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THE ACTUAL CONTRIBUTION OF AIRBORNE ASBESTOS FIBERS TO THE OCCUPATIONAL EXPOSURE OF BY-STANDERS DURING SELECTED PROCESSING OF ENCAPSULATED ASBESTOS GASKETS

HAND WIRE BRUSHING OF ASBESTOS
GASKET RESIDUAL FROM FLANGES

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ABSTRACT

When asbestos gaskets are removed from flanges and machinery they often leave some portion of the gasket stuck to the flange faces. The amount varies according to the size of the flange, heat, pressure, and the method of removal. The residual encapsulated gasket material on the flange faces can be removed with a hand held wire brush and the faces dressed. When the material is firmly stuck a sharp instrument such as a putty knife is needed to peel off the excess materials. Otherwise, the residual will glaze and become a smoothe lump on the flange face.

Sections of piping were removed from a U.S. Navy vessel, the USN Gypsy (ARSD-1) which was built in 1944, served in the Pacific Theatre in World War II and was decommissioned in the 1950's. Some of the gaskets in the piping flanges collected for opening and dressing with a wire brush may have been in place up to 40 years. Gasket are not normally removed unless there is a reason; overhaul, leakage, or machinery removal.

Eight sets of flange faces which had been opened and the gaskets removed were selected for removal of the residual asbestos material with a hand held wire brush. The intent was to dress the flange faces as observed and as described by workmen. Not all gaskets bore a Garlock logo, but all gaskets were similar and were determined to contain chrysotile

asbestos. Therefore, the residual is the same material. The air samplers placed on the operator and 5 and 10 feet away from the operator recorded the release of chrysotile asbestos fibers in air from the wire brushing of the flange faces, and some instances removal with a putty knife to assist the removal. The operation was conducted in a clean room and at low background levels of natural asbestos in the atmosphere.

The results showed that;

1. The electron microscopy analyses for total chrysotile **fibers** averaged .132 structures/cc. Structures/cc is approximately equal to fibers/cc. The concentrations at 5 feet away from the operator was about twice that found at 10 feet away.

2. The electron microscopy analyses for chrysotile asbestos fibers greater than 5 micrometers in length and .25 micrometers in diameter or greater were compared to the phase contrast microscopy method. The results averaged .024 structures/cc, ranging from .01 to .04. This is a method of verification of the phase contrast microscopy method.

3. The phase contrast microscopy analyses revealed the average concentration for fibers greater than 5 micrometers in length was .003 fibers/cc. The personal sample attached to the operator wire brushing the flange faces was .007 fibers/cc, >5 um in length. The phase contrast microscopy method is the only one specified for analyses in the Federal standard.

The differences between this result and that in 2 above is likely due to a larger distribution of smaller fibers near the lower limit of resolution of the phase contrast microscope. Electron microscopy is more precise.

The eight hour time-weighted average to the operator and to a by-stander in the room are 1/10th or less of the daily permissible exposure limit of .2 fibers/cc.

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1. BACKGROUND: Asbestos is one of the most plentiful, useful, and cheap industrial minerals. Because of its high thermal stability and resistance to corrosion it appears in more than 3,000 manufactured goods in the United States. Estimates are that at least 30,000,000 tons have been used in construction and manufacturing since the year 1900. This common use of asbestos has led to the exposure of millions of Americans at levels that may have a significant impact on their health. Today, large numbers of Americans are exposed to asbestos in industry as well as the environment where it occurs naturally. Most environmental exposures occurs in our cities, near industrial complexes, from soil high in asbestos content, in the water, and in the air from these sources.

Therefore, most Americans receive at least some regular low level exposure throughout their lifetimes. In 1980, Dr. Churg (1) determined that most city dwellers retain a considerable amount of asbestos in their lungs in some state of clearance. The retained amounts can be in the millions of fibers just from living and working in the city where low level exposures to asbestos is commonplace.

The concerns about the role of asbestos in the development of a lung disease: asbestosis, began in the United States in the 1930's and progressed slowly as more was learned about the pathogenesis of the disease. Most of the attention was centered on disabled workers with obvious work-related exposure patterns involving exposure to the raw fibers of the various forms of asbestos used commercially. Few, if any, controls were followed so that time and intensity factors led to dose levels that precipitated various degrees of asbestosis. This continued until the 1960's when signs of asbestos-related cancers began to reshape thinking and action about the occupational exposures to asbestos. Today, the exposures of workers to asbestos have been markedly reduced through various means of voluntary controls and legislations that led to the first Federal standards in 1972. Since that time the permissible exposure levels of asbestos have been reduced through the regulatory processes in the United States.

In 1964, Marr (2) concluded that asbestos-related disease was an important problem among insulators working in Naval shipyards. His assumptions were correct; however, the methods of assessment weakened the conclusions. Pioneer work was begun at Puget Sound Naval Shipyard (PSNS) in 1965, culminating in a conclusive report of exposure levels and medical findings by Mangold, Beckett & Bessmer (3,4). Most of the attention was directed at the products and the operations that produced high-level exposures to asbestos workers and associated trades, and because of the large volumes of asbestos used annually in the shipyard. The conclusions were that the threshold limit value (TLV) was still too high at 5 millions of particles per cubic foot (MPPCF), equivalent to about 50 fibers per cubic centimeter, and that intermittent peak exposures were far more important that previously recognized. Both conclusions have been corroborated by more recent literature. About 1964, Selikoff (5,6) and others reported the association of exposure to asbestos with asbestos-related cancers and the effects of smoking.

In 1978, Dr. Selikoff (7) and a team of scientists published a protracted study of asbestos-related diseases which defined the latent effects of exposure and probable dose-response relationship based upon time and intensity of exposure. The model formulated from high level exposures was extrapolated to all levels of exposure however so small. But, J.E. Craighead, et.al. (8), M.R. Becklake (9) and W.J. Nicholson (10) all raised reasonable questions about the validity of the straight line approach because of the latency factors and ill-defined responses to low level exposure. Nicholson (10) further observed that the long lapse time from exposure to the onset of asbestosis, or asbestos-related cancers, creates difficulties in attempting to establish the true dose-response relationship. And, the diseases today were from decades past when few measurements of asbestos concentrations in the breathing zone of workers were made, exposures were high, and controls few.

Since that time Dr. Churg (1) has described the relatively high levels of asbestos fibers in the lungs of city dwellers not occupationally exposed. This suggests a sigmoid, or "S" shaped curve, so often found where a lower no-effect level is reached. Otherwise, millions of Americans receiving daily exposures to asbestos from the environment at low levels should show significant asbestos-related disease. They do not.

Therefore, the assumptions that all levels of exposure have the same risk through the straight line dose-response model is extreme and without proof. It is based upon extrapolation and assumption.

The Occupational Safety and Health Administration (OSHA) used those assumptions in the 1972 Federal regulation for occupational exposure to asbestos (11) and subsequent downward revisions. In addition, they have made the assumption that all forms of asbestos, namely Chrysotile, Amosite, and Crocidolite, and more recently less used commercial forms all produce asbestos-related disease at the same levels of exposure. More recent studies in 1988 by Dr. Churg and others (12,13) show that the potency of the various forms of asbestos are different related to the cancer producing effects. However, OSHA treats them alike; as does the Environmental Protection Agency (EPA) for regulatory control purposes.

2. ENVIRONMENTAL EXPOSURES: The amount of environmental exposure to natural forms of asbestos in the United States

is substantial. Asbestos, mainly *Chrysotile*, is common to the ambient air in the environment especially near mountainous regions in the United States. There are 22 States with major asbestos outcroppings that contribute substantial amounts of asbestos to the air, water, and the eroded soil. Many major cities, as Seattle, Washington may use drinking water for the population that contains 400,000 to 1,000,000 asbestos fibers per liter of water. Because the asbestos occurring naturally is so wide spread on the East and West coast and along the border with Canada, millions of Americans receive daily and substantial exposures to asbestos from birth from these natural sources. The increased activities in cities and the concentration of large numbers of the population on a daily basis causes even further increases in exposures, some from manmade products such as clutches or brakes of vehicles.

It is not uncommon to find airborne concentrations of asbestos in such communities at levels of about .002 fibers/cc of air, rising to occasional peaks of .02 fibers/cc or more.

The background levels of natural occurring asbestos in air is so prevalent that the EPA took into account the influence for clearance of school buildings following an asbestos removal (14). It is not uncommon to find the ambient airborne concentrations exceeding those inside office or school buildings. The current EPA criteria for clearance of a school building following an asbestos removal project is .01 fibers/cc by transmission electron microscopy for total fibers. At that level the EPA considers the building cleared for occupancy.

Doll & Peto (15), Weill & Hughes (16), and Hughes & Weill (17) all have made contemporary predictions of the risk of environmental exposures at these levels. Doll and Peto predict one excess death from environmental exposure in a year in the United Kingdom. Such a low level of risk at the known environmental levels in the United Kingdom and the United States would account for the fact that millions of people so exposed do not demonstrate asbestos-related diseases; suggesting a lower no-effect level.

3. VOLUME OF ASBESTOS USED IN SHIPYARDS: It is important to make a contrast between the discussion of environmental exposures and the amount of asbestos used in a Naval Shipyard in the 1940's during the World War II years. The Fleischer-Drinker report on Naval shipyards published in 1946 shows that in those small industrial communities 100,000 to 200,000 pounds of asbestos products would be used each month in ship construction (18). The report made no mention of the volume of asbestos that needed to be removed prior to overhaul or renovation. The amount of material alone sets the conditions for high levels of exposure to workers handling the asbestos under these conditions. About 90% of the products used were amosite blankets or pads, loose amosite, magnesia block insulation, and asbestos cements.

All of these materials were loose, easily broken or crumbled, and handled directly by workers. The potential for high level exposure, especially peaks, is apparent. Few effective control measures were in place at that time largely because the real risk from high level exposures over long periods of time were not realized because of the extreme latency period.

4. EXPOSURES OF THE CONSTRUCTION AND SHIPYARD TRADES:

There are several studies that attempted to define the occupational exposures to workers in the construction and shipyard trades in the 1960's. They constitute a cross-section of the American experience at controlling high level occupational exposures where they were occurring in industry.

In 1970, Mangold, Beckett, and Bessmer (3,4) published a report on exposures to asbestos at Puget Sound Naval Shipyard showing that 21% of asbestos workers showed pulmonary abnormalities. They concluded that the TLV of 5 MPPCF was too high, that peaks were important, and that changes of work practices were required. The publication contains the levels of exposures recorded for the workers activities.

In 1968, W.C. Cooper and L. Baltzer (19) published a similar study of construction workers in the San Francisco Bay area. About 25% of the construction workers handling asbestos products and receiving high level exposures showed x-ray changes of the lungs. They concluded that the TLV was too high and needed to be reduced. The types of products and the levels of occupational exposure for the construction workers was recorded.

In 1971, Gaensler (20) published a study of exposures and medical findings in a private shipyard on the East coast. He concluded that exposures were too high and that the TLV should be reduced. A comparison of the asbestos exposures by job are contained in the report.

These three studies show that the use of large volumes of asbestos with corresponding high levels of exposure were commonplace among those required to handle or remove it. Such substantial levels of exposure are those that account for the asbestos-related diseases following long latency periods. The concentrations are many orders of magnitude above background levels, or environmental exposures.

5. CURRENT ALLOWABLE LEVELS OF EXPOSURE:

The American Conference of Governmental Industrial Hygienists (ACGIH) adopted a Threshold Limit Value (TLV) for asbestos in 1946 of 5 millions of particles per cubic foot of air sampled for an 8 hour time-weighted average workday (TWA). It remained in effect until 1969, when it was reduced to 2 MPPCF or 12 fibers/cc. Currently, separate TLV's are published for each type of asbestos used commercially;

A. Chrysotile: 2 fibers/cc, 8 hr TWA

B. Amosite: .5 fibers/cc, 8 hr TWA

C. Crocidolite: .2 fibers/cc, 8 hr TWA

D. Other: 2 fibers/cc, 8 hr TWA

The current OSHA Federal standard for occupational exposure to asbestos is .2 fibers/cc for *all* forms of asbestos used commercially. It makes no distinction between the types of asbestos. The regulation specifies the use of a special technique of air sampling and laboratory analysis by phase contrast microscopy at 400 X magnification (11).

The EPA now regulates school clearance following an asbestos removal project to :01 fibers/cc as determined by transmission electron microscopy, a precise method that measures all asbestos fibers present (14).

It is apparent that the ACGIH recommendations do not agree with the OSHA permissible exposure limit. The EPA clearance level is aimed at public policy for schools where asbestos is managed, or removed.

6. CONTINUING EVALUATIONS:

Following control programs in the 1960's and 1970's and more recently those mandated by Federal or State regulations, the overall occupational exposure levels to workers has dropped markedly. Investigators have now turned to other sources of asbestos used in industry to determine the contribution to the overall exposure, if any.

In the 1960's the major goal was to reduce the high level exposures occurring from highly friable asbestos materials used in large volume in construction and in shipyards. The small volume products and those that were encapsulated were not considered because of the small contribution to the overall exposure pattern (3,4). And, because tests revealed that the low emissions were obscured by the high background levels from other highly friable products (3,4,19,20). Most of the data in the earlier reports evaluate processes which include the influence of all sources of asbestos that may be present. It is difficult to differentiate the contributions of the various types of asbestos products which were being used at the same time, or in near proximity to each other.

7. U.S. NAVY GASKET REPORT:

In 1978, the U.S. Department of the Navy (21), as part of a continuing evaluation program, set about evaluating the asbestos exposures to workers from the storage, handling, and processing gaskets of all kinds in Naval shipyards. The evaluation is important because there are only a few such publications that identify and estimate the occupational exposure to gasket materials in shipyards. the report concludes that even the simplest of general housekeeping controls or work practices are sufficient to maintain occupational exposures at acceptable levels. In fact, most of the exposures were found to be less than .1 fiber/cc for an 8 hour TWA, a level at which medical examinations are not required according to the current Federal standard for asbestos.

The 1978 U.S. Navy report did achieve the intended purpose to determine the exposure to <u>any</u> <u>and</u> <u>all</u> <u>asbestos</u> in the breathing zone of workers but does not determine the <u>actual</u> <u>contribution</u> from the gaskets alone. The breathing zone air samples were collected for various forms of gasket processing in some work areas under uncontrolled conditions and in the presence of contamination from other asbestos products. The results are actually the contribution from the gaskets, background levels, and contamination from other asbestos products. They do not reflect the actual contribution from the gaskets. Because the airborne concentrations were extremely low, often .01 fibers/cc or less, the potential for contamination is certain and cause a major contribution to the reported values for gasket processing.

Many of the reported values reflect the actual exposure time; not an 8 hour time-weighted average. The 8 hour TWA measurement or calculation is necessary to be able to compare the values to the current Federal standard. Short term peak exposures measured in this way will nearly always be greater than the 8 hr TWA, often by several orders of magnitude.

While the 1978 U.S. Navy report achieved the intent there are several objections in the use of the data to reflect the <u>actual</u> contribution from gaskets alone. They are;

A. Short term peak exposures are reported that cannot be directly compared to the 8 hour TWA of the Federal standards.

B. No attempt was made to control or factor the contributions of contamination from the results. The contamination levels may even have exceeded the actual contribution from the gaskets processed.

C. The data was intended to determine the overall peak exposures from unit operations that included all asbestos contributions.

The small contributions from gaskets are confounded or obscured by high background contamination levels where the gaskets were processed, contaminated clothing, and atmospheric pollution.

8. VERIFICATION OF THE 1978 U.S. NAVY STUDY:

Because of the objections offered above, the U.S. Navy report could not be used with accuracy to reflect the actual contribution of gaskets alone. In 1982, the Garlock, Inc. commissioned C.A. Mangold (22) to repeat the U.S. Navy investigation on gaskets as nearly as possible and to take into account the effects of contamination in order to make estimates of the <u>actual</u> contribution of gaskets to the occupational exposure of a worker handling or processing them. In addition, the data was to reflect the 8 hour time-weighted average work day for direct comparison to the existing Federal standards for asbestos.

Samples of the ambient air were collected in various cities to show the apparent level of natural and manmade asbestos fiber pollution. The effects of contaminated clothing that a worker may wear were evaluated to determine the contributions. All sources of contribution were considered to control or factor those background levels that were not part of the contributions from the processing of the gaskets.

After the background levels were measured or controlled, the data showed that hardpressed or encapsulated Garlock, Inc. gasket products released insignificant levels into the breathing zone of workers processing gaskets in the same manner as conducted in Naval shipyards. The actual contribution for the processing of gaskets averaged **.02 fibers/cc for an 8 hour TWA** when the effects of contamination from other sources or asbestos products were controlled. The peak background levels of ambient air in industrial areas, or in cities on warm summer days may reach these levels.

This verification of the U.S. Navy report revealed that when the contamination was factored or controlled the values for the actual contribution from gaskets were about 50% of those reported by the U.S. Navy. The study conducted by Mangold (23) more appropriately reflects the **actual** contribution from handling or processing encapsulated gasket for an 8 hour time-weighted average work day. The overall average of .02 fibers/cc is 1/10th of the current Federal standard for occupational exposure to asbestos fibers in air.

9. THE DILEMMA:

The verification of the 1978 U.S. Navy report shows that hardpressed or encapsulated gaskets actually contribute negligible amounts of asbestos when handled or processed as in industry or in shipyard. Negligible exposures present a negligible risk. The risk is in the same magnitude as some environmental exposures to the population at large.

However, additional measurements under highly controlled conditions are needed because;

A. Some workmen describe specific methods of handling, processing or removing gaskets from machinery or piping that were not evaluated in the 1978 U.S. Navy report or the subsequent verification. Some are not standard operating practices expected of workmen experienced in the handling, processing or removal of encapsulated gaskets from machinery or piping.

B. The 1978 U.S. Navy report and the 1982 verification contains the effects of levels of contamination that are in the same range as the expected actual contribution of airborne asbestos fibers from the gasket alone. Therefore, the results will be skewed upward by that contamination contribution. Better definition is needed where the effects of other asbestos products do not interfere with the tests.

C. Ambient concentrations of chrysotile asbestos fibers that occur naturally from soil and water, and from manmade products add some contribution to the measurements of the emission from gaskets. The contributions can be substantial and in the same range as the expected actual emission from the gaskets being handled, processed or removed.

D. New analytical methods that were not available or practical for the U.S. Navy report in 1978 or the verification in 1982, are now readily available and within economic practically. These methods can provide a more precise examination of the actual release of fibers from encapsulated gaskets.

E. The new analytical methods have a much lower limit of detection that those used in the 1978 and 1982 reports. The methods now available can not only determine the total number of fibers present, but determine the types of fibers they are. This is valuable because the *chrysotile* asbestos is used in encapsulated gaskets.

F. The new analytical methods can make a direct comparison to the older Phase Contrast Microscopy (PCM) method specified in the Federal standard through the use of Scanning Transmission Electron Microscopy (STEM). It can verify the PCM method which is easily influenced by other non-asbestos fibers, if they are present.

G. A better definition of by-stander exposure was needed, that is, the levels of exposure of a worker 5 or 10 feet away from another worker making, installing, or removing encapsulated gaskets.

10. EXPERIMENTAL DESIGN:

Although the 1978 U.S. Navy report and the 1982 verification show that only negligible amounts of asbestos fibers are released from the handling or processing of gaskets, additional measurements are needed to utilize the new analytical methods, to better control the effects of ambient or manmade contamination, and to determine the actual contributions from the gaskets handled in the ways described by some workmen. And, the by-stander exposures from those selected processes.

A clean room condition was needed for the testing in order to accurately measure the low level release of chrysotile asbestos fibers from the encapsulated gasket materials processed or removed from flanges. Since the emissions were expected to be near the limit of detection of phase contrast microscopy methods used, special precautions were taken to control potential contamination.

A new metal building was leased in Kent, Washington where electron microscopy samples showed that the amount of natural ambient asbestos was .002 fibers/cc or less for all sizes of fibers. The new building was selected to ensure that accumulation of dust, or previous asbestos insulation contamination was not present.

Inside the building, an enclosure of polyethylene plastic was constructed that measured 20 feet by 20 feet and 10 feet high, or 4000 cubic feet. This represents a small compartment or room where such work may be done in industry or aboard ship and that may be occupied by a by-stander. The ceiling and floor was covered with polyethylene plastic and all the edges were sealed. The only entry was a specially designed flap door that would remain sealed during testing.

A clean work bench was placed in the center of the enclosure. The gaskets were processed on the bench according to the descriptions given by some workmen.

Sample locations were assembled on the points of the compass at head height inside the room. The sample stations were located 5 and 10 feet away from the work bench in the center of the room. The sample cassettes for analysis by phase contrast microscopy and scanning electron microscopy were placed at the sample stations. Air was drawn through the special filters in the cassettes by electrically operated high volume air samplers. The volumes of air were measured by recording the flow rates with a class A rotometer and recording the amount of time the samples were collected. Nine

PCM and 8 STEM samples were collected for each test. One PCM was worn by the operator at the work bench to record the breathing zone exposure. The other sample stations provided a preponderance of data and simulated by-stander exposures at 5 and 10 feet away from the gasket processing.

Samples of gasket material containing chrysotile asbestos were obtained from the manufacturer for processing. And, piping and valves were obtained from a U.S. Naval vessel, the USN Gypsy (ARSD-1) which was scrapped in Portland, Oregon. She was built in 1944, served in the Pacific Theatre during World War II, and was decommissioned in the 1950's.

Some of the flanges had never been opened since the vessel was built. All of the residual asbestos insulation on the outside of the piping was removed to prevent contamination when the gaskets were removed from the flanges.

Plastic impregnated protective clothing (TYVEC) was worn by the operator to control the potential release of non-asbestos fibers from street clothing, and dust from shoes.

The tests were conducted over an 8 hour time-weighted work day. This is necessary to develop data that can be directly compared to the Federal standard for occupational exposure to asbestos. It is inappropriate to attempt to compare peak exposures to the Federal standard.

Following the tests, the sample cassettes were removed and delivered to ESSTEK, a highly qualified asbestos analytical laboratory capable of conducting phase contrast microscopy (PCM) according to Appendix A, of the Federal asbestos standard, and transmission electron microscopy (TEM). Special arrangements were made to directly compare the results by PCM with that obtained by TEM. The PCM analysis is subject to influence by non-asbestos fibers that may be present. But, the TEM method is highly specific, determines all asbestos fibers present, identifies the type of fiber present, and has a very low limit of detection about .002 structures/cc (approximately equal to fibers/cc). Arrangement were made to have at least 75% of the PCM samples blind counted. This means at least two qualified asbestos counters would make a determination without knowing the result of the other. The results are then compared. This minimizes the potential for counting errors.

The PCM and the TEM samples collected at each sample location at the same time and filtering about the same volume of air, were compared as duplicates. This provides two separate determinations with highly specific methods at the same location and gives a high degree of confidence that each determination is comparative.

The results and conclusions for the tests conducted are found in paragraphs 12 and 13.

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RESULTS AND CONCLUSIONS:

When workmen have disassembled piping or machinery and removed the asbestos gasket materials the faces of the flanges or surfaces must be dressed or smoothed. This operation removes rust, paint and residual gasket material that may have stuck to the flange faces or surfaces. The residual gasket material is stuck firmly to the surfaces which may require aggressive methods to remove it. Some workmen have been observed or have described dressing the faces of flanges or machinery surfaces with a hand held wire brush.

This technique is fast and effective if there is only a small amount of loose asbestos gasket material stuck to the surfaces. However, the encapsulated material begins to glaze when brushed hard and develops into a smoothe lump. This requires the use of a sharp tool such as a putty knife to cut beneath the edge and scrape the major portions of the stuck gasket material from the surface. Then the wire brushing is effective.

This final dressing is effective because the flange face or surface needs only to be smoothe and clean for a new gasket to be placed in surface between the flanges or surfaces. Most flange faces or machinery surfaces can be cleaned and dressed in this manner in 10 minutes or less.

This evaluation involved the wire brushing of residual from flange faces that had been opened and the gasket removed. The flanges had been taken from the U.S. Navy vessel, USN Gypsy (ARSD-1) which was built in 1944, saw service in the Pacific Theatre in World War II and was decommissioned in the 1950's. Some of the gaskets in the pipe flanges removed for examination may have been in place up to 40 years.

At least 8 sets of flanges of various sizes with residual asbestos stuck to the faces were dressed using the hand wire brush, and a putty knife when necessary to remove and clean the surfaces over an 8 hour period to determine the 8 hour time-weighted average exposure of a workman dressing flanges in a work day. Not all of the gaskets removed bore the Garlock logo, but all were similar in texture, and contained chrysotile asbestos. The residual on the flange faces was of the same material.

The conduct of dressing flange faces with a hand held wire brush inside a clean room with a low background and low ambient levels in air allows a realistic measurement of the exposure pattern of the operator and any by-stander near the operator. The eight sampling station situated around the room provided sufficient data to establish those ranges of by-stander exposure.

The attached data sheets show that;

1.The electron microscopy methods for total **chrysotile fibers** in samples collected at each of 8 sample stations averaged .132 structures/cc. The structures/cc are approximately equal to fibers/cc. The data shows that the breathing zone level concentrations at 5 feet away from the operator are about double of that at 10 feet away. This is a well known phenomena that the concentration of dust generated from a point source is reduced geometrically with distance. This method determined all of the chrysotile present regardless of fiber size. There is no total asbestos standard.

2. The electron microscopy analyses of the samples for fibers greater than 5 micrometers in length and .25 micrometers in diameter or greater is a method of comparison to the phase contrast microscopy specified in the Federal standard. In this way the phase contrast microscopy results can be verified. The average result showed .024 structures/cc of chrysotile greater than 5 micrometers, ranging from .01 to .04 structures/cc.

3. The phase contrast microscopy results for the 8 sample stations averaged .003 fibers/cc, >5 um in length. This represents the exposure pattern of a by-stander in the room with the operator. The exposure pattern of the operator dressing the flange faces with a hand held wire brush was .007 fibers/cc, >5 um in length. The difference between these results and the electron microscopy results in 2 above is likely due to the production of a larger distribution of smaller fibers produced on brushing. The electron microscopy methods are more precise and better able to detect and measure the sizes of fibers near the lower limit of resolution of the phase contrast microscope. However, the values are approximately comparable and in the same

range. It is not uncommon for electron microscopy values to be 10 times those of phase contrast microscopy results when a preponderance of small fibers are present.

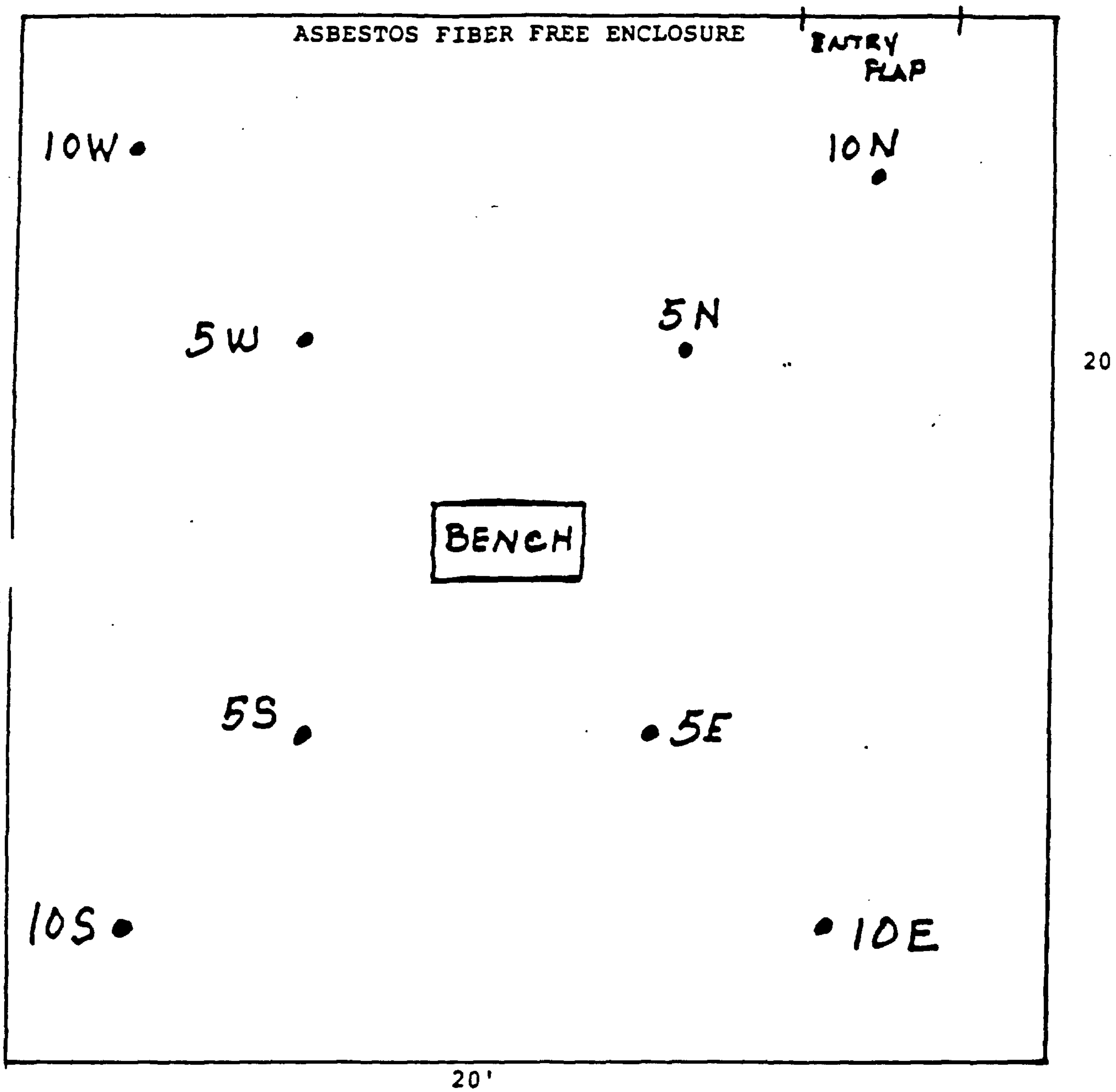
All of the results represent an 8 hour time-weighted average for direct comparison to the Federal standard of .2 fibers/cc, >5 um in length.

The exposure patterns from the hand brushing of residual from flange faces are all 1/10th or less than the Federal standard. The total fiber values by electron microscopy cannot be compared to the Federal standard. The hard pressed, encapsulated gasket material stuck to the flange faces release amounts of chrysotile asbestos substantially less than the daily permissible exposure limit of .2 fibers/cc, >5 um in length for an 8 hour day.

LOCATION OF SAMPLE STATIONS

IN THE

ASBESTOS FIBER FREE ENCLOSURE



Enclosure Height = 10'

SET #VII

"Wire Brushing of Flanges"

TRANSMISSION ELECTRON MICROSCOPY
AIR SAMPLE ANALYSIS RESULTS

CLIENT: Carl A. Mangold, CIH
PROJECT: Garlock Research

REPORT #: 812091

CLIENT SAMPLE ID	ESS-TEK ID	CHRYSOTILE STRUCTURES	CONCENTRATION ALL SIZES COUNTED (S/cc)	CHRYSOTILE STRUCTURE SIZE LENGTH >5.0 um DIAMETER >.25 um	CONCENTRATION LENGTH >5.0 DIAMETER >.25 S/cc
T5N-49	812091	109	0.265	6	0.012
T5E-50	812092	113	0.250	19	0.042
T5S-51	812093	109	0.250	8	0.018
T5W-52	812094	136	0.312	11	0.025
T10N-53	812095	66	0.151	15	0.034
T10E-54	812096	63	0.153	14	0.034
T10S-55	812097	47	0.116	6	0.015
T10W-56	812098	53	0.110	6	0.012
LAB BLANK		NSD			
			$\bar{X} = .132$		$\bar{X} = .024$

Analytical Sensitivity = 0.002 S/cc
NSD - No Structures Detected
BLD - Below Level of Detection
S/cc - Structures per cc = fibers per cc

ESS Environmental Safety Systems, Inc.

Gateway Corporate Park, Bldg. 5
12822 Gateway Drive
Seattle, Washington 98168
(206) 243-6573

AIR SAMPLE ANALYSIS REPORT

CLIENT: Carl A. Mangold, C.I.H.
3033 170th Place SE
Bellevue, WA 98008

REPORT #: 50-128416
REPORT DATE: 12-13-88

PROJECT: Garlock Research, Set VII
Wire Brushing of Flanges

DATE RECEIVED: 12-08-88
PO #: None Given

CLIENT SAMPLE ID	ESS ID	SAMPLE DATE	SAMPLE VOL (L)	FIBER COUNT	FIELD COUNT	BLANK CNT /100 FLDS	FIBERS PER CC *	BKGRND MAT **
P5N-49	128416	12-06-88	5760	31.0	100	2.00	0.002	H
P5E-50	128417	12-06-88	5760	34.0	100	2.00	0.003	H
.5S-51	128418	12-06-88	5760	36.0	100	2.00	0.003	H
P5W-52	128419	12-06-88	5520	55.0	100	2.00	0.005	H
P10N-53	128420	12-06-88	5760	54.0	100	2.00	0.004	H
P10E-54	128421	12-06-88	5520	45.0	100	2.00	0.004	H
P10S-55	128422	12-06-88	5520	23.0	100	2.00	0.002	H
P10W-56	128423	12-06-88	5760	24.0	100	2.00	0.002	H
P-BLK-7	128424	12-06-88	0	2.0	100	N/A	BLANK	
PP-7 (personal)	128425	12-06-88	1080	17.0	100	2.00	$\boxed{0.007}$	M

$\bar{X}$ = .003

SAMPLE LOCATIONS:

Sample #128416 was taken north 5ft at sample station.

Sample #128417 was taken east 5ft at sample station.

Sample #128418 was taken south 5ft at sample station.

mple #128419 was taken west 5ft at sample station.