouth-Newport News, VA in August 1983, and more recently .01 in communities in Wisconsin.

These comparable data have been collected by the standard sampling method and phase contrast microscopy counting to the values found in workplaces where samples and counting represent occupatinal exposures that relate to the standard. The Federal standard is supported by many years of epidemiological evidence.

It is important that such exposures are occurring regularily to the general population in cities, especially near industrial sites, during the destruction of buildings in summer, and in asbestos insulated office buildings and schools.

As the Federal standards are lowered these ambient levels of asbestos exposure and the actual contribution of individual asbestos containing products or their application become increasingly important (40,41,42,43,44,45). It is particularly important because hard pressed, or encapsulated asbestos containing products like gaskets contribute only a negligible fraction to the overall exposure. This is based on the availability of the encapsulated fibers for release, and the lower comparative volume of materials in use that are openly exposed and can be abraded from the surface. The extremely low level contributions from the processing of gaskets is obscured by the high ambient levels, high environmental levels near industrial operations, and the contributions from contaminated buildings.

Rigorous procedures must be followed to avoid the effects of ambient asbestos fiber concentrations or sources of contamination when evaluating the low contributions of products like encapsulated gasket materials; otherwise reported values will be skewed upward. This also brings into question some of the earlier reported values for such products that were evaluated in potentially contaminated workplaces commonly used for asbestos work.

The natural ambient ventilation in communities known to have airborne asbestos fibers in the air from natural or a variety of sources is highly influenced by the wind direction, and ambient stability. Atmospheric stable conditions trap fibers in the air leading to higher concentrations. Well conducted studies in the city of Asbestos, Quebec reveal such trends (46).

The asbestos release in buildings during removal process or disturbance of friable asbestos materials leads to a trapping of fibers both airborne, and those fallen onto surfaces. As late as 1985, careful studies of wet vs. dry removal processes in schools reveals the relatively high asbestos fiber release rates ranging from 1 fibers/cc (wet) to 39 fibers/cc (dry). In addition fibers were detected outside protective barriers leading to the common conclusion that the higher the release volume, the higher potential contamination (47).

Concentrations of airborne asbestos fibers in Colorado schools analyzed by phase contrast microscopy, and scanning electron microscopy showed realitively constant elevated levels ranging from .007 to .019 fibers/cc, greater than 5 micrometers in length (48). Such levels could easily obscure any attempts at measuring low level releases from encapsulated materials such as Garlock pipe gaskets.

III

INTRODUCTION

Because of the difficulties of properly evaluating the actual contribution of gasket materials to the overall exposures in a school containing exposed friable asbetos insulation covering large surface areas, a series of investigative research projects were commissioned by GARLOCK, INC. The research was intended to reveal the actual release of asbestos fibers, if any, from GARLOCK INC. gaskets under conditions of use in schools or other large structures where sprayed-on asbestos insulation is in the building.

The only reasonable way was to process the gaskets in a contamination-free environment. Otherwise, the potentially high ambient asbestos levels in the city, and environmental asbestos levels in the building would obscure results, or at least make them suspect. Asbestos gaskets are known to release only very low concentrations of asbestos fibers on handling and use because the fibers are held in place by an encapsulant, and the surface is hard-pressed.

The values obtained must be the result of the prescribed sampling and counting methods so that the results my be directly comparable to the Federal standard of 2 fibers/cc, greater than 5 micrometers in length, for an 8 hour time weighted average exposure.

IV

EXPERIMENTAL DESIGN

In order to meet the technical requirements previously stated and to control the effects of contamination during testing from other sources an experimental design as developed to determine the actual release of chrysotile asbestos fibers from the GARLOCK INC. gasket materials. The design was intended to determine the natural release of asbestos fibers from undisturbed encapsulated gaskets during an eight hour day for each of 5 days without the influence of unknown sources of contamination for 1. New Gasket Materials, 2. Used Gasket Materials Removed From Flanges, and 3. Gaskets in Place Inside Flanges.

An enclosure measuring 10' x 10' x 10', or 1000 cubic feet was constructed of PVC plastic Pipe and .004 inch thickness polyethylene plastic sheeting. All sides of the cubic enclosure were covered including the floor to form a chamber. A new enclosure was constructed for testing each of the three conditions to eliminate potential cross-contamination. This type of enclosure was selected because it represents the smallest practical size of small work spaces, rooms, or voids. The enclosures were erected in a residential area where airborne asbestos fibers are known to remain at very low levels, or about .002 fibers/cc, greater than 5 micrometers in length or less.

The gasket materials were placed on a metal table inside the plastic enclosure. The table had been scrubbed with hot soapy water to remove dust and contamination prior to use. A high-volume air sampling pump was placed in the enclosure to which 4 separate 25 mm diameter, .8 micron pore size, open-faced, mixed cellulose ester filters were attached upon which the airborne asbestos fibers were to be collected. A flow rate of 4 liters per minute was drawn through each of the 4 filters for an 8 hour period during each of the 5 days of testing. This provided 4 replicate analyses per day to increase the counting reliability. This procedure was designed to follow the NIOSH Sampling Method for Asbestos in Air, #7400, of February 15, 1984; developed for the collection of low level asbestos fibers in air, which increases the reliability of the counting. After each 8 hour sample period, the cassettes were sealed and removed to the laboratory for counting by the NIOSH Method, P&CAM 239 by phase contrast microscopy. Four wedges were counted from each filter to further increase the reliablility. At least 100 microscope fields per wedge were counted for asbestos fibers present greater than 5 micrometers in length. The higher flow rates of 4 liters per minute for 8 hours each day, the 4 replicate samples collected each day, and counting 4 wedges per sample provided an adequate statistical base. The 25 mm diameter filters were used to increase the ratio of fibers collected per unit area of filter surface, and which meets the requirements of the NIOSH Sampling Method #7400. Representative samples were selected for examination by polarized light microscopy to identify fibers on the filters for positive identification.

The exhaust from the high volume pump provided reasonable turbulence in the enclosure to keep asbestos fibers airborne for collection. The use of these methods allows measurement of very low release levels of asbestos fibers.

Air samples were collected outside the enclosure to establish the ambient airborne asbestos fiber levels for comparison. No values exceeded the lower limit of detection of .002 fibers/cc, greater than 5 micrometers in length.

The findings are contained in Section V.

V

FINDINGS

TABLE I ----- ASBESTOS FIBER RELEASE LEVELS FROM GASKETS INSIDE FLANGES

This table shows that 7 flanges containing asbestos gaskets did not release concentrations of fibers above that expected as ambient levels in a residential area, or about .002 fibers/cc.

TABLE II ---- ASBESTOS FIBER RELEASE LEVELS FROM NEWLY CUT GARLOCK INC. ASBESTOS FLANGE GASKETS

This table shows that the release of asbestos fibers from six newly cut gaskets spread on the table in the enclosure was negligible compared to ambient levels of .003 f/cc/

TABLE III --- ASBESTOS FIBER RELEASE LEVELS FROM USED GARLOCK GASKETS TAKEN FROM PIPE FLANGES

This table shows that the release of asbestos fibers from six GARLOCK INC. flange gaskets that had been in use for some time and which were removed from the flanges and placed on the table in the enclosure was negligible; only a slight release of fibers over the ambient levels was noted.

The tables follow.

TABLE I

ACTUAL RELEASE OF ASBESTOS FIBERS FROM ASBESTOS GASKETS INSIDE BOLTED FLANGES.

DAY	SAMPLE # (1)	Airborne Asbestos Fibers Released From 7 Bolted Flanges in Fibers/cc, Greater than 5 Micrometers in Length during an 8 hour Period (2)	Environmental Background
1	101	.002	
	102	.002	
	103	.002	
	104	.000	
	B-1		.001
2	201	.002	
	202	.004	
	203	.002	
	204	.002	
	B-2		.002
3	301	.000	
	302	.000	
	303	.001	
	304	.002	
	B-3		.000
4	401	.004	
	402	.002	
	403	.002	
	404	.002	
	B-4		.002
5	501	.000	
	502	.002	
	503	.000	
	504	.002	
	B-5		.002
		.0016	.0016
5 Day Time Weighted Ave.		.002	.002

(1) Four samples collected simultaneously at 4 liters/minute for 8 hours to meet NIOSH Sampling Method #7400

(2) As counted by Phase Contrast Microscopy by NIOSH Method P&CAM #239

TABLE II

ASBESTOS FIBER RELEASE LEVELS FROM NEWLY CUT GARLOCK ASBESTOS FLANGE GASKETS

DAY	SAMPLE # (1)	Asbestos Fibers Released from Six Newly Cut Asbestos Flange Gaskets in Fibers/cc, Greater than 5 Micrometers in Length for an 8 Hour Time Weighted Average (2)	Environmental Background, Fibers/cc
1	101	.003	
	102	.004	
	103	.005	
	104	.005	
	B-1		.002
2	201	.006	
	202	.004	
	203	.004	
	204	.006	
	B-2		.004
3	301	.008	
	302	.004	
	303	.003	
	304	.004	
	B-3		.002
4	401	.006	
	402	.006	
	403	.004	
	404	.004	
	B-4		.004
5	501	.006	
	502	.008	
	503	.006	
	504	.008	
	B-5		.002
5 Day Time Weighted Ave.		.005	.003

(1) Four samples collected simultaneously at 4 liters/minute for 8 hours to meet NIOSH Sampling Method #7400

(2) As counted by Phase Contrast Microscopy at 400X by NIOSH Method P&CAM # 239

TABLE III

ASBESTOS FIBER RELEASE LEVELS FROM OLD AND USED GARLOCK INC. GASKETS

DAY	SAMPLE # (1)	Asbestos Fibers Released From Six Old and Used Garlock Gaskets Removed from Flanges (2)	ENVIRONMENTAL BACKGROUND FIBERS/CC
1	101	.004	
	102	.006	
	103	.008	
	104	.008	
	B-1		.002
2	201	.006	
	202	.006	
	203	.004	
	204	.006	
	B-2		.004
3	301	.006	
	302	.004	
	303	.008	
	304	.008	
	B-3		.004
4	401	.004	
	402	.005	
	403	.006	
	404	.003	
	B-4		.002
5	501	.006	
	502	.008	
	503	.005	
	504	.008	
	B-5		.002
5 Day Time Weighted Ave.		.006	.003

(1) Four samples collected simultaneously at 4 liters/minute for 8 hours to meet NIOSH Sampling Method #7400

(2) As counted by Phase Contrast Microscopy by NIOSH P&CAM Method #239 .

VI

CONCLUSIONS OF TESTS

A study commissioned by GARLOCK INC. was designed to determine the actual release of Chrysotile asbestos fibers from the encapsulated Garlock gaskets. The evaluation was conducted for gaskets inside flanges, newly cut Garlock gaskets, and old gaskets removed from flanges. Each type of gasket material was placed inside a separate sealed 1000 cubic foot plastic enclosure to limit any effects of contamination and to simulate work in small enclosures, rooms, or spaces. Four eight hour replicate samples were collected for each of 5 days for each type of gasket material. The samples were removed to the laboratory and counted for the presence of asbestos fibers greater than 5 micrometers in length by Phase Contrast Microscopy using the NIOSH Method P&CAM #239.

The 8 hour time weighted average of the asbestos fibers released from the <u>gaskets sealed inside flanges</u> did not exceed the background levels of ambient asbestos fibers in a residential environment of .002 fibers/cc, greater than 5 micrometers in length. The release from <u>newly cut gaskets</u> averaged .005 fibers/cc, while <u>used gaskets removed from flanges</u> averaged .006 fibers/cc, greater than 5 micrometers in length.

These results show that the encapsulated nature of the gaskets hold the asbestos fibers in place, and that substantial releases do not occur from these products on standing, and open to the air, and undisturbed, in the presence of moderate air currents. The positive air currents were caused by the exhaust from the high volume air sampler operated in the enclosure during the 8 hour sampling periods. A high volume air sampler at 4 liters/minute through a 25 mm filter would be expected to trap any fibers more effeciently than lower volumes with larger filters, which is why the NIOSH # 7400 method was used.

The 8 hour time weighted average allowable exposure is currently 2 fibers/cc, greater than 5 micrometers in length, according to the Federal Standard, 29CFR 1910.1001-Asbestos, as counted by Phase Contrast Microscopy at 400X according to the NIOSH Method P&CAM 239. By comparison the asbestos fiber release by Garlock Inc. gasket materials is fractionally small and presents a negligible risk to anyone in the vicinity even for long periods of time.

VII

REFERENCES

1. G.S. Le Moine, "A Survey of the Asbestos Levels in the Ambient Air of Seattle," Master of Science Thesis, School of Public Health, University of Washington, Seattle, WA (May 1981).

2. W.J. Nicholson, A.M. Hanger, I.J. Selikoff, "Epidemiological Evidence on Asbestos, Proceedings of a Workshop on Asbestos Definitions and Measurement Methods" (July 1977). Gaithersburg, MD, U.S. Dept of Commerce Publication No. 506 (Nov 1978).

3. L. Polissor and E. Eldridge, "Cancer Incidence and Asbestos in the Drinking Water in Western Washington", Washington Public Health, Vol. 3, No. 1, Autumn 1982.

4. Rahl, A.N., Langer, A.M. and Selikoff, I.J., "Airborne Asbestos in the Vicinity of a Freeway." Atmospheric Environment, Vol. 12, No. 10, pg. 2030-2031 (1978).

5. EPA, "Ambient Water Quality Criteria for Asbestos", (EPA 440/5-80-022), (October 1980).

6. Nicholson, W.J., et al, "Control of Sprayed Asbestos Surfaces in School Buildings; A Feasibility Study under NIEHS Contract (1-ES-7-2113) Nat. Inst. Env. Hlth. and Safety (1978).

7. EPA, "Asbestos-Containing Materials in School Buildings", A Guidance Document, Part II (EPA-450/2-78-014) (March 1978).

8. Chidester, A.H., Schride, A.F.: Asbestos in the United States (exclusive of Alaska and Hawaii), U.S. Geological Survey, (1962).

9. DHEW PUB(NIH) 79-1681, Asbestos; An Information Source, (May 1978).

10. Lanting, R.W. and den Boeft, Ing J., "Atmospheric Pollution by Asbestos Fibers", Institut Voor Milieuhygiene en Gezondheidstechniek, Rpt G-908, Delft, Netherlands, (November 1979).

11. Nicholson, W.J. and Pundsack, F.L., "Asbestos in the Environment; Biological Effects of Asbestos, IARC Publication # 8, pp. 126-30, Lyon, France Symposium (1973).

12. I. J. Selikoff, MD; "Disability Compensation for Asbestos Associated Disease in the United States", Env. Sci. Lab., Mt. Sinai Hospital, City Univ. N.Y. (Report to the U.S. Dept of Labor- Contract J-0-M-8-0165, (June 1982).

13 A. Churg and M. Warnock, "Asbestos Fibers in the General Population", Amer. Rev. Resp. Disease, Vol. 122 (1980).

14 M. R. Becklake, "Exposure to Asbestos and Human Disease", N. Eng. J. Med., No. 306 (June 17, 1982).

15. J. E. Craghead, B.T. Mossman, "The Pathogenesis of Asbestos-Associated Diseases", N. Eng. J. Med., 306 (June 17, 1982).

16. National Academy of Science, "Non-Occupational Health Risks of Asbestiform Fibers", National Academy Press, Washington D.C., (1984).

17. Sawyer, R., "Asbestos Exposure in a Yale Building; Analysis and Resolution". Env. Res. 13:1, 146 - 168, (1977).

18. W. J. Nicholson, A.M. Hanger, I.J. Selikoff, "Epidemiological Evidence on Asbestos, Proceedings of a Workshop on Asbestos Definitions and Measurement Methods", (July 1977), Gaithersburg, MD., U.S. Dept. of Commerce Publication No. 506 (Nov 1978).

19. I. J. Selikoff, J. Churg, E. C. Hammons, "Asbestos Exposure and Neoplasia", JAMA 188:22 (1964).

20. I. J. Selikoff, J. Churg, E. C. Hammons, "Relation Between Exposure to Asbestos and Mesothelioma", N. Eng. J. Med., 272: 560-565 (1965).

21. Gary Stephen LeMoine, "A Survey of the Asbestos Levels in the Ambient Air of Seattle", A Master of Science Thesis, School of Public Health, University of Washington, Seattle, Washington (May 1981).

22. Nicholson, W. J., Rahl, A. N. and Weisman, I., "Asbestos Contamination of Building Air Supply Systems", The Instit. of Elect. and Electronics Eng., Ann No. 75CH1004-I-29-6, (1976).

23. Nicholson, W. J., et al, "Control of Sprayed Asbestos Surfaces in School Buildings; A Feasibility Study Under NIEHS Contract (1-ES-7-2113), Nat. Inst. Env. Hlth. and Safety (1978).

24. C. A. Mangold, "A Model Asbestos Control Program for the U.S. Public Health Services Hospital", Seattle, Washington (October 1979).

25. Rossiter, C. F., and R. M. Coles, H. M. Dockyard, Devonport-1947 Mortality Study, (Page 713 - 721 in J. C. Wagners, ed. Biological Effects of Mineral Fibres. IARC Scientific Publication No. 30, International Agency For Research on Cancer, Lyon, France (1980).

26. Nicholson, W. J., "Measurement of Asbestos in Ambient Air:, National Air Pollution Control Administration (Contract CPA 70-92) (1971).

27. W. T. Marr, "Asbestos Exposure During Navel Vessel Overhaul", Am. Indust. Hyg. J., 25:264 (May-June 1964).

28. C. A. Mangold, R. R. Beckett, D. J. Bessmer, "Asbestos Exposure and Pulmonary X-Ray Changes to Pipe Coverers and Insulators at Puget Sound Navel Shipyard", Puget Sound Naval Shipyard, Bremerton, Washington (Aug 1968)

29. C. A. Mangold, R. R. Beckett, D. J. Bessmer, "Asbestos Exposure Control - Puget Sound Naval Shipyard, U.S. Dept. of the Navy (May 1970).

30 W. E. Fleischer, F. J. Viles, R. L. Gade, P. Drinker, "A Health Survey at Pipe Covering Operations in Constructing Naval Vessels", J. Ind. Hyg. & Tox., 28:9 (Jan 1946).

31. H. E. Ayer, J. R. Lynch, J. H. Fanney, "A Comparison of Impinger and Membrane Filter Techniques for Evaluating Air Samples in Asbestos Plants", Ann N.Y. Acad. Sci., Vol 132, Pg 274, (Dec 31, 1965).

32. Occupational Safety and Health Administration, OSHA Instr. CPL 2-2.21A, interpretation of 29 CFR 1910.1001 (j) (2), (3), and (4), "Minimum Airborne Fiber Concentration for Initiating and Continuing Asbestos Medical Examinations", (Feb 18, 1981).

33. Occupational Safety and Health Administration, Industrial Hygiene Field Operations Manual (CPL 2-2.20, April 2, 1979 w Changes).

34. National Institute for Occupational Safety and Health (NIOSH): Manual of Analytical Methods, Asbestos Fibers in Air (P & CAM 239), Vol 1, ed 2, U.S. Govt. Printing Office, Wash. D.C., p 239-1 (April 1977).

35. National Institute for Occupational Safety and Health (NIOSH), Revised Recommended Asbestos Standard, DHEW (NIOSH) Pub. 77-169 (Dec 1976).

36. G. S. LeMoine, "A Survey of the Asbestos Levels in the Ambient Air of Seattle", School of Public Health, U of Washington, Seattle (1982).

37. C. A. Mangold, "The Actual Contribution of Garlock Asbestos Gasket Materials to the Occupational Exposure of Asbestos Workers", A Report (1982).

38. C. A. Mangold, "Asbestos Fibers in the Ambient Air in the Greater San Francisco Area; A Report (March 1983).

39. J. D. Wendlick, "Ambient Asbestos Fiber Levels in the Metropolitan Area of Norfolk-Portsmouth-Newport News, Virginia, December 1983.

40. Henderson, V., P. E. Enterline, "Asbestos Exposure: Factors Associated with Excess Cancer and Respiratory Disease Mortality", Ann. N.Y. Acad. Sci. 330:117-126, (1979).

41. K. A. Busch, N.A. Lidel, R. W. Horning, R. J. Smith, "Unbiased Estimates of Co-efficients of Variation for Asbestos Counting Determined from Johns Manville Data". NIOSH, U.S. Dept. of HEW, Cincinnati, Ohio (Dec 1977).

42. Leslie Preger, et al., "Asbestos-Related Disease", Grune and Stratton, N.Y., NY (1978).

43. L. Michaels and S.S. Chissick, "Asbestos, Properties, Applications and Hazards", Vol 1, John Wiley & Sons, N.Y., NY (1979).

44. Thomas A. Mercer, "Aerosol Technology in Hazard Evaluation", Academic Press, N.Y., NY (1973).

45. G. A. Peters, B. J. Peters, "Source Book on Asbestos Diseases: Medical, Legal, and Engineering Aspects", Garland and STPN Press, N.Y., NY (1980).

46. B. Singh, Jean-Pierre Thouez, "Ambient Air Concentrations of Asbestos Fibers Near the Town of Asbestos, Quebec", Env. Research, 36; 144 - 59 (1985).

47. Robert N. Sawyer, Arthur Rohl, Arthur M. Langer, "Airborne Fiber Control in Buildings During Asbestos Material Removal by Amended Water Methodology", Env. Reseach 36, 46 - 55 (1985).

48. D. A. Chadwick, R. Buchan, H. Beaulieu, "Airborne Asbestos in Colorado Public Schools", Env. Research, 36, 1 - 13 (1985).

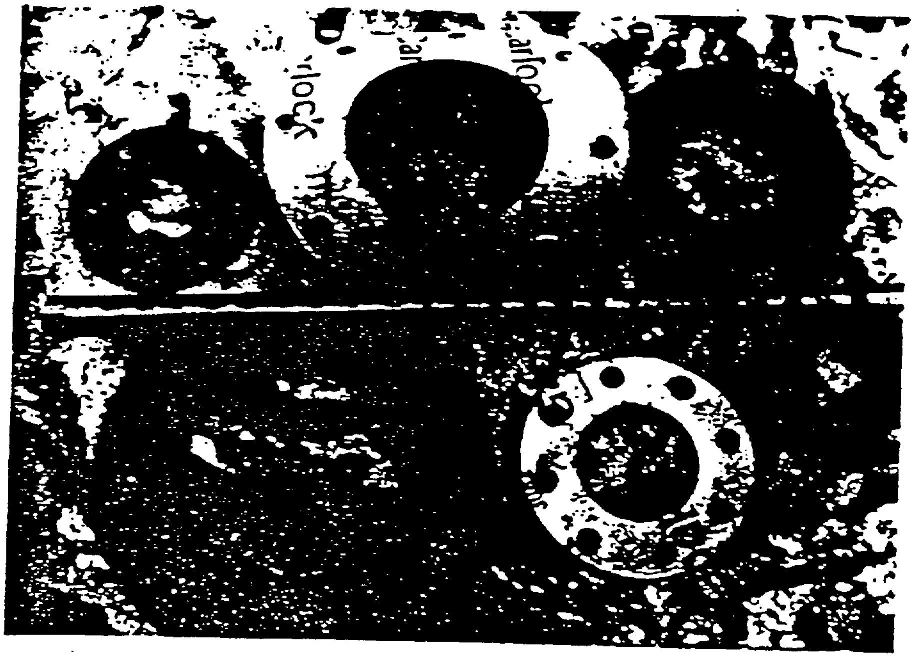
TYPICAL FLANGE CONTAINING A GARLOCK GASKET

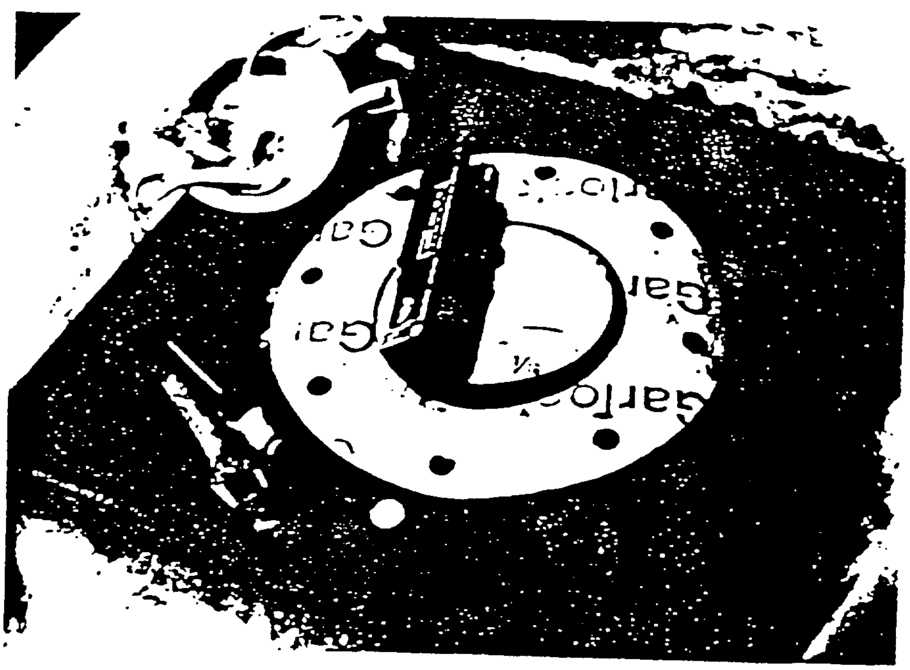
SUBJECTED TO TEST

TABLE II

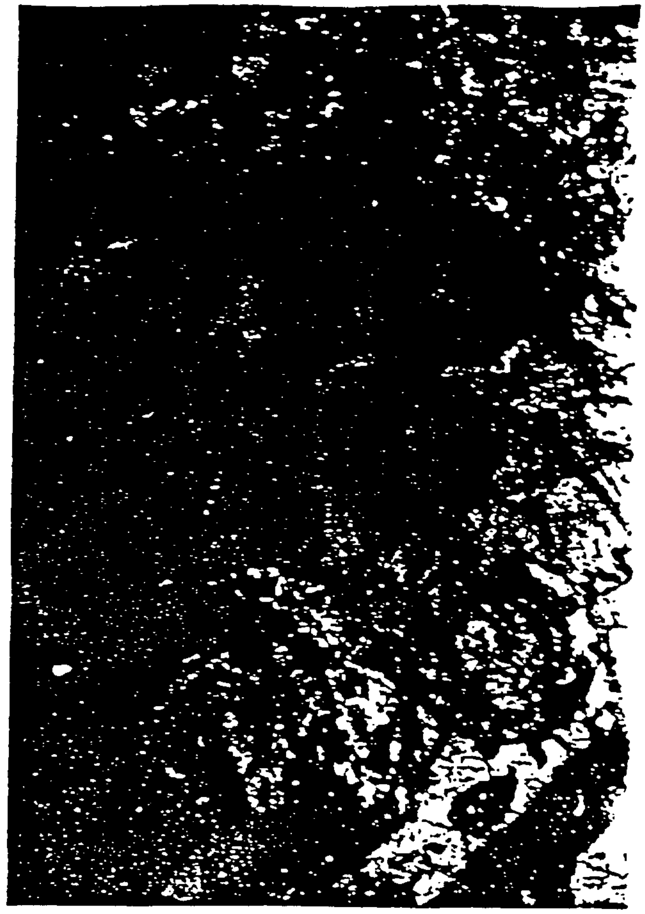
SIX NEWLY CUT GARLOCK INC ASBESTOS FLANGE GASKETS

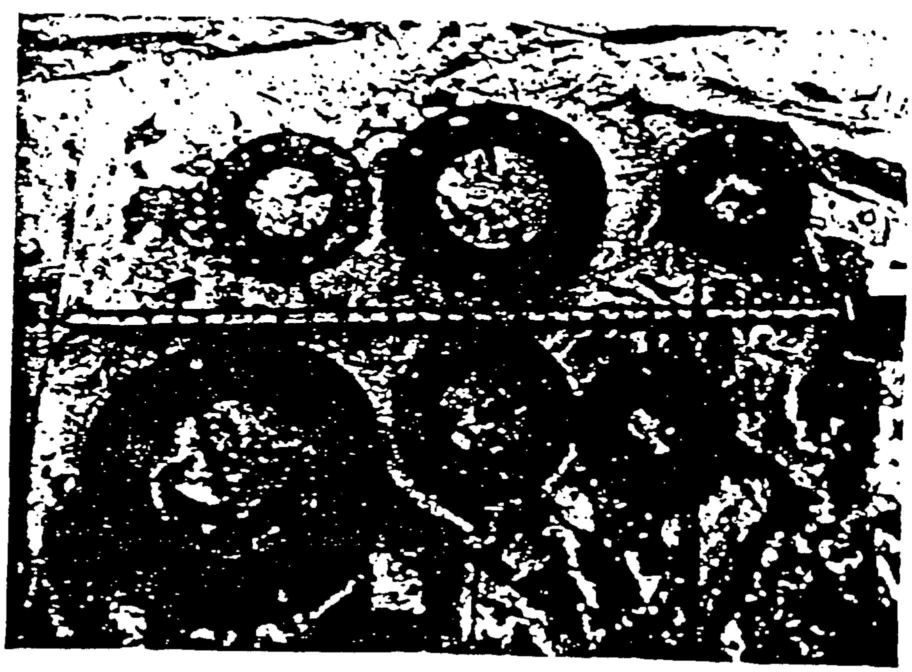
AND METHODS OF CUTTING





USED GARLOCK GASKETS TAKEN FROM PIPE FLANGES THAT HAVE BEEN IN PLACE SINCE ABOUT 1944 AND SUBJECTED TO TEST





POLYETHYLENE PLASTIC AND PLASTIC PIPE

ENCLOSURE USED FOR TESTING

HIGH VOLUME AIR SAMPLER USED IN TESTING