IN THE UNITED STATES DISTRICT COURT

FOR THE EASTERN DISTRICT OF TEXAS

BEAUMONT DIVISION

FILED
U. S. DISTRICT COURT
EASTERN DISTRICT OF TEXAS
DEC 29 1969
JAMES R. COONEY, CLERK
By Myra Barton

S. R. POTTER /

vs. / CIVIL ACTION NO. 6329

FIBREBOARD PAPER PRODUCTS / CORPORATION

ANSWERS OF THE DEFENDANT, JOHNS-MANVILLE PRODUCTS CORPORATION, TO INTERROGATORIES PROPOUNDED BY PLAINTIFF

TO: PLAINTIFF, SAMUEL R. POTTER, AND MR. WARD STEPHENSON, STEPHENSON, THOMPSON & MORRIS, STEPHENSON BUILDING, ORANGE, TEXAS, HIS ATTORNEYS OF RECORD:

In accordance with the provisions of Rule 33, Federal Rules of Civil Procedure, Johns-Manville Products Corporation, hereby answers the interrogatories of Plaintiff served on Defendant's counsel on or about October 14, 1969.

Based on information obtained from Defendant's employees, with the advice of its counsel, Defendant has attempted to furnish the information requested in the interrogatories, but it reserves the right to amend or supplement its answers if it finds that inadvertent omissions or errors have been made, or if additional or more accurate information becomes available. Such answers to each interrogatory bears the same number as the request:

INTERROGATORY NO. 1

Defendant objects to Interrogatory No. 1 for the following reasons:

a) Said Interrogatory covers too long a period of time, i.e., thirty (30) years, and it would constitute an unnecessary burden on Defendant to require it to answer this interrogatory.

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b) Said Interrogatory is too broad in its scope and would impose upon this Defendant an undue burden and great expense in searching for the material and information requested in said Interrogatory.

c) The information requested by said Interrogatory is not presently available, and to assimilate same from the year 1940 would require an undue amount of time on the part of this Defendant, and its employees, and would cause them to go to great expense in searching for such information.

d) Plaintiff is seeking by said Interrogatory to force this Defendant to accumulate information upon which the Plaintiff can prepare his own case, and therefore, places the burden upon this Defendant of establishing the Plaintiff's case, if any he has.

e) Said Interrogatory amounts to no more than a fishing expedition on the part of the Plaintiff.

Subject to the foregoing objections, the insulation products manufactured by the Industrial Insulations Division of Defendant during the period 1959 to 1967 are listed on Exhibit "A" attached hereto and made a part hereof by reference. The printed block capitalized name given for each product is Defendant's trade name for such product. Where there is a generally recognized name for a product in the sense of a generic term, that designation is included in parenthesis. Many of the products were manufactured by Defendant long before 1959. The precise dates of which are not immediately known to Defendant, for example, "85% MAGNESIA", "SUPEREX","ASBESTOCEL", pipe and block covering, asbestos paper and many of Defendant's weatherproofing jackets

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have been manufactured by it since the early 1900's. "THERMOBESTOS" has been manufactured by Defendant since 1955. Most of Defendant's mineral wool products have been manufactured by it since 1929. Defendant has made inquiry of its libarian at its research center, to determine what products were manufactured prior to 1959, but has been unsuccessful in obtaining information in that regard.

INTERROGATORY NO. 2

Defendant objects to this Interrogatory on the grounds that it does not recognize that its products are "dangerous." Further, Defendant says that each of the products manufactured by it were suitable and reasonably fit for the purpose for which the products were intended.

On or about December 15, 1964, Defendant began (and has since continued) to place a precautionary label on the following products: THERMOBESTOS; #500 INSULATING CEMENT; # 450 INSULATING CEMTNT; #301 CEMENT; #302 ASBESTOS CEMENT; #0352 ASBESTOS CEMENT; #304 ASBESTOS CEMENT; #400 ASBESTOS CEMENT; #319 REF. CEMENT; #678 SEMI-REF. CEMENT; 85% MAGNESIA CEMENT; SUPEREX CEMENT; MAGNESIA & SUPEREX P/I; MAGNESIA & SUPEREX BLOCK; and #352 CEMENT. Said precautionary label read and reads as follows:

CAUTION

THIS PRODUCT CONTAINS ASBESTOS FIBER.

INHALATION OF ASBESTOS IN EXCESSIVE QUANTITIES OVER LONG PERIODS OF TIME MAY BE HARMFUL.

IF DUST IS CREATED WHEN THIS PRODUCT IS HANDLED, AVOID BREATHING THE DUST.

IF ADEQUATE VENTILATION CONTROL IS NOT POSSIBLE, WEAR RESPIRATORS APPROVED BY THE U. S. BUREAU OF MINES FOR PNEUMOCONIOSIS PRODUCING DUSTS.

In addition, Defendant has participated in a program designed to communicate to the employers of workers who work with insulation products that contain asbestos that inhalation of asbestos fibers in excessive quantities over long periods of time in the course of continuous employment under certain conditions may be harmful to some persons; and has communicated means for minimizing the inhalation of asbestos fibers by their workers to such employers.

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INTERROGATORY NO. 3

Defendant understand the word "use" in the context of this Interrogatory to mean the handling and/or applying and/or installing of its industrial insulation products which contain asbestos by an "Asbestos worker" such as Plaintiff alleges he was.

Defendant is currently participating in and supporting an insulation Industry Hygiene Research Program being conducted by Mt. Sinai Environmental Sciences Laboratory, Mt. Sinai Hospital, New York, New York. This is a combined industrial hygiene and preventative engineering research program designed to develop improved methods to minimize exposures of insulation workers to dust, etc., encountered on their jobs. This program was instituted on May 14, 1968.

Additionally, an epidemiological study on the biological effects of asbestos dust among the Port of Genoa and LaSpezia Arsenal insulation workers, among others, is being conducted by the Clinica del Lavoro, Milano, Italy, under the sponsorship of the Institute of Occupational and Environmental Health, which Institute in turn is funded by the Quebec Asbestos Mining Association. An affiliate corporation of Defendant is the principal contributor to the funding of the Quebec Asbestos Mining Association. This study was initiated early in 1968, and is scheduled to be completed within three to four years from its inception.

INTERROGATORY NO. 4

The studies are being conducted by the Mt. Sinai Environmental Sciences Laboratory and the Clinical del Lavoro, Milano, Italy, respectively. To Defendant's knowledge no written reports based upon such studies have yet been issued by the Laboratory or the Clinical del Lavoro respectively.

INTERROGATORY NO. 5

Defendant objects to this Interrogatory on the grounds that it is improper because it is too broad, irrelevant and immaterial in that "from the years 1940 to 1967" Defendant packaged and sold

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many products containing asbestos other than industrial insulation products of the nature of those with which Plaintiff could have worked in his alleged capacity as an industrial insulation applicator. Defendant further objects that Plaintiff has not shown that said information is relevant and material to the instant case, insofar as the time period concerned is involved, i.e. "from the years 1940 to 1967". Defendant submits that it is incumbent upon Plaintiff to allege precisely what periods of time he claims to have worked with Defendant's insulation products which contain asbestos, and that the mere general allegation that he worked as an insulator "from the years 1940 to 1967" is not sufficient and would place an unreasonable burden upon Defendant to answer with respect to periods during which Plaintiff may not claim to have worked with Defendant's industrial insulation products containing asbestos.

INTERROGATORY NO. 6

Defendant objects to this Interrogatory on the same grounds set forth in response to Interrogatory No. 5, supra."

INTERROGATORY NO. 7

Defendant objects to this Interrogatory on the grounds that the word "use" is too vague, ambiguous and broad to be meaningfully understood in the context. Defendant further objects that the term "insulating materials" is too broad, immaterial and irrelevant. Defendant further objects that insofar as the Interrogatory relates to diseases other than those alleged by Plaintiff in his Complaint it is too broad, immaterial and irrelevant. However, assuming (1) that the word "use" in this Interrogatory has reference to the normal and customary end use; and (2) that the words "insulating materials" mean "insulating materials that contain asbestos", Defendant answers in the negative.

INTERROGATORY NO. 8

Defendant objects to the word "using" in this Interrogatory for the same reasons set forth in Interrogatory 7., to wit: the word is too vague, ambiguous and broad to be meaningfully under-

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stood in the context. Defendant further objects to the word "exposed" on the grounds that it is too vague, ambiguous and broad in the context to be meaningful and further objects on the grounds that use of the word "exposed" is argumentative and improper. Defendant further objects on the grounds that the phrase "asbestos materials" is too broad, irrelevant and immaterial.

INTERROGATORY NO. 9

Defendant objects to the phrase "exposed to the use" on the grounds that it is too vague, ambiguous and broad to be meaningful and on the further grounds that such phrase is argumentative and improper. Defendant further objects to the Interrogatory on the grounds that it addresses itself to "your company's products" and is therefore entirely too broad, irrelevant and immaterial. Moreover, Defendant states that if the word "use" is to be understood to have reference to normal and customary end use the entire Interrogatory is argumentative and assumes a fact that has not been proven.

INTERROGATORY NO. 10

Defendant states that it does not understand what Plaintiff means by "areas where workers are using "its" products. Once the products have been installed they are essentially immobile and not used by workers. They merely become an integral part of a functioning system. There would be no call for a dust count in such areas. If, however, Plaintiff's question has reference to the handling and/or application and/or installation of Defendant's products by insulation workers so that such products may serve their end use, then Defendant answers as follows:

Defendant does make regular inspections of areas where workers who are employed by Defendant or its affiliates are working with industrial insulation products manufactured by Defendant which contain asbestos.

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Defendant does not make dust counts at such locations because:

a) Defendant has affixed clear warning labels on the packaging of those industrial insulation products manufactured by it which contain asbestos;

b) Defendant and its affiliates conduct regular safety and proper housekeeping programs at their facilities;

c) Defendant and its affiliates require their respective employees to use respirators approved by the Bureau of Mines where any dust producing operations are conducted;

d) Defendant and its affiliates follow established and proven safe operating practices. These practices include those outlined in the National Insulation Manufacturers Association safe practices booklets which booklets are available to Plaintiff from said Association.

Defendant does not conduct inspections of areas where workers who are not employed by Defendant or an affiliate of Defendant are working with industrial insulation products manufactured by Defendant which contain asbestos because:

a) Defendant has no jurisdiction over these people or any right to inspect the premises of their respective employers who are independent contractors and independent of Defendant;

b) Clear warning labels have been placed on the packaging of industrial insulation products manufactured by Defendant which contain asbestos;

c) Defendant has participated in the educational program conducted by the National Insulation Manufacturers Association desgined teach safe and healthful operating procedures to the employers of such employees.

INTERROGATORY NO. 11

Defendant objects to this Interrogatory on the grounds that no proper predicate has been laid. Moreover, Defendant objects on the grounds that any findings made by Dr. Murray would constitute hearsay and such findings would be irrelevant and immaterial and would not lead to the discovery of admissable evidence. Defendant objects to the question posed in the second sentence of the Interrogatory on the grounds that it constitutes a non sequitor.

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INTERROGATORY NO. 12

Defendant objects to this Interrogatory on the grounds that no proper predicate has been laid, Moreover, Defendant objects on the gounds that the publications asked about would constitute hearsay, and such publications would be irrelevant and immaterial and would not lead to the discovery of admissable evidence.

INTERROGATORY NO. 13

Defendant objects to the questions posed in the first sentence of this Interrogatory on the grounds that it asks Defendant for a conclusion of law, and further on the grounds that the question would place upon Defendant the burden of employing counsel to research the law and formulate an opinion. Defendant further objects that the question is irrelevant and immaterial and not designed to lead to the discovery of admissable evidence. Defendant objects to the questions posed in the subsequent portions of this Interrogatory on the same grounds, because they are predicated upon Defendant's response to the question posed in the first sentence. Further, Defendant objects to the question posed in the second sentence on the grounds that it constitutes a non sequitor. Defendant further objects to the question posed in the third sentence on the grounds that it is argumentative.

INTERROGATORY NO. 14

No.

INTERROGATORY NO. 15

Defendant has employed industrial hygiene engineering techniques to dust samplings. The techniques have been those then prescribed by the United States Public Health Service and have utilized at different times the midget impinger, the Greenburgh Smith impinger and Milapore filter techniques. Descriptions of these techniques are attached as Exhibits 15-A, 15-B, 15-C and 15-D hereto, and are hereby incorporated herein by reference.

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The Milapore method for dust samplings was introduced in 1968. This method was adopted by Defendant in February, 1969. Evaluation and analysis of industrial hygiene dust samplings have been conducted in accordance with the standards promulgated by the American Conference of Governmental Industrial Hygienists published Threshold Limit Values which are also attached as Exhibit 15-E hereto, and are hereby incorporated herein by reference. The purpose was to determine whether any risks due to the inhalation of asbestos dust existed with respect to employees of Defendant or Defendant's affiliates in mining, milling and manufacturing operations. Defendant's response to its findings has been to introduce dust control techniques to reduce the dust levels below the threshold limit values deemed potentially unhealthy, and to require employees of Defendant and of Defendant's affiliates to wear respiratory protective equipment until such time as dust levels could be reduced below such threshold limit values. Defendant has also introduced dust control equipment. Further, inasmuch as the inhalation of asbestos dust is only unhealthy in excessive quantities over prolonged periods of time under certain conditions, such as working in confined areas in stagnant air, Defendant has taken steps to protect employees of Defendant and Defendant's affiliates by limiting or reducing their exposure through change of jobs, changing their working conditions, etc.

INTERROGATORY NO. 16

Defendant objects to this Interrogatory on the grounds that it is improper, irrelevant and immaterial because Plaintiff has not alleged in his complaint that he has lung cancer.

INTERROGATORY NO. 17

Defendant objects to this Interrogatory on the grounds that it is improper, irrelevant and immaterial, because Plaintiff has not alleged in his complaint that he has the disease mesothelioma.

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INTERROGATORY NO. 18

Defendant places warning notices on the packaging of its industrial products which contain asbestos. The warning states:

CAUTION

THIS PRODUCT CONTAINS ASBESTOS FIBER.

INHALATION OF ASBESTOS IN EXCESSIVE QUANTITIES OVER LONG PERIODS OF TIME MAY BE HARMFUL.

IF DUST IS CREATED WHEN THIS PRODUCT IS HANDLED, AVOID BREATHING THE DUST.

IF ADEQUATE VENTILATION CONTROL IS NOT POSSIBLE, WEAR RESPIRATORS APPROVED BY THE U. S. BUREAU OF MINES FOR PNEUMOCONIOSIS-PRODUCING DUSTS.

This warning is used on the packaging of all industrial insulation products of Defendant which contain asbestos. Its use was commenced during 1964. Defendant used such warning notices, because in 1963 it was first reported by a member of the medical profession that there might exist a risk to some persons who continuously handled and/or applied and/or installed industrial insulation products containing asbestos in that inhalation of asbestos fibers that might be generated from such handling, etc. of such products over prolonged periods of time under certain conditions might create a risk of the contracting asbestosis to some persons, if the instructions given on such warning notices were not heeded.

INTERROGATORY NO. 19

Defendant objects to this Interrogatory on the grounds that it is improper, irrelevant and immaterial, because Plaintiff has not alleged in his Complaint that he has the disease of cor pulmonale.

INTERROGATORY NO. 20

No.

INTERROGATORY NO. 21

Defendant recognizes that more asbestos is being used year by year, but as to the remainder of the Interrogatory the answer is no.

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INTERROGATORY NO. 22

Defendant does not understand the question in that it does not know what Plaintiff means by the phrase "consulted with Dr. Irving J. Selikoff of New York, New York concerning asbestosis". On many occasions representatives of Defendant have discussed pulmonary disease manifestations with Dr. Selikoff. However, Dr. Selikoff is not engaged as a consultant of Defendant other than through Defendant's relationship with the Insulation Industry Hygiene Research Program of Mt. Sinai Environmental Sciences Laboratory.

INTERROGATORY NO. 23

Defendant does contribute funds to research concerning asbestos dust and its relation to lung disease. Defendant does not contribute funds to research concerning asbestos in relation to larynx disease. Defendant objects to the question posed in the second sentence of this Interrogatory on the grounds that the question constitutes a non sequitor in that it is predicated on the question posed in the first sentence which asks a question in the present tense, but the second sentence inquires as to the past.

INTERROGATORY NO. 24

Defendant objects to the word "used" on the grounds that it is too vague, ambiguous and broad to be meaningful in the context. Insofar as the Interrogatory relates to products beyond industrial insulation products which contain asbestos Defendant objects on the grounds that the Interrogatory is too broad, irrelevant and immaterial and not designed to lead to the discovery of admissable evidence. However, once again assuming that the word "used" has reference to the normal customary end use of its industrial insulation products which contain asbestos, the answer is in the negative.

INTERROGATORY NO. 25

Defendant is aware that the hearing described was conducted, but it states that it cannot answer further, because it does not understand what Plaintiff means by the words "familiar with".

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INTERROGATORY NO. 26

Defendant objects to this Interrogatory on the grounds that it is too vague, broad, ambiguous, irrelevant and immaterial and on the further grounds that it assumes a fact that has not been proven (i.e., that there is any "problem of asbestos dust" with respect to thos merely using Defendant's products) and on the additional grounds that it is argumentative in nature.

INTERROGATORY NO. 27

Non-applicable inasmuch as Defendant has objected to Interrogatory 26. Moreover, Defendant objects to this Interrogatory on the grounds that testimony of Dr. Stewart would constitute hearsay and a proper predicate has not been laid for such a question.

INTERROGATORY NO. 28.

Defendant objects to this Interrogatory on the grounds that it is too vague, irrelevant and immaterial and on the further grounds that it is argumentative.

INTERROGATORY NO. 29

Defendant objects to this question insofar as it relates to "products containing asbestos" other than industrial insulation products on the grounds that as to such other products it is irrelevant, immaterial and too broad. As to industrial insulation products containing asbestos, Defendant states that all commercial insulating products look alike. Trained technicians could possibly identify by their appearance alone the different asbestos papers, cements and molded insulation made by different manufacturers. The Defendant doubts that a worker or layman could do so. The visual variations are those of color and the degree of color variations is usually very slight. Each manufacturer has his own carton or contained marking which is distinctive, but the product, once outside of the container, is not in Defendant's opinion distinguishable by the worker or layman as aforesaid.

The sole exception to the foregoing rule is that some THERMOBESTOS block produced by Defendant during the period 1940 - 1967 had

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the initials "JM" or some Johns-Manville trade-mark imprinted thereon.

INTERROGATORY NO. 30

No.

INTERROGATORY NO. 31

Johns-Manville Products Corporation was organized as "Delaware Johns-Manville Corporation" and incorporated in the State of Delaware, January 12, 1927. Its name was changed on January 18, 1927 to "Johns-Manville Corporation of Delaware"; and in May, 1932, its name was changed to "Johns-Manville Products Corporation."

INTERROGATORY NO. 32

Apprxoimately 42 years.

INTERROGATORY NO. 33

Defendant contends that respirators are currently on the market that will significantly and substantially reduce the inhalation of asbestos dust and fibers to a safe limit. Such respirators are available under the U. S. Bureau of Mines Schedule 21B. Tests upon which said approval are based were designed and conducted by that governmental agency and are described in the Respiratory Protective Devices Manual published by the American Industrial Hygiene Association, American Conference of Governmental Hygienists, 1963. Since such respirators are available to Plaintiff on the open market, Defendant declines to describe them.

INTERROGATORY NO. 34

It is true that for many years Defendant has manufactured insulating materials containing asbestos. However, such products were not placed by Defendant upon "the open market to be purchased by the public." They were intended to be sold to the industrial insulation trade, and were intended to be applied, etc., by industrial insulation applicators, i.e., person who had been specifically trained in, and specialized in, the use of such products; and not "the public." While Defendant cannot categorically state that none of its insulating materials containing asbestos have ever been purchased by the public (from third parties) and used by the public, Defendant believes that the amount of any such materials so purchased would be de minimus.

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INTERROGATORY NO. 35

Defendant understands the phrase "such asbestos insulating materials" to mean "insulating materials containing asbestos" in accordance with Interrogatory 34. Accordingly, Defendant states that it does not recognize that such asbestos insulating materials are dangerous and harmful to human beings and to the health of man when employed in their usual and customary end uses. Therefore, Defendant has not had anything to notify the public about in this regard. Defendant states that to its knowledge no tests as to such danger have been made by anyone because to date reliable medical and scientific opinion has been and is that there is no such risk to the public. Insulating materials which contain asbestos have been produced in this country for over seventy years and no such risk to the public from end uses has been reported by any responsible scientific or medical authorities. Defendant does presently recognize that inhalation of asbestos dust by an insulation applicator such as Plaintiff in the continuous course of his employment in excessive quantities over long periods of time under certain conditions may be harmful. Such inhalation would be the result of failure to take proper precautions, such as the wearing of appropriate respirators. See Defendant's answer to Interrogatory 2. supra. The medical-scientific world first perceived such danger to such a category of persons in 1963. Shortly thereafter Defendant concluded that such a danger might exist and accordingly Defendant began to label its industrial insulation products which contain asbestos in 1964. See Defendant's answer to Interrogatory 2., supra. Moreover, Defendant has participated in the educational program conducted by the National Insulation Manufacturers' Association to teach safe and healthful operating procedures to the employers of insulation applicators such as the Plaintiff claims to have been.

INTERROGATORY 36

Defendant has had knowledge of deaths or serious lung disease among its employees which have been attributed to the inhalation of dust or fibers in extensive concentrations over long

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periods of time, generally in excess of 20 years, under certain previously existing environmental conditions within Defendant's facilities. In the vast majority of these cases the deaths or serious lung disease were not solely attributable to the inhalation of asbestos dust or fibers, but were caused by a multiplicity of factors and in the majority of the cases known to the Defendant, the resultant lung disease was not asbestosis, but pneumoconiosis. The inhalation of dust or fibers by these employees incurred in the course of their employment in mining, milling and manufacturing processes where the fibers were still in a free state and had not yet been incorporated or embodied in a finished product. The inhalation did not result from the application of finished products in which the asbestos fibers had been incorporated or embodied. Defendant states that virtually all of these cases were covered by the applicable Workmen's Compensation laws and Defendant states that the cases filed with the various Workmen's Compensation Boards are a matter of public record, and therefore, are available to Plaintiff. Such files would normally contain the information requested in the second sentence of this Interrogatory. Since 1927, Defendant has engaged in business in the following states: California; Colorado; Florida; Georgia; Illinois; Indiana; Louisiana; Maryland; Massachusetts; Michigan; Minnesota; Mississippi; Missouri; Nebraska; Nevada; New Hampshire; New Jersey; New York; North Carolina; Ohio; Pennsylvania; Texas; and Washington.

INTERROGATORY NO. 37

Defendant objects to this Interrogatory on the grounds that it is improper, because it asks Defendant to describe what it did with respect to a state of affairs which may never have existed in fact.

INTERROGATORY NO. 38

(1) Defendant manufactures cements containing asbestos. They are loose materials which are mixed with water. They are applied in plastic form with a trowel and allowed to dry.

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(2) Defendant manufactures pipe insulations of which asbestos constitutes less than ten percent (10%). These insulations are preformed to fit the surface and are tied in place with wire or bonds. It is sometimes necessary to cut the pipe insulation to fit or fabricate it. This is done with either a hand saw or a table band saw. On the average job, less than ten percent (10% of the total pipe insulation used is cut.

(3) Defendant manufactures block insulation of which asbestos constitutes less than ten percent (10%). It is sometimes necessary to hand cut or machine such block insulation. Cut or machined pieces constitute less than ten percent (10%) of the total block insulation used on the average job.

(4) Defendant does not manufacture asbestos sheeting.

(5) Defendant does not manufacture asbestos insulation used to cover extremes of heat as well as cold.

(6) Defendant does not manufacture asbestos insulation in loose form which may be blown into homes or buildings.

(7) Defendant does not manufacture asbestos in spray form.

The above products can be used and applied without the worker inhaling unhealthful quantities of asbestos dust or fibers if the proper respirators are worn by the worker. Additionally, the use of dust collection systems when cutting or machining would prevent inhalation of dust and fibers in quantities that would be unhealthy.

INTERROGATORY NO. 39

No.

INTERROGATORY NO 40

Defendant has no such "medical information or information of its own knowledge.

INTERROGATORY NO. 41

Defendant objects to this Interrogatory on the grounds that it is irrelevant, immaterial and improper.

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INTERROGATORY NO. 42

Defendant objects to this Interrogatory on the grounds that it is irrelevant, immaterial and improper.

INTERROGATORY NO. 43

Defendant objects to this question on the grounds that it is irrelevant, immaterial and improper.

INTERROGATORY NO. 44

The President of Johns-Manville Products Corporation is Francis E. Dutcher. His business address is: 22 East 40th Street, New York, New York 10016. There is no Chairman of the Board of Directors of Johns-Manville Products Corporation.

INTERROGATORY NO. 45

To the extent that Defendant has been unable to answer any of the interrogatories propounded Defendant does not know of any person in Defendant's employ having knowledge of the matters inquired about in the interrogatories.

INTERROGATORY NO. 46

Defendant recognizes that Dr. Selikoff has done considerable research in the field of asbestosis, particularly among insulation workers, and that Dr. Selikoff is continuing to work in this field. However, Defendant states that insofar as the Interrogatory asks Defendant whether or not Dr. Selikoff"is an outstanding authority" the Interrogatory calls for an opinion or conclusion and is objected to on such grounds.

INTERROGATORIES NOS. 47 through 84

Subject to the reservation stated below, Defendant objects to each of these Interrogatories on the grounds that each of them is improper in that each of them calls for a conclusion of law. Defendant further objects to each of these Interrogatories on the grounds that each of them would require Defendant to engage lawyers to conduct legal research in order that such lawyers might render an opinion to Defendant and Defendant maintains that this constitutes an unreasonable burden on Defendant.

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Defendant further objects on the grounds that each of these Interrogatories is irrelevant and immaterial to the matters properly at issue in this litigation, except insofar as the Workmen's Compensation laws of certain of the states and/or territories involved may directly pertain to Plaintiff's right of recovery herein. Defendant maintains that such legal issues are for the Court to decide upon appropriate motions, etc., and are not the proper subject of Interrogatories of the sort propounded. Further, Defendant objects on the grounds that the best proof of such laws are the laws themselves.

Gordon R. Pate

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THE STATE OF TEXAS I

COUNTY OF JEFFERSON I

GORDON R. PATE, being duly sworn, upon oath states that he is the attorney of record for the Defendant, Johns-Manville Products Corporation, and authorized in the course of his employment to make and present the foregoing answers to Plaintiff's Interrogatories, which he does under said authority, and being cognizant of the matters therein set forth and based upon the information furnished him and the investigation conducted as to the subject matter of the Interrogatories, says that the said answers are true and correct.

Gordon R. Pate

GORDON R. PATE

SWORN TO and SUBSCRIBED before me, the undersigned authority, on this the 24th day of December, 1969.

Terri K. Boone

NOTARY PUBLIC IN AND FOR JEFFERSON COUNTY, TEXAS

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CERTIFICATE OF SERVICE

A true and correct copy of the foregoing answers to Interrogatories was on the 24 day of December, 1969, served upon counsel for each of the other parties herein by depositing the same in the United States mail, postage prepaid, addressed to Mr. Ward Stephenson, Stephenson Building, Orange, Texas; Mr. Dale Dowell, Beaumont Savings Building, Beaumont, Texas; Mr. George A. Weller, Goodhue Building Beaumont, Texas; Mr. George Duncan, Beaumont Savings Building, Beaumont, Texas; Mr. John Tucker, Beaumont Savings Building, Beaumont, Texas; Mr. Robert E. Barnes, Jr., Post Office Box 5098, Beaumont, Texas; Mr. Gerald P. Coley, First City National Bank Building, Houston, Texas; Mr. Ben Reynolds, 877 San Jacinto Building, Houston, Texas; Mr. Charles S. Pipkin, San Jacinto Building, Beaumont, Texas; Mr. W. N. Arnold, Jr., Bank of the Southwest Building, Houston, Texas; Mr. James W. Mehaffy, Sr., San Jacinto Building, Beaumont, Texas.

Gordon Pate

GORDON R. PATE

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EXHIBIT "A" to Answers of Johns-Manville Products Corporation to Interrogatory No. 1 of Interrogatories propounded to Defendants in Samuel R. Potter vs. Fibreboard Paper Products Corporation, et al (where there is a generally recognized generic term, that description appears in parenthesis).

1. *A.R.P. 40. (Aero Space Insulation) Asbestos-reinforced plastic.*
2. *ACOUSTICAL TOPLINER. (Automotive Insulation) Molded glass fiber.*
3. *ACOUSTI-SHELL. 3-dimensional fiber glass "lay-in" acoustical ceiling units.*
4. *AERTITE COATING. (Insulation Coating) An asphalt-asbestos coating for troweling over the outside of boiler walls.*
5. *AGGREGATE. (Insulation Refractory) Lightweight aluminum silicate aggregate.*
6. *AIR SET CEMENT. (Insulating Refractory) Used in back-up insulation for setting brick or shallow patching; sets hard within 24 hours.*
7. *ALBASEAL. Plastic, putty-like materials for sealing out (or in) air, dust, moisture, etc.*
8. *ANTI-SWEAT. (Pipe Insulation) A pipe covering.*
9. *ASBESTOBOARD. (Weather Proofing) An asbestos-cement board.*
10. *ASBESTOCEL. (Asbestos Pipe & Block Insulation) An inexpensive insulation available in pipe covering, sheets and blocks for temperatures up to 300° F.*
11. *ASBESTOCITE. (Weather Proofing) Asbestos-cement sheets.*
12. *ASBESTOS CEMENTS. (Insulating Cement) General purpose cements used as a finish over insulation.*
13. *ASBESTOS CLOTH. (Insulation Jacketing) Cloth woven from asbestos yarn.*

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14. ASBESTOS EBONY. (Electrical Panel Insulation) Asbestos-cement board impregnated with asphaltic compound.

15. ASBESTOS FIRETARD. (Weather Proofing) A sheet of asphalt-saturated asbestos felt cemented to a sheet of unsaturated asbestos felt.

16. ASBESTOS FLEXBOARD. (Weather Proofing) Tough, fireproof asbestos-cement sheet.

17. ASBESTOS MILLBOARD. (Asbestos Sheathing) Made from asbestos fiber and various binders.

18. ASBESTOS PAPER. (Asbestos Paper) Paper formed from asbestos fibers and a suitable binder.

19. ASBESTOS ROLLBOARD. (Asbestos Paper) Asbestos paper 3/32" or 1/8" thick.

20. ASBESTOS ROLL FIRE-FELT. (Asbestos Paper) Made from felted and molded asbestos fiber.

21. ASBESTOS TEXTILES. Asbestos fiber twisted, woven or felted into cloth, yarn, tape, tubing, etc; usually a small percentage of organic fiber such as cotton or rayon is woven in with the asbestos.

22. ASBESTOS TRANSITOP. (Insulation Panel) A structural sandwich panel made with an insulating core faced on both sides with fireproof Asbestos FLEXBOARD.

23. ASBESTOS WATERPROOFING FELT. (Weather Proofing) An asphalt-saturated asbestos felt weighing 32 lbs.

24. ASBESTOS YARNS. Made from Asbestos Roving which has been mechanically twisted to give it tensile strength; furnished in several grades ranging from 75% asbestos to 100% asbestos.

25. BX-SPINTEX. (Bulkhead Insulation) Made from molten inorganic materials spun off into long fibers.

26. BAND PIPE INSULATION. (Accessory) Strip of metal which holds insulation in place on the pipe.

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27. BANROC. (Hi-Temp Insulation) A mineral wool insulation furnished in the form of metal-reinforced blankets.

28. BLAKITE. (Insulating Refractory) A ready-mixed air-setting cement.

29. BLAZECRETE. (Insulating Refractory) A hydraulic-setting refractory for slap troweling or gun applications.

30. BODY SEALER. Plastic, putty-like materials for sealing out (or in) air, dust, moisture, etc.

31. BONDING MORTAR. (Insulating Refractory) A material used for filling the joints between brick used as back-up insulation; several kinds are sold for use with different types of brick and varying service conditions.

32. C-2 REFRACTORY CEMENT. (Insulating Refractory) An extremely hard cement.

33. C-31M CEMENT. (Insulating Refractory) A chrome base cement.

34. CA INSULATING FIRECRETE. (Insulating Refractory) A hydraulic-setting castable refractory for temperatures up to 3000°F.

35. CALCIUM SILICATE INSULATIONS. (Insulation Panel) A composition of asbestos fiber, diatomaceous silica and lime formed into calcium silicate sheets.

36. CANVAS. (Insulation Jacketing) Fabric wrapped around pipe insulation.

37. CEILINITE. (Asbestos Sheathing) Made from Asbestos Roll FIRE-FELT reinforced on one side with asbestos cloth.

38. CERAFELT. (Refractory Fiber) A lightweight felted refractory fiber insulation.

39. CERAFIBER. (Refractory Fiber) A loose refractory fiber insulation for service to 2000°F.

40. CERA FORM. (Refractory Fiber) Molded board and shapes of refractory fiber with multi-component, organic and inorganic binders.

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41. CERA-KOTE. (Refractory Cement) A high-temperature adhesive and coating cement.

42. CERA-PAK. (Net Refractory Fiber 1963) Refractory-fiber.

43. CERA-PREG. (Refractory Impregnant 1964) Inorganic impregnant that is brushed on CERAFELT or CERA FORM to provide a hard, abrasion-resistant coating.

44. COLORED MARINE VENEER. (Insulating Panels) 3/16" thick sheets of integrally-colored Marine Veneer laminated to MARINITE panels.

45. COMMERCIAL GRADE ASBESTOS CLOTH. (Asbestos Sheathing) Cloth containing from 75% up to but not including 80% asbestos fiber.

46. DOUBLE-COATED FLEXSTONE. (Weather Proof Jacket) An asphalt-saturated asbestos felt coated with a mineral-filled asphalt.

47. DOUBLEX PAPER. (Asbestos Paper) A completely inorganic paper made from asbestos and a lime silicate binder.

48. DURAMESH. (Weather Proofing) A porous glass fiber fabric.

49. DYNA-FLEX. (Refractory Fiber 1963) Flexible refractory fiber felt material.

50. FESCO BOARD ROOF INSULATION. (Tank Top Insulation) Used for insulating under a built-up roof; furnished in 24" x 36" sheets, from 1/2" to 2" thick, and in cant strips and edge strips.

51. FIBERCHROME. (Refractory Fiber 1964) Flexible refractory fiber felt material.

52. FIBROFIL. (Insulation Fill) A mixture of diatomaceous silica and asbestos fibers.

53. FIBROUS ADHESIVE. (Insulation Adhesive) Materials such as Cold Water Paste, Lath, Staples, Jute, Fibrous Adhesive, Silicate of Soda and S-A Adhesive.

54. FIBROUS ROOF COATING. (Weather Proofing) A heavy-bodied coating made of asphalt and asbestos fiber.

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55. FIL-INSUL. (Insulation Fill) A resilient fill composed of mineral fibers.

56. FINISHING CEMENTS. (Cements) Asbestos and hydraulic-setting cements generally used over pipe insulation to provide a smooth, hard finish.

57. FIRE FELT. (Asbestos Sheathing) Insulating material made from felted and molded asbestos fiber.

58. FIREBLOK. (Insulating Refractory) A brick made principally from refractory clay.

59. FIREBRICK. (Insulating Refractory) A brick made principally from refractory clay.

60. FIRECRETE. (Insulating Refractory) A hydraulic-setting castable refractory for temperatures up to 3000°F.

61. FIREITE ASBESTOS FURNACE CEMENT. (Asbestos Cement) An Asbestos compound used for sealing joints of domestic heating equipment.

62. FIRETARD. (Weather Proofing) A specially fire-resistant gypsum wallboard.

63. FIRETARD. (Weather Proofing) A pipe covering weatherproof jacket.

64. FLAME-BAR. (Insulation Jacket 1961) A vapor-barrier jacket for MICRO-LOK, and THERMOBESTOS pipe insulations with excellent fire-resistant properties.

65. FLAME-SAFE GC PIPE INSULATION. (Giver Glass Pipe Insulation and Jacket 1965) Lightweight, fiber glass.

66. FOIL-FELT. (Weather Proofing) Made of .002" aluminum foil bonded to asphalt saturated asbestos felt.

67. GUMMED ASBESTOS TAPE. (Asbestos Tape) A 12-lb. asbestos paper tape.

68. H. T. BLOCK. (High Temperature H. T. Block Insulation) Gaskets for sealing handhold, tube cap and manhole covers of boilers, economizers and superheaters; made in KEARSARGE, SPIROTALLIC and single-jacket construction.

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69. HEAT TREATING CEMENT. (Insulating Refractory) A ready-mixed refractory cement.

70. HELLITE. (Insulating Refractory) A refractory mortar for laying fire brick or for wash-coating brick.

71. HULL BOARD. (Marine Insulation) A glass fiber marine insulation; furnished plain or faced with treated glass fiber cloth.

72. INSULATING BRICK. (Insulating Refractory) A brick of high insulating value generally used as back-up insulation behind insulating value generally used as back-up insulation behind linings of fire brick; J-M insulating brick is made from diatomaceous silica (CELITE).

73. INSULATING CEMENT. (Insulating Cement) Cement.

74. INSULATING FILL. (Insulation Fill) a resilient fill composed of mineral fibers.

75. INSULATING FIREBLOK. (Insulating Refractory) made of diatomaceous silica (CELITE).

76. INSULATING FIREBRICK. A brick made principally from refractory clay.

77. INSULATION ACCESSORIES. Materials such as Cold Water Paste, Lath, Staples, Jute, Fibrous Adhexive, Silicate of Soda and S-A Adhesive.

78. INSULKOTE. (Weather Proofing) Compounded of bitumens, asbestos fiber and mineral fillers.

79. L. W. AGGREGATE. (Insulating Refractory) Lightweight aluminum silicate aggregate.

80. LAPTITE. (Cement) An asphaltic cement.

81. LATH. (Accessories) Materials such as Cold Water Paste, Lath, Staples, Jute, Fibrous Adhesive, Silicate of Soda and S-A Adhesive.

82. LOOSE WOOL. (Insulation Fill) A mineral wool insulation furnished in the form of metal-reinforced blankets.

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83. MAGNESIA, 85%. (H.T. Pipe & Block Insulation & Cement) Composed of 15% asbestos fiber and approximately 85% basic carbonate of magnesia.

84. MARINE ACOUSTICAL UNIT. (Marine Insulation) A two-foot square section of perforated Marine Veneer with an attached element of sound-absorbing mineral wool.

85. MARINE VENEER. (Marine Insulation) Strong, flexible, fire-resistant sheets made of asbestos and cement.

86. MARINITE. (Insulation Panel) A composition of asbestos fiber, diatomaceous silica and lime formed into calcium silicate-sheets.

87. METAL-K. (Metal Insulation) An all-metallic pipe and blanket insulation consisting of inner reflective foils and a stainless steel outside cover sheet.

88. METAL-LOK PIPE INSULATION. (Fiber Glass Pipe Insulation 1964) MICRO-LOK fiber glass pipe insulation with factory-applied aluminum jacket.

89. METAL-ON INSULATION. (H. T. Pipe Insulation System) THERMO-BESTOS Pipe Insulation with a factory-applied jacket of aluminum.

90. MICROBESTOS PAPER. (Asbestos Paper) An asbestos reinforcing material which after saturation is used in the manufacture of reinforced plastic products.

91. MILLBOARD. (Asbestos Sheathing) Made from asbestos fiber and various binders.

92. MINE CEMENT. (Asbestos Cement) Cement made from short asbestos fibers.

93. MIN-K. (Molded Insulation) A molded fibrous insulating material.

94. MIN-KLAD. (Molded insulation) A molded combination of MIN-K and asbestos-reinforced plastic faces.

95. MIN-KLAD INTERLOK. (Molded Insulation) MIN-K and asbestos-reinforced plastic.

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96. MOLTEN METAL MARINITE. (Insulation Panel) Made of amosite Asbestos fiber, diatomaceous silica and an inorganic binder.

97. PAL-LITE. (Foundry Board) Made from asbestos fiber and inorganic binder.

98. PERFORATED MARINE VENEER. (Marine Insulation) Marine Veneer perforated for use as acoustical treatment in ship construction.

99. PIPE COVERING. Combination Pipe Insulation; FIRE-FELT: FLAME-SAFE: Magnesia 85%; METAL-ON: MICRO-LOK: METAL-LOK: Sectional Pipe Covering; Segmental Pipe Covering; SUPEREX: THERMOBESTOS: THERMO-TAPE: THERMO-WRAP: Wool Felt.

100. POLYSTYRENE INSULATION. (Foam Insulation) Expanded Polystyrene Insulation for residential and commercial building. Rigid foam board used for perimeter insulation, cavity wall insulation, with wallboard on exterior masonry walls, cold storage insulation and flotation; low in thermal conductivity and extremely light in weight.

101. RANGE BOILER JACKET. (Asbestos Sheathing) An inexpensive insulation available in pipe covering, sheets and blocks for temperatures up to 300°F.

102. REEFERITE. (Marine Insulation) Formed by sandwiching a sheet of aluminum between sheets of Marine Veneer; provides rat-proofing.

103. REFRACTORY FIBER. See CERAFELT, CERAFIBER, CERAFORM, DYNA-FLEX, FIBERCHROME, MICRO-QUARTZ, THERMOFLEX.

104. REFRACTORY PRODUCTS. See AERTITE: BLAKITE: BLAZECRETE: FIRE-CRETE: FIREITE: HEAT TREATING CEMENT: HELLITE: L. W. AGGREGATE: MORTAR: PAL-LITE: SIL-O-CEL: SUPER BLAKITE: TRANSITE Core Plate; transite Slip Jacket Stock.

105. RIS-A-SLEEV. (Insulating Riser) Made of refractory fibers.

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106. ROLL FIRE-FELT. (Asbestos Sheathing) See FIRE-FELT.

107. ROLLBOARD. (Asbestos Sheating) Asbestos paper 3/32" or 1/8" thick.

108. S-A ADHESIVE. (Insulation Adhexive) Materials such as Cold Water Paste, Lath, Staples, Jute, Fibrous Adhesive, Silicate of Soda and S-A Adhexive.

109. SEALING COMPOUNDS. (Plastic, putty-like materials for sealing out (or in) air, dust, moisture, etc.

110. SECTIONAL PIPE INSULATION. The standard form of pipe insulation; usually furnished in 3' lengths, molded in two half-sections or cut longitudinally.

111. SEGMENTAL PIPE INSULATION. A form in which 85% Magnesia, SUPEREX and THERMOBESTOS pipe insulation are furnished when large pipe sizes are involved.

112. SERVICE SHEET. Made from asbestos fiber and heat-resisting rubber compounds.

113. SILICATE OF SODA. (Insulation Adhesive) See Insulation Accessories.

114. SIL-O-CEL. (Insulating Refractory) Made from diatomaceous silica (CELITE).

115. SIL-O-CEL INSULATING BRICK. (Insulating Refractory) Made from diatomaceous silica.

116. SPEED-INSUL. (Insulation Panel) An insulation panel consisting of embossed, ribbed aluminum sheet factory applied to SPINTEX Mineral Wool Blanket.

117. SPIN-GLAS. (Glass Fibers) Fine-fibered, fiber glass blanket-type insulation, bonded with thermosetting resin.

118. SPINTEX. (Mineral Fibers) Made from molten inorganic materials spun off into long fibers.

119. SPONGE-FELT. (Asbestos Pipe & Block Insulation) See ASBESTOS-SPONGE Felted.

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120. STAPLE. (Accessories) Materials such as Cold Water Paste, Lathe, Staples, Jute, Fibrous Adhesive, Silicate of Soda and S-A Adhesive.

121. SUPER BLAKITE. (Insulation Refractory) Similar to BLAKITE but particularly designed for application directly to boiler wall tubes.

122. SUPER BRICK. (Insulation Refractory) Made from diatomaceous silica (CELITE).

123. SUPEREX. (H. T. Pipe & Block Insulation - H. T. Cement) Made from asbestos fiber, diatomaceous silica and other insulating materials.

124. SUPER FIRE FELT. (Asbestos Sheets & Blocks) Made of felted asbestos fibers and a binder.

125. THERMOBESTOS. (H. T. Pipe & Block Insulation) Made from lime, diatomaceous silica and asbestos fiber.

126. THERMOFLEX. (Refractory Fiber) A lightweight refractory fiber insulation which withstands temperatures up to 2000°F; used in blanket or felted form as an insulating or acoustical material, in loose form as a filter medium, insulating packing or fill, and in wrapping-around or molded form (encased in foil or mesh) as high-temperature duct insulation and jet engine shrouds; its most common use is in aviation insulation applications.

127. THERMOMAT. (Aviation Insulation) A nonwoven long fiber asbestos felt saturated with phenolic resin.

128. THERMOMAT TAPE. (Aviation Insulation) As asbestos-phenolic molding compound designed for tape winding; used to create components and parts that withstand tremendous heat and pressure. See THERMOMAT.

129. THERMO-TAPE. (Pipe Insulation) Made of an asbestos pad in a neoprene coated asbestos cloth jacket.

130. THERMO-WRAP. (Pipe Insulation) Made up of a blanket of asbestos fibers held together by asbestos yarns and enclosed in a neoprene-coated asbestos jacket.

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131. TRANSITE CORE PLATE. (Asbestos Cement Sheets) Smoothly sanded tray of asbestos and cement for holding cores during baking or drying.

132. TRANSITE SLIP JACKET STOCK. (Asbestos Cement Sheets) Asbestos-cement material.

133. VINYLCEL. (Foam Insulation 1965) Rigid polyvinyl chloride foam thermal and structural insulation.

134. WEATHERPROOFING JACKETS. Felts used for weather-proofing and fire protecting pipe insulation.

135. WET REFRACTORY CEMENTS. (Insulating Refractory) See BLAKITE: FIREITE: Heat Treating Cement; HELLITE: Super Blakite.

136. WHITE SURFACE ASBESTOS JACKET. (Weatherproofing) Made from asbestos weatherproof felt.

137. WOOL FELT. (Pipe Insulation) A pipe insulation available in single or double layer for temperatures from 40F to 212F.

138. ZELIE. (Insulating Refractory) A lightweight aggregate used in making insulating refractory concrete. Also used as insulating refractory fill.

139. ZERO. (Cold Pipe Insulation) A pipe insulation consisting of a layer of Hair Felt and a layer of Woolfelt for temperatures 32F to 100F.

140. ZEROFIL. (Insulation Fill) Made of asphalt-impregnated loose mineral wool.

141. ZERO-FOAM. (Foam Insulation) A rigid polyurethane block insulation for temperatures of minus 200 to plus 300F

142. ZERO-LITE. (Foam Insulation) Expanded Polystyrene Insulation for residential and commercial buildings. Rigid foam board used for perimeter insulation, cavity wall insulation, with wallboard on exterior masonry walls, cold storage insulation and flotation; low in thermal conductivity and extremely light in weight.

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The following insulation products were previously manufactured by Defendant, Johns-Manville Products Corporation, but are no longer manufactured by this Defendant, having been discontinued at various dates after 1959;

143. *ASBESTO-SPONGE FELTED. (Asbestos Pipe & Block Insulation) Made from many layers of asbestos paper in which bits of asbestos fiber are imbedded.*

144. *BX-MARINE BLOCK. (Marine Insulation) A rigid mineral wool thermal and acoustical insulation sold for use aboard ships.*

145. *BRINE and AMMONIA SEALING TAPE. (Accessories) A waterproof fabric tape.*

146. *FIBROCEL. (H. T. Pipe Insulation) A molded silica pipe insulation.*

147. *HAIR FELT. (Felt) Made from cattle hair.*

148. *J-FOAM. (Foam Insulation) An expanded polystyrene block insulation.*

149. *PERLOX. (Insulation Fill) An expanded perlite insulating fill.*

150. *ROCK CORK. (Cold Insulation) Made from mineral wool bonded with a waterproof binder.*

151. *SIGMA-K. (Insulating Board) A board product which is both a high-temperature neutron shield and a thermal insulation.*

152. *ZEROGLOSS. (Accessory) An accessory for ROCK CORK pipe insulation; it is an asphaltic paint.*

153. *ZEROSEAL. (Accessory) An accessory for ROCK CORK pipe insulation; it is a fibrated asphalt.*

154. *ZEROTAPE. (Tape) A waterproof fabric tape.*

155. *ZEROTEX. (Blanket) A felted mineral wool blanket.*

156. *AIRCELL INSULATION. (Paper Pipe Insulation) Fabricated in a cellular structure from asbestos paper.*

157. *ASBESTO-SPONGE. (Asbestos Pipe Insulation & Block) Felted insulation.*

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Exhibit 15-4

RECOMMENDED

ASBESTOS DUST CONCENTRATION

Approved By The

ASBESTOS TEXTILE INSTITUTE

OCTOBER 4, 1963

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FOREWORD

The Asbestos Textile Institute is a non-profit organization of manufacturers of asbestos textile products and other products of asbestos fibers. One of its primary aims is the development, through a continuous program of research and practical testing, of improved quality standards in the various products made by its members. The Institute also serves as a clearing house for the dissemination of useful information relating to asbestos textiles and their many applications.

Of common interest to all members of the Institute is the promotion of safe working conditions for plant employees, and this "Method for Determining Asbestos Dust Concentration" has been prepared by our Air Hygiene & Manufacturing Committee, one of several working committees of the Asbestos Textile Institute.

The method as described here, represents the technique approved for use in member's own plants, and is believed to be in accordance with the highest standards for determination of dust concentrations.

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Method For

DETERMINING ASBESTOS DUST CONCENTRATION



Approved By The

ASBESTOS TEXTILE INSTITUTE

(FOUNDED 1944)

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1. SCOPE:

This method covers a procedure for determining the total asbestos dust concentration in air, also a method to differentiate particle and fiber size.

2. DESCRIPTION OF TERMS AND ABBREVIATIONS:

(a) Asbestos Dust:

In asbestos textile manufacturing no differentiation is made between asbestos dust and other dust. Dust includes both fibers and particles.

(b) Fibers: (3)

A fiber is a particle having a length not less than four (4) times its diameter and the diameter must be less than five (5) microns. Asbestos fibers may have fracture ends. In this procedure fibers must be at least ten (10) microns long.

(c) Particles:

A particle is any material that cannot be classified as a fiber in accordance with (2b) above.

(d) M. P. P. C. F.:

Millions of particles per cubic foot of air.

(e) M. F. P. C. F.:

Millions of fibers per cubic foot of air.

3. OUTLINE OF METHOD:

Air borne asbestos dust is collected in the standard Greenburg-Smith Impinger by drawing a specific amount of dust laden air, at a constant rate, through the impinger which has been inserted in a flask containing a liquid collecting medium. The sample is diluted if necessary to bring the count to a maximum of 150 particles in the ¼ sq. mm. counting area; the total count is composed of two components, fibers over 10 microns in length and particles below 10 microns. A record is kept of all pertinent data during sampling and counting.

4. APPARATUS:

(a) Standard Greenburg-Smith Impinger:

The Greenburg-Smith Impinger has a 500 cc cylinder capacity, it may be an all glass construction or glass construction with rubber stoppers. A suitable Erhlenmeyer flask can be used instead of the cylinder.

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(b) Vacuum Pump:

The vacuum pump shall be electrically driven, capable of maintaining a constant sampling rate of one (1) cubic foot ± 3% per minute. A suitable gauge should be on this pump to indicate variation in pressure or flow rate.

(c) Rubber Tubing:

Heavy wall rubber tubing should be used to connect the pump to the impinger. Thin wall tubing will collapse and kink.

(d) Rubber Stoppers:

Rubber stoppers suitable for closing the ends of the impinger tubes are used.

(e) Wash Bottle:

A wash bottle containing the same fluid as used in the impinger flask is used to rinse down the impinger after sampling in preparation for counting.

(f) Pipettes:

Pipettes are used to transfer the sample from the impinger flask to the cell. A clean pipette is used for each flask.

(g) Counting Cells:

A cell 1 mm deep is used for counting. A Sedgwich-Rafter or Dunn type being suitable. Cells should be free from defects which may show up as dust under the microscope. The depth of all new cells shall be measured before being used.

(h) Microscope and Accessories:

A microscope shall be used with a 10X objective and a 10X eyepiece. A Whipple disc or ocular grid is placed on the eyepiece of the microscope, a Porton graticule may also be used. The microscope tube shall be adjusted, if possible, so that the counting area corresponds to ¼ sq. mm. in the counting area, or, in the case of a fixed tube length, the ruled area shall be equivalent to ¼ sq. mm. ± 3%. The counting area shall be accurately recorded by means of a stage micrometer. The microscope is used with an artificial light using a day light filter, a diaphragm and condenser are used to adjust the light. The microscope is equipped with a mechanical stage. If available, a binocular type microscope is recommended.

(i) Stop Watch – Counter:

An accurate stop watch is used for timing the sampling and settling of the sample. A mechanical hand counter may be used for counting the dust.

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5. COLLECTING LIQUID:

(a) Distilled Water

(Particles free as possible.) Distilled water can be filtered through a filter membrane with a pore size ½ micron or smaller.

(b) Isopropyl Alcohol – Ethyl Alcohol:

(Particles free as possible.) A medium consisting of 100% isopropyl alcohol or ethyl alcohol is used in the collecting flask. Alcohol can be filtered through a filter membrane with a pore size ½ micron or smaller.

6. PREPARATION AND CLEANING OF APPARATUS:

(a) All equipment used in dust counting should be isolated and used only for this purpose.

(b) All glassware should be thoroughly cleaned with a hot cleaning solution, rinsed several times in distilled water and finally rinsed with the fluid used as a sampling liquid. Rubber stoppers should be cleaned by scrubbing with a brush in a warm soap solution. These should be rinsed thoroughly and finally rinsed in the sampling liquid. The collecting liquid is placed in the flask and the impinger stoppered and capped with plastic bags over the top held in place by a rubber band. The clean filled impinger assembly is stored until ready for use.

(c) The counting cells are washed in soapy water with a very soft camel's hair brush or soft sponge, and rinsed thoroughly with distilled water. Dry cell parts between lint free filter paper and then with lens paper, The effectiveness of cleaning each cell shall be checked by microscopic examination before being filled.

(d) The microscope should be cleaned with a camel's hair brush; the lens should be wiped with lense paper. The Whipple disc should be free from dust.

(e) The dust counting procedure should be done in the cleanest part of the laboratory; and, if possible, in a separate room.

7. CONTROL OF COLLECTING LIQUID CLEANLINESS:

(a) Distilled Water:

This should be as dust free as possible. If bateria, fungus or other foreign materials are visually present, the water should be discarded. The water shall show not more than six (6) countable particles in a ¼ sq. mm. counting area.

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(b) Isopropyl Alcohol -- Ethyl Alcohol:

This should be particle free the same as in 7a.

(c) All Collecting Liquids shall be stored in a container with a permanent siphon hose. The flow is controlled by a clamp.

8. CALIBRATION:

The impinger should be calibrated against a primary or accurate secondary standard. Usually the flowmeter or other instrument is connected by a short length of hose to the impinger, a mercury manometer is placed between the impingers and suction device. The pump is started and regulated to obtain 1 cubic foot per minute intake of air. The manometer is read to determine the pressure. A record is kept of this pressure which is maintained during sampling. Each impinger must be calibrated. During calibration the impinger flask should contain 100 ml of the collecting medium. Unless the orfice of the impinger is damaged, the calibration should not change.

9. PROCEDURE FOR BLANK:

With each set of samples a blank shall be made on the same collecting liquid as used in the actual test. This blank should contain a maximum of six (6) particles, the contamination of the blank shall be less than 1/10 of the sample count. The blank is recorded and used in the calculation. It is good practice to carry the blank into the area where the testing is to be done.

10. PROCEDURE FOR SAMPLING:

(a) The impinger assembly is prepared in the laboratory, in the field it is removed from its case and placed in a tripod or other suitable holder. It is then connected to the vacuum line and the air input regulated to 1 cubic foot per minute, the timer is started when the pump is started.

(b) The average sampling time is 20 minutes. If a very low count is anticipated, the time can be increased. A minimum sampling time of five (5) minutes shall be used.

(c) All significant data shall be recorded during testing, such as temperature, relative humidity, machine, material in process, etc. The operator should be on the alert to observe any defective machinery or abnormal situation that would contribute to dustiness.

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(d) After sampling the suction hose is disconnected and the openings on the impingers are stoppered, care being taken to prevent contamination. The impinger is then replaced in the transportation box and another sample started.

(e) For determining the dust concentration of a general workroom, several samples can be taken in locations that would be representative. These should be taken in the breathing zone, stationary or with motion.

(f) An individual can be followed with an extension hose on the impinger, care being taken not to kink the hose. Care should be taken to get a representative sample of the air being breathed by the employee.

11. METHOD OF COUNTING:

(a) The count must be made within 24 hours after collecting the sample.

(b) The impinger flask is taken into the dust counting area of the laboratory and unstoppered. The impinger is removed approximately one half way from the base of the flask and washed down with the sampling solution in the wash bottle, care is taken to wash all particles from the impinger before removing it. If necessary, dilution is made at this time and the flask is stoppered and shaken vigorously in order to secure a representative portion of the sample.

(c) A clean cell is marked in a corner with a red crayon as a focus point. The flask is again vigorously shaken and a clean pipette is used to remove a portion of the sample. The cell is filled and the cover glass is slid into position, care is taken to prevent the introduction of air bubbles into the cell.

(d) The cell is allowed to stand for 30 minutes to allow the dust to settle to the bottom.

(e) The cell is carefully placed on the microscope and focused to the red mark. The cell is scanned to determine the overall appearance and distribution. Five (5) fields (.25 sq. mm.) are counted, one in the center and four (4) diagonally from the center toward the corners, stay at least 3/16 of an inch away from the corners. With the Dunn cell which has no corners a modified method of counting is necessary, the center and four (4) other points away from the center. During counting the fine adjustment of the microscope can be manipulated in order to be certain that all dust is counted.

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(f) A break down of the dust is made into fibers between ten (10) and fifty (50) microns and particles below ten (10) microns. (See attached sheet for recommended reporting method.)

CALCULATION OF RESULTS:

The concentration of dust shall be expressed in millions of particles per cubic foot of air (m.p.p.c.f.), reported to two (2) significant figures only.

Concentration is determined as follows:

$$\text{Conc. (m.p.p.c.f.)} = \frac{(N_s - N_c) \times C.F. \times V_w}{V_a \times 10^6}$$

Where:

N_s = Mean Count per Field for the Sample (5 Fields)

N_c = Mean Count per Field for the Blank (5 Fields)

C.F. = Cell Factor = 1000/ (Area of Counting Field in sq. mm x Depth of Cell in mm.)

V_w = Total Alcohol Volume (Equivalent Total, When Portion Diluted, i.e., Initial Sample Volume x Dilution Factor)

V_a = Air Volume Sampled in Cu. Ft.

MIDGET IMPINGERS:

The Midget impinger is a small scale duplicate of the standard Greenburg-Smith impinger. It is very light in weight and easy to move into awkward locations. The suction is usually produced by a hand cranked pump. The Midget impinger operates at an impinging velocity of 70 meters/sec. compared to more than 100 meters/sec. for the larger instrument. This would indicate that the Midget impinger is less efficient for small particles. These small particles are normally below the resolving power of the microscope; therefore, the large and Midget impingers give similar results. The sampling rate is .1 cfm with a resistance across the nozzle of 12" of water. A liquid volume of 10 ml is required in the flask. All precaution necessary for the large impinger should be followed with the Midget impinger; the rate of the air flow should be checked with an appropriate flowmeter. The counting technique is the same with the Midget impinger; the calculation is also the same.

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14. MICROPROJECTION:

If eye strain or discomfort is associated with microscopic dust counting, a portable microprojector can be used for counting. The slide is prepared the same as in the normal procedure. The standard technique in dust counting work with a microscope and Whipple disc at 100X cells for counting five (5) fields, each .25 sq. millimeters, in a dust counting cell 1 mm deep, then averaging out and multiplying by four (4) to determine the number of dust particles in a representative 1 cubic millimeter of collecting fluid. With the microprojector, the entire area is counted on the screen for five (5) different fields and the total count is obtained, not the average. The total count is multiplied by four (4) to obtain the number of dust particles in a representative 1 cubic millimeter of the collecting fluid. A magnification of 1000X is used with the microprojector. A standard monocular microscope can be used with a 16 mm apochromatic objective and a 30X compensating eye piece. An Abbe condenser with an iris diaphragm is used to regulate the light which is critical with this equipment. The field image is 250 mm x 200 mm or 50 square centimeters. The area observed on the projector is .05 square millimeters as against .25 square millimeters in direct microscopic counting. The volume observed with the projector is .00005 ml as against .00025 ml with direct microscopic counting. The optical set up for this type projection is furnished by the manufacturer.

15. PARTICLE AND FIBER SIZING:

With the microprojector the screen is marked for particle size measurements. At 1000 magnification, a 1 micron particle is seen as a 1 mm image. The screen is graduated for 2, 5, 10, and 50 mm measurements. Thus, fibers and particles can readily be measured. The maximum length of the fiber is measured. For routine dust work the Whipple disc can be used to estimate the size. By knowing the graduations on the grid the particle size can be estimated. The filar micrometer is normally used to measure particles; however, in routine dust counting this method is impractical because of the amount of time necessary to measure each particle. It is recommended that the microprojector be used or else the size be estimated from the Whipple disc or a Porton graticule.

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INDUSTRIAL HYGIENE WORK SHEET

1. DATE & TIME SAMPLED: .....
   DATE TESTED: .....
   WEATHER: .....
   DEPT.: .....
   TEMP. & R.H.: .....

   SAMPLE STATION: .....
   IMPINGER NUMBER: .....
   RATE .....CF/M
   TIME: .....
   VOL. SAMPLED: ..... CF

2. SPECIFIC PRODUCT & MATERIALS

3. OPERATION

4. VENTILATING CONTROL

5. DRAFTS

SAMPLE ANALYSIS (TOTAL)

TOTAL SAMPLE COUNT PER ¼ MM: .....

AVERAGE COUNT: .....

BLANK COUNT PER ¼ MM: .....

NET COUNT: .....

MPPCF: .....

SAMPLE ANALYSIS (FIBERS)

COUNT PER ¼ MM: .....

AVERAGE COUNT: .....

BLANK COUNT PER ¼ MM: .....

NET COUNT: .....

MFPCF: .....

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PERMANENT RECORD

STATION LOCATION: .....

STATION NUMBER: .....

RAW MATERIALS: .....

PRODUCT: .....

VENTILATING CONTROL: .....

PLACE PHOTOGRAPH OF STATION LOCATION HERE

*SURVEY RESULTS:

SAMPLE	ANALYSIS MPPCF OR OTHER	MEDIAN OR AVERAGE	ANALYSIS MFPCF OR OTHER	MEDIAN OR AVERAGE	ANALYSIS BY

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Exhibit 15-B

INDUSTRIAL HYGIENE SAMPLING AND ANALYSIS PROCEDURES

JOHNS-MANVILLE

Standard Impinger Sampling and Counting Technique

A. Application. For the determination of the atmospheric concentration of an insoluble inorganic dust such as that associated with the production of lung fibrosis, the particle size of which is generally below 10 microns and, from the hygienic standpoint, is not of interest below 0.5 micron. This method is not recommended for the determination of organic dust, metallic fumes, vapors and gases.

B. Equipment Assembly. Basically, the impinger sampling equipment consists of an impinger assembly unit and a suction pump unit. The impinger assembly of pyrex glass is dimensioned per Drawing 7237-4 (Modified Standard Greenburg-Smith Impinger). The suction pump unit is equivalent to the Willson #3A motor driven pump unit with calibrated vacuum gauge and V belt drive.

The impinger assembly in a 500 ml. Erlenmeyer pyrex flask is mounted in a holder on a tripod or other suitable stand so as to be in the breathing zone of employees at the operation being studied. A 1/2" ID non-collapsible rubber tubing of suitable length is connected to the exhaust elbow and to the inlet side of the pump. The pump motor operates on 110V A.C current or 220V A.C. with the series resistance. Adjustment of the bleeder valve of the pump should be made to maintain vacuum at the appropriate gauge setting.

1. Calibration. The apparatus is set up in the same manner as for sampling. The inlet of the impinger is attached to the outlet tube of a standard wet test meter. The pump valve is adjusted to a definite gauge reading (the single line on the Willson pump units), and the time for intake of 1 cubic foot of air is measured by stop watch. Five readings in hundredths

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of a minute for a 1 cubic foot air intake should be taken and averaged. The average time is then divided into 1.00 to give the rate of cubic feet of air per minute for that impinger tube. The impinger should be permanently identified (letter, number, etc.) and the rate recorded.

A copy of the impinger ratings in the field will prove of value. For example:

Impinger Tube	Vacuum Gauge Reading	Cubic Foot of Air Per Minute
J	Line (2)	1.06
Z	Line (2)	1.11
L	Line (2)	1.03

Should the cubic feet of air per minute of an impinger be more or less than .15 from 1 cubic foot, a new gauge setting for that impinger should be established, identified and recorded to bring the flow within those limits.

The meter used for calibrating should be checked frequently to insure accuracy.

C. Sampling

1. Location

Sample stations should be established in the working area at all operations where health hazards are believed to exist. They should be permanently identified by photographs and station numbers, and this designation used as the sample number for all samples taken at this location. In addition to samples collected in the breathing zone of the exposed workers, samples should be taken to determine the dust concentration in the general workroom atmosphere and in special studies to determine the sources of the dust dispersion or distribution. It may be necessary to follow an operator with an extension hose on the impinger to be certain of a representative sample of the breathing zone.

The sampling unit should be secured to the stand and placed in the breathing zone of the employees at the operation being studied. If such placement is not feasible (due to cramped quarters, etc.) the flask and impinger unit may be secured to some object which will be in the desired sampling area.

Appropriate data should be recorded on Form 50191-46.

2. Preparation

The sampling fluid should be comparatively free from suspended matter. If possible, distilled water should be prepared by one of the continuous types of water stills, and, after distillation, allowed to stand for 24 hours, the upper part being drawn off for use. To minimize the solubility of mineral dusts and inhibit bacterial growth, a mixture of distilled water and 2 propanol U.S.P. should be used.

All glassware should be thoroughly cleaned with a hot cleaning solution, rinsed several times, and finally rinsed with the fluid used as sampling medium. Rubber stoppers and corks should be cleaned by scrubbing with a brush in warm, pure soap solution. These should be rinsed thoroughly and rinsed finally in the sampling medium.

250 ml. of sampling fluid should be placed in cleaned flasks and the flask stoppered with solid rubber stopper and capped with paper over the top held by a rubber band. Cleaned impinger assemblies should be stoppered and wrapped pending use. Prior to entry into the sampling field, the cleaned stoppered impinger assemblies should be inserted in place of the solid stopper.

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The impinger outlet elbow is connected by appropriate lengths of rubber hose to the inlet connection of the pump. A 110 V A.C. 25 or 60 cycle (220V with resistance) current supply is necessary for the pump motor.

Start the motor, noting the starting time and adjust the pump valve to obtain the appropriate gauge reading. This gauge reading should be maintained throughout the sampling.

The number and spacing of the samples at a given station, the locating of the sampling point, and the length of each sampling period shall be so chosen as to yield a representqative measure of the exposure throughout the cycle of operation, and also to indicate the peak or low concentration.

When the sample has been completed, the inlet and exhaust impinger tubes should be stoppered and the flask removed from the sampling area. The sample number should be indicated on the flask. The impinger assembly should be removed and washed with distilled water into the sample flask. A clean solid rubber stopper should be inserted in the flask and capped with paper and a fairly heavy rubberband or scotch tape.

A flask containing the sampling fluid only, "Blank Count", should be included with the samples to be analyzed.

a. Preparation of Sample

1. Wash all cell parts in soapy water with a fine camel's hair brush. Rinse thoroughly with distilled water.

2. Dry cell parts between filter paper and then with lens paper.

3. Make a small mark on the floor of cell with red wax crayon for care of microscope focusing.

4. The effectiveness of cleaning shall be checked by microscopic examination of each cell before being filled.

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5. One cell shall be filled from each sample.

6. One cell shall be made from the blank flask.

7. The sample of known volume should be shaken vigorously and a portion transferred immediately to the cell by means of a clean pipette, taking care to prevent the inclusion of air bubbles.

8. The concentration of the suspension shall be such as to give a dust count at least 4 times the "blank" count and not greater than 150 particles in the 1/4 sq. mm. counting area. When further dilution from the initial volume of 250 cc is required to reduce the field count to the limits specified above, the dilution shall be made in steps not exceeding 1:10. Complete mixing of the suspension by vigorous agitation is required before removing a portion for dilution. Excessive dilutions are to be avoided by proper gauging of the sampling time in relation to the dust concentration. For example:

Volume Removed From Original	Original Volume	Ratio	Dilution Factor in Formula
125 cc	250 cc	1:2	X2
62.5 cc	250 cc	1:4	X4
50 cc	250 cc	1:5	X5
25 cc	250 cc	1:10	X10

b. Counting

1. Counting shall be done in a dust free room, using artificial illumination in the microscope.

2. The light and mirror shall be centered so that no shift of position of the particles is seen when focusing up and down. The condenser and diaphragm shall be adjusted to give even, moderate illumination. Each observer should determine and employ the optimum [illegible]

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3. Before counting, the field of the microscope shall be examined and, if necessary, the ocular grid cleaned to remove dust particles.

4. The count shall be made in a plane just above the surface of the cell rather than throughout the depth of the liquid. The microscope may be focused up and down by means of the fine adjustment in order to bring individual particles into focus. Before making the count, the cell contents shall be carefully examined throughout the entire depth to make certain that all countable particles have settled. Allow sample cell to settle a minimum of 20 minutes before counting.

5. Five fields of 1/4 sq. mm in area shall be counted, one in the central part and the other 4 towards the edges of the cell.

6. Count and record the number of particles, 10 microns or less. Particles are defined as having a length to width ratio of less than 3 to 1.

D. Sample Counting

1. Method

Dust and fiber concentrations in the air, collected by impinger methods, are determined by calculation after light-field counting of samples under a microscope.

2. Equipment

100X Microscope (16 mm 10X Objective and 10X Eyepiece) with simple condenser; whipple disc; Micrometer; dust count cells - Plankton (Sedgwick-Rafter) or Dunn; pipette.

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3. Procedure

The sample should be counted within 36 hours after collection, except that in the case of flocculating dusts, the permitted holding time shall not exceed 12 hours. Special collecting liquids may be employed to minimize the degree of flocculation for certain dusts.

4. Computation of Results

The concentration of dust shall be expressed in millions of particles per cubic foot of air (mppcf) reported to significant figures only.

Concentration is determined as follows:

$$\text{Conc. (mppcf)} = \frac{(N_s - N_c) \times \text{C.F.} \times V_w}{V_a}$$

Where:

N_s = Mean count per field for the sample (5 fields)

N_c = Mean count per field for the blank (5 fields)

C.F. = Cell Factor = 100/ (area of counting field in sq. mm)
(x depth of cell in mm)

V_w = Total water volume (equivalent total, when portion diluted, i.e. initial sample volume x dilution factor)

V_a = Air volume sampled in cu. ft.

Example:

Duration of sampling time	:	10 minutes
Rate of sampling	:	One (1) cubic foot per minute
Vol. in flask after washing	:	250 cc
Ratio of added dilution (125 cc in 250 cc flask)	:	1:2
Cell depth	:	1 mm

Dust count, light field (1 cell) particles less than 10 microns in size.

79	
85	
80	84 Av. Total/Field
84	-5 Blank Count
82	79 Av. Net Count
5)420 = 84	

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Calculations:

$$\frac{\text{Av. Net Count Per 1/4 sq mm} \times 4 \times \text{cu. mm per cc} \times \text{Flask Vol.} \times \text{extra dil. ratio}}{\text{Cu. Ft. Per Minute Sampled} \times \text{Sampling Time}}$$

$$\frac{79 \times 4 \times 1000 \times 250 \times 2}{1 \times 10} = 15.8 \text{ Million Particles Per Cubic Foot of Air}$$

Adapted with modifications from:

Transactions - Fifth Annual Meeting (1942)

National Conference of Governmental Industrial Hygienists.

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Exhibit 15-C

Ann. Occup. Hyg. Vol. 11, pp. 1–6. Pergamon Press [illegible]

THE METHOD USED BY THE U.S. PUBLIC HEALTH SERVICE FOR ENUMERATION OF ASBESTOS DUST ON MEMBRANE FILTERS

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(*Received* 30 *May* 1967)

Abstract—Samples of air-borne mineral dusts are collected by drawing air through cellulose ester membrane filters. Particles smaller than nominal pore size are retained. Varying sampling rate and filter holder controls the distribution of dust across the filter face. Samples are mounted on standard microscope slides using a high viscosity solution of membrane filter material in a mixture of diethyl oxalate and dimethyl phthalate to render the filter transparent. The mount is stable for 28–30 days, but after this period migration of the dust particles causes a loss of areal concentration.

The grain and fiber dust particles, which lie on the surface of the filter, are counted with a phase contrast microscope, using 10X eye-pieces and a 4 mm "high-dry" objective. The field area is delineated with a Porton graticule. Count data are recorded in a form allowing data reduction and statistical analysis by electronic computer. The method, although not suitable to determine compliance with the threshold limit value for asbestos that was developed from a different enumeration method, is highly suited for developing basic data for a more precise recommendation of the limit for asbestos.

INTRODUCTION

IN THE early epidemiologic studies of the asbestos industry by FULTON (1935) and DREESEN (1938), the impinger was settled upon as the standard method for appraising dustiness. Since few fibers were seen it was necessary to count both grains and fibers to obtain a statistically useful count despite the assumption that asbestosis was caused by fibers. This inconsistency notwithstanding, dust control based on impinger results has considerably reduced asbestosis where it has been conscientiously applied in the asbestos textile industry. However, a number of investigators (LYNCH and SMITH, 1955; DOLL, 1955) have suggested other health hazards associated with asbestos, and a more relevant and sensitive method is required for estimation of the hazard, especially in industries using only part asbestos in their product.

A further weakness in the impinger method is that it is not amenable to long personal samples. It is believed that personal samples best approximate the worker's actual exposure, and ROACH (1966) has recommended a sample duration of 10 work shifts for mineral dusts.

New methods were therefore needed, and among those studied were grain and

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fiber counts at 430X phase contrast on membrane filters that had been made transparent. This paper deals with the development and standardization of this method.

The principle variable which needed to be considered was the mounting procedure in relation to maximum transparency and the effect of time on the dimensional stability of the mount. Methods using immersion oil, airplane glue or acetone were found to be either too cumbersome or resulted in an imperfectly cleared or mottled filter, particularly as viewed with phase contrast optics. In methods which involved the application of liquid over the dust deposit the movement of the meniscus across the deposit sometimes caused redistribution of the dust. The use of a 50–50 mixture of diethyl oxalate–dimethyl phthalate was attempted and found to result in satisfactory clearance. However, since this medium dissolved the filter, the migration of particles resulted in changing counts with time and needed to be examined to evaluate the method.

SAMPLING PROCEDURE

Samples for count are collected on Millipore® type AA filters* by personal samplers operated by battery powered pumps worn by the employees, and as simultaneous samples collected in conjunction with impingers. The filters are contained in plastic filter holders and are supported on thick pads which also aid in controlling the distribution of air through the filter. Several methods of admitting air to the filter have been attempted. With the face cap removed and the filter completely exposed, the air may enter the filter evenly, but large high velocity particles and foreign objects may also hit the filter and possibly cause damage. As an alternative, the face cap may be left in place and the small plug removed. The passage of air through this 4 mm opening at a flow rate of 2 l. per min produces a velocity of 265 cm/sec, which yields an impaction parameter of 0·081† for 1 micron (μ) unit density spheres. Although this impaction parameter would predict a very low collection efficiency of 1μ particles by impaction, some larger particles would tend to be impacted on the center of the filter. This was found not to affect count distribution, which is dominated by small particles; however, it does result in obscuring a small portion of the filter, particularly if many large particles are present, as in friction product plants. The third alternative was to drill 6 additional 4 mm holes in some face caps and to fit these perforated caps to the filter holder during sampling. This reduced the velocity to 38 cm/sec thus eliminating the impaction problem while still protecting the filter from damage.

MOUNTING THE SAMPLE

The mounting medium used in this method is prepared by dissolving 0·1 g of membrane filter per ml of a 1:1 solution of dimethyl phthalate and diethyl oxalate. The exact proportions of the 3 components are not critical, but the medium must have as high a viscosity as possible without being difficult to handle. The index of refraction of the medium thus prepared is $N_D = 1{\cdot}47$.

*Millipore® filters are named in this paper since the method was developed using this brand of filters. Similar techniques may be developed for other filter brands.

†Ranz, W. E. and Wong, J. B. (1952) *Archs. ind. Hyg.* **5**, 462.

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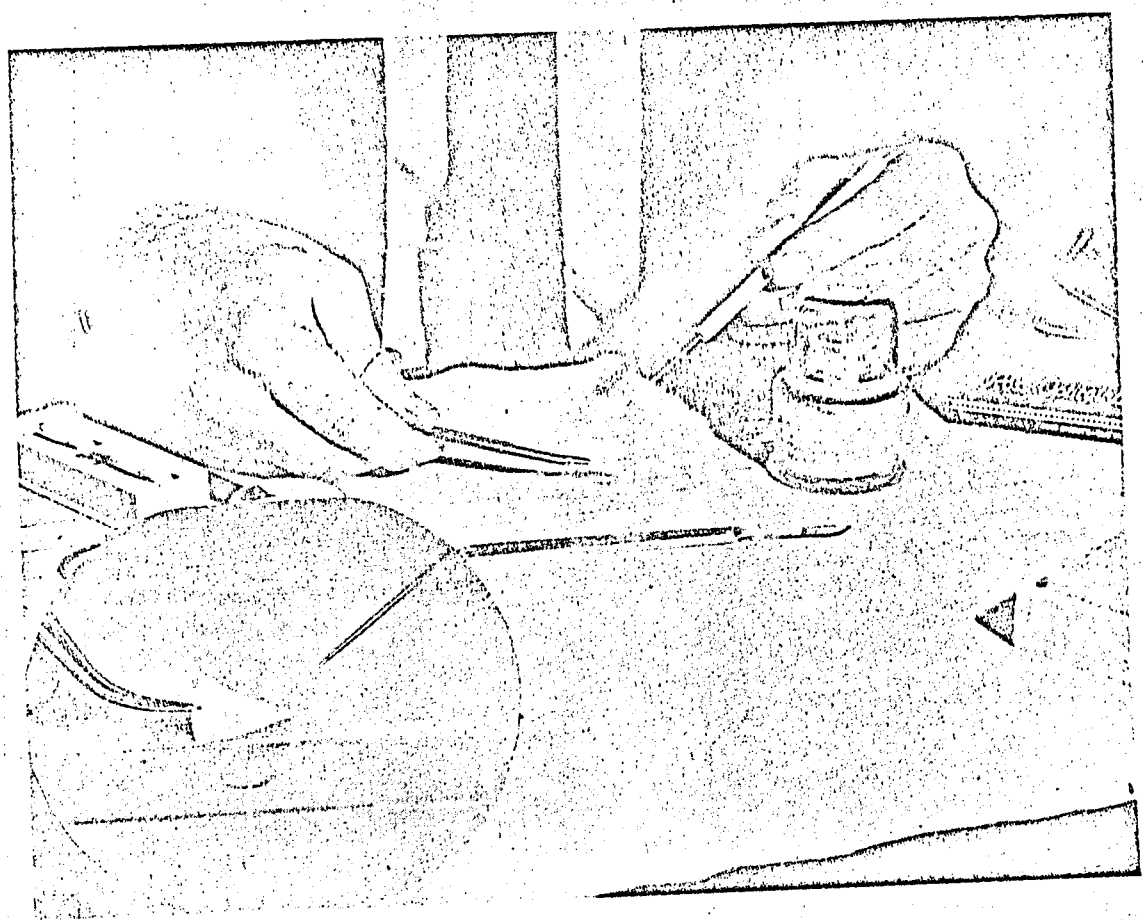


FIG. 1. The wedge-shaped piece of membrane filter is placed dust side up on a drop of mounting medium which has been applied to a standard microscope slide. The mount will be covered with a #1½ coverslip.

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To prepare a sample for microscopic examination, a drop of the mounting medium is placed on a freshly cleaned standard (25 mm × 75 mm) microscope slide, using a dropper or applicator. The volume of the drop is approximately 0·05 ml. A wedge-shaped piece about 1 cm × 2 cm is excised from the filter using a scalpel and forceps, and placed dust side up on the drop of mounting solution (Fig. 1). A #1½ coverslip carefully cleaned with lens tissue is placed over the filter wedge. Slight pressure on the coverslip achieves contact between it and the mounting medium.

Clearing of the filter with this method is slow, requiring about 15 min. The sample may be examined as soon as the mount is transparent.

The transition of the dust-supporting substrate from translucent solid membrane filter cellulose ester material to a transparent, optically homogeneous gel is very gentle, and at no time does a meniscus sweep across the dust deposit. Rather, the substrate slowly softens beneath the dust, and there is no opportunity for washing away or redistribution of the dust.

The optical homogenity of the resulting mount is nearly perfect, with only a slight background granularity under phase contrast, which disappears within 1 or 2 days.

STABILITY

Observers noted a reduction with time in apparent concentration for samples mounted with only dimethyl phthalate and diethyl oxalate. By observation, this loss was due to the migration of the dust particles outward from the center through the gelatinous material of the fixed mount, with a decrease in areal concentration. The cause of this migration was not determined but may be related to a disordering or distortion of the membrane filter polymer caused by partial solution. To determine the magnitude of this loss, a group of samples was mounted using 1:1 dimethyl phthalate and diethyl oxalate only, and counted at 1–3 day intervals for periods ranging up to 76 days. Counts were displayed as fractions in per cent of the original, or first day counts (Fig. 2). At the end of 1 week, samples mounted by this method yielded only 75 per cent of their original values. By 30 days after mounting,

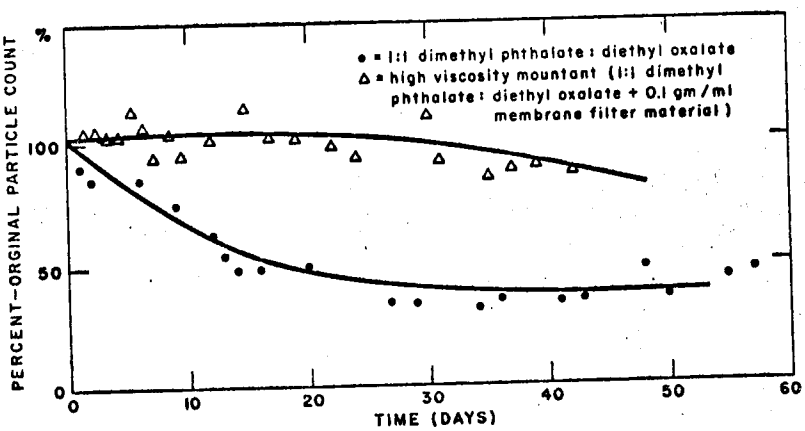


FIG. 2. Decrease in percentage of original particle count with time for the original 1:1 dimethyl phthalate–diethyl oxalate mixture and for the high viscosity mixture containing 0.1 g/ml of membrane filter material.

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the counts using this method had declined to 40 per cent of their first day value, and continued at this level with no further decline until counting was terminated 76 days after mounting.

A group of samples mounted in the method described in the section *Mounting the Sample* using high-viscosity mounting medium were counted at 1-day intervals for 11 days. No loss of areal concentration was apparent over this short period and a second group was similarly mounted and counted for a period of 46 days. The composite of these two series is shown in Fig. 2. No loss of concentration was detectable during the first 30 days, but the count declined to 85 per cent of its original value by the 46th day, when the series was terminated.

A 6 mm square of membrane filter with a vacuum-deposited film of carbon was mounted in the manner described to provide a macroscopic observation of the distortion of the filter areas. After a few days, the square began to disintegrate at the edges, but the major portion showed no discontinuity during the initial 30 day period. By the end of 62 days, most of the square had disintegrated and the fragments migrated over an area 16 mm × 17 mm.

EVALUATION

The filter samples mounted in the manner previously described are evaluated in terms of grain and fiber concentration, and fiber size. Binocular research microscopes equipped with fixed mechanical stages have been used. Phase contrast optics fitted to these instruments include an Abbe condenser with rotating phase turret and a 4 mm "high-dry" achromatic objective used for all membrane filter determinations. In all cases 10X Huygens eyepieces, one of which contained a Porton reticle at the level of the field-limiting diaphragm, were used. The left half of the Porton reticle field served to define the counting area or field.

A ribbon filament illuminator was critically adjusted to provide Kohler illumination through a clear blue filter.

Twenty fields located at random on the sample were counted and total grains, total fibers, fibers greater then 5μ, and fibers greater than 10μ were recorded. Any particle having an aspect ratio of 3 or greater was considered a fiber.

RECORDING OF DATA

Since it was recognized early in the study of the asbestos products industry that the large number of samples to be collected would present a burdensome data processing problem, the data were collected on forms designed for transcription to punch cards (Fig. 3). Computer programs were then written to calculate dust concentrations and to produce statistical summaries consisting of mean, standard deviation, median, etc., for any group of samples by plant, operation, job, type, etc. These programs, written in Automath (Fortran II) are applicable to any problem using the sample and count forms as source documents. Additional analyses possible are correlation and regression of simultaneous samples and Poisson index of dispersion of field counts for various counters.

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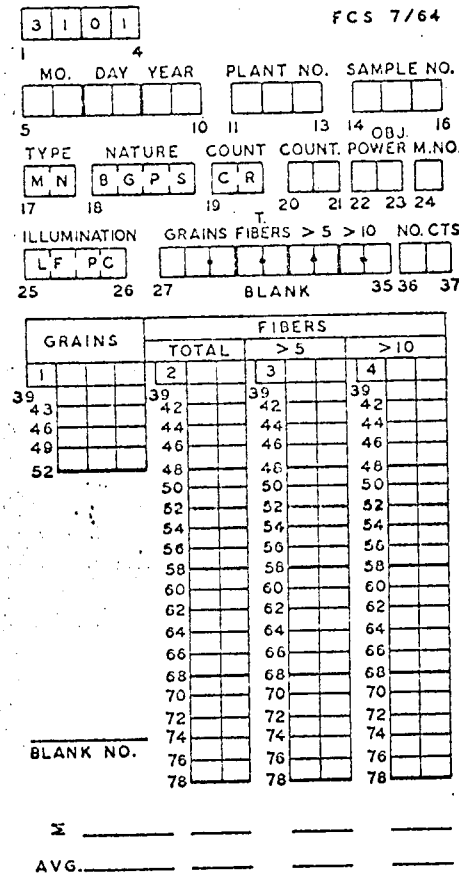


FIG. 3. Count tabulation form used for the evaluation of dust samples taken on membrane filters. *M* = Membrane filter, *U* = Elutriated membrane filter, *B* = Breathing zone sample, *G* = General sample, *P* = Personal sample, *S* = Sequential sample, *C* = Count (1st), *R* = Recount. *COUNT* provides for the technician's initials, *OBJ POWER* indicates the magnification, *M. NO* provides for the microscope number for calibration purposes, and *LF* and *PC* are light-field and phase contrast.

SUMMARY

A method for sampling and counting asbestos dust using membrane filters has been developed and evaluated. The mounting medium developed clears the filter gently so as to not redistribute the dust deposit, and produces a mount with adequate dimensional stability for a period of 30 days. This method has been used in developing environmental data in connection with the Public Health Service study of the asbestos products industry, and is recommended for research studies in other dusty trades although not for application to Threshold Limit Values. A system of data handling involving electronic computer processing, which is also applicable to other studies, was discussed.

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February 10, 1969

E+4.6.+ 15-D

Proposed Membrane Filter Method

A. Application

The membrane Filter Method is applicable for the determination of the atmospheric concentration of asbestos fibers. This method is suited for sampling in both asbestos textile operations and mixed dust operations containing asbestos fiber. This procedure is particularly valuable in mixed dust areas since asbestos fibers alone are counted without interference from granular dusts.

B. Equipment Assembly

Basically, the membrane filter sampling equipment consists of suction pump unit and a filter holder assembly. The suction pump unit is the Casella Personal Air Sampler. This instrument will sample for 10 hours on one charge at a flow rate of 2 liters per minute (lpm). Batteries are recharged overnight.

Alternate suction pump units are the Monitaire Sampler with a suitable flow tube (0-10 CFH), and the Unico Model C110 Personnel Air Sampler.

The filter holder assembly is the Aerosal Field Monitor containing a Millipore type AA 37 mm, 0.8 micron pore size. The filters are supported on thick pads which aid in controlling the distribution of air through the filter. Rubber or plastic tubing of suitable length is connected to the inlet side of the pump and to the filter holder assembly. The pump is turned on and adjusted to the appropriate gauge setting. This gauge reading should be maintained throughout the sampling period.

C. Sampling

1. Location

Established sampling stations should be taken with the Casella Personal Air Sampler attached to the operator's belt and the filter

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holder clipped to the operator's clothing. Where this is not possible and in general room samples, the filter holder assembly may be attached to a suitable stand or holder in the worker's "breathing zone". The sampling time should be gauged to obtain sufficient material on the filter for satisfactory counting under the microscope. Excessive dust deposits should be avoided since no dilution is possible.

D. Sample Counting

1. Preparation of Mounting Solution

The mounting solution used in this method is a 1:1 mixture of dimethyl phthalate and diethyl oxalate. This solution may be used when the sample is to be counted within 24 hours after preparation. If samples are to stand for longer periods of time an alternate solution may be prepared by dissolving 0.05 grams of membrane filter material per milliliter of solution. For example, in a 100 cc solution, 50 cc of dimethyl phthalate are mixed with 50 cc of diethyl oxalate. Five grams of sampling filter material are weighed up and dissolved in the 100 cc solution. The purpose of the dissolved material is to provide a solution with as high a viscosity as possible without being difficult to handle. The highly viscous solution delays the migration of particulate outward from the center of the mount. The samples will remain stable with no apparent loss in concentration for approximately 30 days.

2. Mounting Sample

To prepare a sample for microscopic examination, a drop of mounting solution is placed in the center of a freshly cleaned standard microscope slide (25 mm x 75 mm) using a dropper. A wedge-shaped piece about 1 cm x 2 cm is excised from the filter paper using a scalpel and forceps.

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Proposed Membrane Filter Method

EXAMPLE

area of membrane sample = 855 m^2

area of field of view = 0.005 mm^2

number of fibers counted = 200

sampling rate = 2 lpm = 2000 ccs/min

sampling time = 90 minutes

Calculations

$$C = \frac{855}{0.005} \times \frac{200}{20} \times \frac{1}{2000 \times 90}$$

$$= 171{,}000 \times 10 \times \frac{1}{180{,}000}$$

$$= 9.5 \text{ fibers/cc}$$

The maximum allowable concentration for counts made of fiber 5 microns in length and greater by this method is 12 fibers/cc.

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The piece is placed dust side up on the drop of solution. A number 1½ coverslip carefully cleaned with lens tissue is placed over the filter wedge. Apply slight pressure on the coverslip to achieve contact between it and the mounting solution. The sample may be analyzed as soon as the mount is transparent. The "clearing" of the filter requires about 15 minutes .

3. Sample Counting

Analysis of the filter sample is performed with a binocular microscope at 430 X. The phase contrast optics fitted to the microscope include an Abbe condenser, a 4 mm (43X) achromatic objective, and two 10X Huygens eyepieces. One of the eyepieces should contain a suitable grid (e.g., Porton Reticule) to define the counting field and assist in judging lengths of fibers. Phase contrast illumination is supplied with a ribbon filament illuminator. Twenty fields located at random on the sample are counted. Two counts are recorded, (1) total fibers, and (2) fibers 5 microns in length and greater. Any particle having a length to width ratio of 3:1 or greater is considered a fiber.

E. Computation of Results

In the following calculations, let

A = area of membrane sample

a = area of field of view

N = number of fibers counted

n = number of fields observed (20)

V = volume of sample in ccs.

Then the concentration (C) in fibers/cc is given by

$$C = \frac{A}{a} \times \frac{N}{n} \times \frac{1}{V}$$

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Exhibit 15-E

Threshold Limit Values of Airborne Contaminants Adopted By ACGIH For 1969

ND INTENDED CHANGES

PREFACE

THRESHOLD LIMIT VALUES FOR 1969

Threshold limit values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit, a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Simple tests are now available (J. Occup. Med. 9, 537, 1967; Ann. N.Y. Acad. Sci. 151 Art. 2, p. 968, 1968) that may be used to detect those individuals hypersusceptible to a variety of industrial chemicals (respiratory irritants, hemolytic chemicals, organic isocyanates, carbon disulfide). These tests may be used to screen out by appropriate job placement the hyperreactive worker and thus in effect improve this "coverage" of the TLVs.

Threshold limit values refer to time-weighted concentrations for a 7 or 8-hour workday and 40-hour workweek. They should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations. (Exceptions are the substances listed in Appendices A and E and those substances designated with a "C" or Ceiling value, Appendix C.)

Time-weighted averages permit excursions above the limit provided they are compensated by equivalent excursions below the limit during the workday. In some instances it may be permissible to calculate the average concentration for a workweek rather than for a workday. The degree of permissible excursion is related to the magnitude of the threshold limit value of a particular substance as given in Appendix C. The relationship between threshold limit and permissible excursion is a rule of thumb and in certain cases may not apply. The amount by which threshold limits may be exceeded for short periods without injury to health depends upon a number of factors such as the nature of the contaminant, whether very high concentrations - even for short periods - produce acute poisoning, whether the effects are cumulative, the frequency with which high concentrations occur, and the duration of such periods. All factors must be taken into consideration in arriving at decision as to whether a hazardous condition exists.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance or other forms of stress may form the basis for others.

The committee holds to the opinion that limits based on physical irritation should be considered no less binding than those based on physical impairment. There is increasing evidence that physical irritation may initiate, promote or accelerate physical impairment through interaction with other chemical or biologic agents.

In spite of the fact that serious injury is not believed likely as a result of exposure to the threshold limit concentrations, the best practice is to maintain concentrations of all atmospheric contaminants as low as is practical.

These limits are intended for use in the practice of industrial hygiene and should be interpreted and applied only by a person trained in this discipline. They are not intended for use, or for modification for use, (1) as a relative index of hazard or toxicity (2) in the evaluation or control of community air pollution or air pollution nuisances, (3) in estimating the toxic potential of continuous uninterrupted exposures, (4) as proof or disproof of an existing disease or physical conditions, or (5) for adoption by countries whose working conditions differ from those in the United States of America and where substances and processes differ.

Ceiling vs Time-Weighted Average Limits. Although the time-weighted average concentration provides the most satisfactory, practical way of monitoring airborne agents for compliance with the limits, there are certain substances for which it is inappropriate. In the latter group are substances which are predominantly fast acting and whose threshold limit is more appropriately based on this particular response. Substances with this type of response are best controlled by a ceiling "C" limit that should not be exceeded. It is implicit in these definitions that the manner of sampling to determine compliance with the limits for each group must differ; a single brief sample, that is applicable to a "C" limit, is not appropriate to the time-weighted limit: here, a sufficient number of samples are needed to permit a time-weighted average concentration throughout a complete cycle of operations or throughout the work shift.

Whereas the ceiling limit places a definite boundary which concentrations should not be permitted to exceed, the time-weighted average limit requires an explicit limit to the excursions that are permissible above the listed values. The

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magnitude of these excursions may be pegged to the magnitude of the threshold limit by an appropriate factor shown in Appendix C. It should be noted that the same factors are used by the Committee in making a judgment whether to include or exclude a substance for a "C" listing.

"Skin" Notation. Listed substances followed by the designation "Skin" refer to the potential contribution to the over-all exposure by the cutaneous route including mucous membranes and eye, either by air-borne, or more particularly, by direct contact with the substance. Vehicles can alter skin absorption. This attention-calling designation is intended to suggest appropriate measures for the prevention of cutaneous absorption so that the threshold limit is not invalidated.

Mixtures. Special consideration should be given also to the application of the TLVs in assessing the health hazards which may be associated with exposure to mixtures of two or more substances. A brief discussion of basic considerations involved in developing threshold limit values for mixtures, and methods for their development, amplified by specific examples are given in Appendix B.

"Inert" or Nuisance Particulates. A number of dusts or particulates that occur in the working environment ordinarily produce no specific effects upon prolonged inhalation. Some insoluble substances are classed as inert (e.g. iron and steel dusts, cement, silicon carbide, titanium dioxide, cellulose); others may be soluble (starch, soluble oils, calcium carbonate) but are of such a low order of activity that in concentrations ordinarily encountered do not cause physiologic impairment; still others may be rapidly eliminated or destroyed by the body (vegetable oils, glycerine, sucrose). In the case of the insoluble substances, there may be some accumulation in the respiratory passages. In the case of the soluble substances, this accumulation will ordinarily be temporary but may interfere to some extent with respiratory processes. Hence, it is desirable to control the concentrations of such particulates in the air breathed by any individual, in keeping with good industrial hygiene practice.

A threshold limit of 15mg/M^3, or 50 mppcf, of total dust <1% SiO_2, whichever is less, is recommended for substances in these categories and for which no specific threshold limits have been assigned. This limit, for a normal workday, does not apply to brief exposures at higher concentrations. Neither does it apply to those substances which may cause physiologic impairment at lower concentrations but for which a threshold limit has not yet been adopted. Some "inert" particulates are given in Appendix D.

Simple Asphyxiants - "Inert" Gases or Vapors. A number of gases and vapors, when present in high concentrations in air, act primarily as simple asphyxiants without other significant physiologic effects. A TLV may not be recommended for each simple asphyxiant because the limiting factor is the available oxygen. The minimal oxgyen content should be 18 percent by volume under normal atmospheric pressure (equivalent to a partial pressure, pO_2 of 135 mm Hg). Atmospheres deficient in O_2 do not provide adequate warning and most simple asphyxiants are ordorless. Several simple asphyxiants present an explosion hazard. Account should be taken of this factor in limiting the concentration of the asphyxiant. Specific examples are listed in Appendix E.

Physical Factors. It is recognized that such physical factors as heat, ultraviolet and ionizing radiation, humidity, abnormal pressure (altitude) and the like may place added stress on the body so that the effects from exposure at a threshold limit may be altered. Most of these stresses act adversely to increase the toxic response of a substance. Although most threshold limits have built-in safety factors to guard against adverse effects to moderate deviations from normal environments, the safety factors of most substances are not of such a magnitude as to take care of gross deviations. For example, continuous work at temperatures above 90°F or over-time extending the workweek more than 25%, might be considered gross deviations. In such instances judgment must be exercised in the proper adjustments of the threshold limit values.

"Notice of Intent" At the beginning of each year, proposed actions of the Committee for the forthcoming year are issued in the form of a "Notice of Intent." This Notice provides not only an opportunity for comment, but solicits suggestions of substances to be added to the list. The suggestions should be accompanied by substantiating evidence.

As Legislative Code. Although the Conference does not consider the TLVs appropriate matter for adoption into legislative codes and regulations, it recognizes that the values may be so used. If so used, the intent of the concepts contained in the Preface should be maintained and provisions should be made to keep the list current. These values are reviewed annually by the Committee on Threshold Limits for revision or additions, as further information becomes available.

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ADOPTED VALUES
(In Alphabetical Order)

Substance	ppm[a]	mg/M^3
*Abate	-	15
Acetaldehyde	200	360
Acetic acid	10	25
Acetic anhydride	5	20
Acetone	1,000	2,400
Acetonitrile	40	70
Acetylene dichloride, see 1, 2 Dicloroethylene		
Acetylene tetrabromide	1	14
Acrolein	0.1	0.2
Acrylamide-skin	-	0.3
Acrylonitrile-Skin	20	45
Aldrin-Skin	-	0.2
Allyl alcohol-Skin	2	5
Allyl chloride	1	3
C Allyl glycidyl ether (AGE)	10	45
Allyl propyl disulfide	2	12
2-Aminoethanol, see Ethanolamine		
2-Aminopyridine	0.5	2
** Ammonia	50	35
Ammonium sulfamate (Ammate)	-	15
n-Amyl acetate	100	525
sec-Amyl acetate	125	650
Aniline-Skin	5	19
Anisidine (o, p-isomers)-Skin	-	0.5
Antimony & compounds (as Sb)	-	0.5
ANTU (alpha naphthyl thiourea)	-	0.3
Arsenic & Compounds (as As)	-	0.5
Arsine	0.05	0.2
Azinphos-methyl-Skin	-	0.2
Barium (soluble compounds)	-	0.5
C Benzene (benzol)-Skin	25	80
Benzidine-Skin	-	A[1]
p-Benzoquinone, see Quinone		
Benzoyl peroxide	-	5
Benzyl chloride	1	5
Beryllium	-	0.005
Biphenyl, see Diphenyl		
Boron oxide	-	15
* Boron tribromide	1	-

a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm. Hg pressure.

b) Approximate milligrams of particulate per cubic meter of air.

A Numbers, See Appendix A

* 1969 Addition
** See Notice of Intended Changes

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Substance	ppm[a]	mg/M^3 [b]
C Boron trifluoride	1	3
Bromine	0.1	0.7
* Bromine pentafluoride	0.1	-
Bromoform-Skin	0.5	5
Butadiene (1, 3-butadiene)	1,000	2,200
Butanethiol, see Butyl mercaptan		
2-Butanone	200	590
2-Butoxy ethanol (Butyl Cellosolve) Skin	50	240
Butyl acetate (n-butyl acetate)	150	710
n-Butyl acetate	150	710
sec-Butyl acetate	200	950
tert-Butyl acetate	200	950
Butyl alcohol	100	300
sec-Butyl alcohol	150	450
tert. Butyl alcohol	100	300
C Butylamine-Skin	5	15
C tert. Butyl chromate (as CrO3) - Skin	-	0.1
n-Butyl glycidyl ether (BGE)	50	270
** Butyl mercaptan	10	35
p-tert. Butyltoluene	10	60
Cadmium (Metal dust and soluble salts)	-	0.2
** Cadmium oxide fume	-	0.1
Calcium arsenate	-	1
Calcium oxide	-	5
* Camphor	2	-
Carbaryl (Sevin ®)	-	5
Carbon black	-	3.5
Carbon dioxide	5,000	9,000
Carbon disulfide-Skin	20	60
Carbon monoxide	50	55
Carbon tetrachloride-Skin	10	65
Chlordane-Skin	-	0.5
Chlorinated camphene, - Skin	-	0.5
Chlorinated diphenyl oxide	-	0.5
*Chlorine	1	-
Chlorine dioxide	0.1	0.3
C Chlorine trifluoride	0.1	0.4
C Chloroacetaldehyde	1	3
∝-Chloroacetophenone (phenacyl-chloride)	0.05	0.3
Chlorobenzene (monochloroben-zene)	75	350
o-Chlorobenzylidene malononitrile (OCBM)	0.05	0.4
Chlorobromomethane	200	1,050
2-Chloro-1, 3 butadiene, see Chloroprene		
Chlorodiphenyl (42% Chlorine) - Skin	-	1

** See Notice of Intended Changes

Substance	ppm[a]	mg/M^3 [b]
Chlorodiphenyl (54% Chlorine) - Skin	-	0.5
1, Chloro, 2, 3 epoxypropane, see Epichlorhydrin		
2, Chloroethanol, see Ethylene chlorohydrin		
Chloroethylene, see Vinyl choride.		
C Chloroform (trichloromethane)	50	240
1-Chloro-1-nitropropane	20	100
Chloropicrin	0.1	0.7
Chloroprene (2-chloro-1, 3-buta-diene)-Skin	25	90
Chromic acid and chromates (as CrO3)	-	0.1
Chromium, sol. chromic, chrom-ous salts as Cr	-	0.5
Metal & insol. salts	-	1
Coal tar pitch volatiles (benzene soluble fraction) anthracene, BaP, phenanthrene, acridine, chrysene, pyrene)	-	0.2
Cobalt, metal fume & dust	-	0.1
Copper fume	-	0.1
Dusts and Mists	-	1
Cotton dust (raw)	-	1
Crag ® herbicide	-	15
Cresol (all isomers) - Skin	5	22
Crotonaldehyde	2	6
Cumene-Skin	50	245
Cyanide (as CN)-Skin	-	5
* Cyanogen	10	-
Cyclohexane	300	1,050
Cyclohexanol	50	200
Cyclohexanone	50	200
Cyclohexene	300	1,015
Cyclopentadiene	75	200
2, 4-D	-	10
DDT-Skin	-	1
DDVP-Skin	-	1
Decaborane-Skin	0.05	0.3
Demeton ® -Skin	-	0.1
Diacetone alcohol (4-methyl-2-pentanone)	50	240
1, 2 Diaminoethane, see Ethy-lenediamine Diazomethane	0.2	0.4
Diborane	0.1	0.1
C 1, 2-Dibromoethane (ethylene dibromide)-Skin	25	190
Dibutyl phosphate	1	5
Dibutylphthalate	-	5
C o-Dichlorobenzene	50	300
p-Dichlorobenzene	75	450

** See Notice of Intended Changes

Substance	ppm[a]	mg M
Dichlorodifluoromethane	1,000	4,950
1, 3-Dichloro-5, dimethyl hy-dantoin	-	0.
1, 1-Dichloroethane	100	400
1, 2-Dichloroethane	50	200
1, 2-Dichloroethylene	200	790
C Dichloroethyl ether-Skin	15	90
Dichloromethane, see Methylene-chloride		
Dichloromonofluoromethane	1,000	4,200
C 1, 1-Dichloro-1-nitroethane	10	60
1, 2-Dichloropropane, see Pro-pylenedichloride		
Dichlorotetrafluoroethane	1,000	7,000
Dieldrin-Skin	-	0.2
Diethylamine	25	75
Diethylamino ethanol-Skin	10	50
*C Diethylene triamine-Skin	10	-
Diethylether, see Ethyl ether		
Difluorodibromomethane	100	860
C Diglycidyl ether (DGE)	0.5	2.8
Dihydroxybenzene, see Hydroquin-one		
Diisobutyl ketone	50	290
Diisopropylamine-Skin	5	20
* Diphenyl amine	-	10
Dimethoxymethane, see Methylal		
Dimethyl acetamide-Skin	10	35
Dimethylamine	10	18
Dimethylaminobenzene, see Xyli-dene		
Dimethylaniline (N-dimethylaniline)-Skin	5	25
Dimethylbenzene, see Xylene		
Dimethyl 1, 2-dibromo-2, 2-di-chloroethyl phosphate, (Dibrom)	-	3
Dimethylformamide-Skin	10	30
2, 6 Dimethylheptanone, see Diisobutyl ketone		
1, 1-Dimethylhydrazine-Skin	0.5	1
Dimethylphthalate	-	5
Dimethylsulfate-Skin	1	5
Dinitrobenzene (all isomers)-Skin	-	1
Dinitro-o-cresol-Skin	-	0.2
Dinitrotoluene-Skin	-	1.5
Dioxane (Diethylene dioxide)-Skin	100	360
Diphenyl	0.2	1
*Diphenyl Amine	-	10
Diphenylmethane diisocyanate (see Methylene bisphenyl isocyanate (MDI)		

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Substance	ppm[a]	mg/M^3 [b]
Dipropylene glycol methyl ether-Skin	100	600
Di-sec, octyl phthalate (Di-2-ethylhexylphthalate	-	5
Endrin-Skin	-	0.1
Epichlorhydrin-Skin	5	19
EPN-Skin	-	0.5
1,2-Epoxypropane, see Propylene-oxide		
2,3-Epoxy-1-propanol, see Glycidol		
Ethanethiol, see Ethylmercaptan		
Ethanolamine	3	6
2 Ethoxyethanol-Skin	200	740
2 Ethoxyethylacetate (Cellosolve acetate)-Skin	100	540
Ethyl acetate	400	1,400
Ethyl acrylate-Skin	25	100
Ethyl alcohol (ethanol)	1,000	1,900
Ethylamine	10	18
Ethyl sec-amyl ketone (5-methyl-3-heptanone)	25	130
Ethyl benzene	100	435
Ethyl bromide	200	890
Ethyl butyl ketone (3-Heptanone)	50	230
Ethyl chloride	1,000	2,600
Ethyl ether	400	1,200
Ethyl formate	100	300
** Ethyl mercaptan	10	25
Ethyl silicate	100	850
Ethylene chlorohydrin-Skin	5	16
Ethylenediamine	10	25
Ethylene dibromide, see 1,2-Dibromoethane		
Ethylene dichloride, see 1,2-Dichloroethane		
C Ethylene glycol dinitrate and/or Nitroglycerin-Skin	0.2[d]	1
Ethylene glycol monomethyl ether acetate, see Methyl cellosolve acetate		
Ethylene imine-Skin	0.5	1
Ethylene oxide	50	90
Ethylidine chloride, see 1,1-Dichloroethane		
N-Ethylmorpholine-Skin	20	94
Ferbam	-	15
Ferrovanadium dust	-	1
Fluoride (as F)	-	2.5
Fluorine	0.1	0.2
Fluorotrichloromethane	1,000	5,600
C Formaldehyde	5	6

d) An atmospheric concentration of not more than 0.02 ppm, or personal protection may be necessary to avoid headache.

Substance	ppm[a]	mg/M^3 [b]
Formic acid	5	9
Furfural-Skin	5	20
Furfuryl alcohol	50	200
Gasoline	-	A[3]
Glycidol (2,3-Epoxy-1-propanol)	50	150
Glycol monoethyl ether, see 2-Ethoxyethanol		
Guthion,® see Azinphosmethyl		
Hafnium	-	0.5
Heptachlor-Skin	-	0.5
** Heptane (n-heptane)	500	2,000
Hexachloroethane-Skin	1	10
Hexachloronaphthalene-Skin	-	0.2
Hexane (n-hexane)	500	1,800
2-Hexanone	100	410
Hexone	100	410
sec-Hexyl acetate	50	300
Hydrazine-Skin	1	1.3
Hydrogen bromide	3	10
C Hydrogen chloride	5	7
Hydrogen cyanide-Skin	10	11
Hydrogen fluoride	3	2
** Hydrogen peroxide, 90%	1	1.4
Hydrogen selenide	0.05	0.2
Hydrogen sulfide	10	15
Hydroquinone	-	2
* Indium and compounds, as In	-	0.1
C Iodine	0.1	1
Iron oxide fume	-	10
* Iron salts, soluble, as Fe	-	1
Isoamyl acetate	100	525
Isoamyl alcohol	100	360
Isobutyl acetate	150	700
Isobutyl alcohol	100	300
Isophorone	25	140
Isopropyl acetate	250	950
Isopropyl alcohol	400	980
Isopropylamine	5	12
Isopropylether	500	2,100
Isopropyl glycidyl ether (IGE)	50	240
Ketene	0.5	0.9
Lead	-	0.2
Lead arsenate	-	0.15
Lindane-Skin	-	0.5
Lithium hydride	-	0.025
L. P. G. (Liquified petroleum gas)	1,000	1,800
Magnesium oxide fume	-	15
Malathion-Skin	-	15
Maleic anhydride	0.25	1
C Manganese	-	5
** Mercury-Skin	-	0.1

* 1969 Addition
** See Notice of Intended Changes

Substance	ppm[a]	mg/M^3 [b]
** Mercury (organic compounds)-Skin	--	0.0
Mesityl oxide	25	100
Methanethiol, see Methyl mercaptan		
Methoxychlor	--	15
2-Methoxyethanol, see Methyl cellosolve		
Methyl acetate	200	610
Methyl acetylene (propyne)	1,000	1,650
Methyl acetylene-propadiene mixture (MAPP)	1,000	1,800
Methyl acrylate-Skin	10	35
Methylal (dimethoxymethane)	1,000	3,100
Methyl alcohol (methanol)	200	260
Methylamine	10	12
Methyl amyl alcohol, see Methyl isobutyl carbinol		
Methyl (n-amyl) ketone (2-Heptanone)	100	465
C Methyl bromide-Skin	20	80
Methyl butyl ketone, see 2-Hexanone		
Methyl cellosolve-Skin	25	80
Methyl cellosolve acetate-Skin	25	120
C Methyl chloride	100	210
Methyl chloroform	350	1,900
Methylcyclohexane	500	2,000
Methylcyclohexanol	100	470
o-Methylcyclohexanone-Skin	100	460
Methyl ethyl ketone (MEK), see 2-Butanone		
Methyl formate	100	250
Methyl iodide - Skin	5	28
Methyl isobutyl carbinol-Skin	25	100
Methyl isobutyl ketone, see Hexone		
Methyl isocyanate - Skin	0.02	0.05
**C Methyl mercaptan	10	20
Methyl methacrylate	100	410
Methyl propyl ketone, see 2-Pentanone		
*C Methyl silicate	5	--
C α Methyl styrene	100	480
C Methylene bisphenyl isocyanate (MDI)	0.02	0.2
Methylene chloride (dichloromethane)	500	1,740
Molybdenum (soluble compounds)	-	5
(insoluble compounds)	-	15
Monomethyl aniline-Skin	2	9
C Monomethyl hydrazine-Skin	0.2	0.35
Morpholine-Skin	20	70
Naphtha (coal tar)	100	400

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E - 5

Substance	ppm[a]	mg/M^3 [b]
Naphthalene	10	50
β-Naphthylamine	-	A[1]
Nickel carbonyl	0.001	0.007
Nickel, metal and soluble cmpds.	-	1
Nicotine-Skin	-	0.5
Nitric acid	2	5
Nitric oxide	25	30
p-Nitroaniline-Skin	1	6
Nitrobenzene-Skin	1	5
p-Nitrochloro-benzene-Skin	-	1
Nitroethane	100	310
Nitrogen dioxide	5	9
Nitrogen Trifluoride	10	29
Nitroglycerin-Skin	0.2	2
Nitromethane	100	250
1-Nitropropane	25	90
2-Nitropropane	25	90
N-Nitrosodimethyl-amine (Di-methyl-nitrosoamine)-Skin	-	A[1]
Nitrotoluene-Skin	5	30
Nitrotrichloromethane, see Chloropicrin		
Octachloronaphthalene-Skin	-	0.1
* Octane	500	2,350
* Oil mist (mineral)	-	5
Osmium tetroxide	-	0.002
Oxalic acid	-	1
Oxygen difluoride	0.05	0.1
Ozone	0.1	0.2
Paraquat-Skin	-	0.5
Parathion-Skin	-	0.1
Pentaborane	0.005	0.01
Pentachloronaphthalene-Skin	-	0.5
Pentachlorophenol-Skin	-	0.5
* Pentane	1,000	2,950
2-Pentanone	200	700
Perchloroethylene	100	670
Perchloromethyl mercaptan	0.1	0.8
Perchloryl fluoride	3	13.5
* Petroleum Distillates (naphtha)	500	2,000
Phenol-Skin	5	19
p-Phenylene diamine-Skin	-	0.1
Phenyl ether (vapor)	1	7
Phenyl ether-Biphenyl mixture (vapor)	1	7
Phenylethylene, see Styrene		
Phenyl glycidyl ether (PGE)	10	60
Phenylhydrazine-Skin	5	22
Phosdrin (Mevinphos)® -Skin	-	0.1
Phosgene (carbonyl chloride)	0.1	0.4
Phosphine	0.3	0.4

** See Notice of Intended Changes

Substance	ppm[a]	mg/M^3 [b]
Phosphoric acid	-	1
Phosphorus (yellow)	-	0.1
Phosphorus pentachloride	-	1
Phosphorus pentasulfide	-	1
Phosphorus trichloride	0.5	3
Phthalic anhydride	2	12
Picric acid-Skin	-	0.1
Pival® (2-Pivalyl-1,3-indandione)	-	0.1
Platinum (Soluble Salts)	-	0.002
Polytetrafluoroethylene decomposition products	-	A[2]
Propane	1,000	1,800
β Propiolactone	-	A[1]
* Propargyl alcohol-Skin	1	-
n-Propyl acetate	200	840
Propyl alcohol	200	500
n-Propyl nitrate	25	110
Propylene dichloride	75	350
Propylene imine-Skin	2	5
Propylene oxide	100	240
Propyne, see Methylacetylene		
Pyrethrum	-	5
Pyridine	5	15
Quinone	0.1	0.4
* RDX-Skin	-	1.5
Rhodium, Metal fume and dusts	-	0.1
Soluble salts	-	0.001
Ronnel	-	15
Rotenone (commercial)	-	5
Selenium compounds (as Se)	-	0.2
Selenium hexafluoride	0.05	0.4
Silver, metal and soluble compounds	-	0.01
Sodium fluroacetate (1080)-Skin	-	0.05
Sodium hydroxide	-	2
Stibine	0.1	0.5
** Stoddard solvent	500	2,900
Strychnine	-	0.15
**C Styrene monomer (phenylethylene)	100	420
Sulfur dioxide	5	13
Sulfur hexafluoride	1,000	6,000
Sulfuric acid	-	1
Sulfur monochloride	1	6
Sulfur pentafluoride	0.025	0.025
Sulfuryl fluoride	5	20
Systox, see Demeton®		
2,4,5 T	-	10
Tantalum	-	5
TEDP-Skin	-	0.2
Teflon® decomposition products	-	A[4]
Tellurium	-	0.1

* 1969 Addition

Substance	ppm[a]	mg/M^3 [b]
Tellurium hexafluoride	0.02	0.2
TEPP - Skin	-	0.05
C Terphenyls	1	9
1, 1, 1, 2-Tetrachloro-2, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloro-1, 2-difluoroethane	500	4,170
1, 1, 2, 2-Tetrachloroethane-Skin	5	35
Tetrachloroethylene, see Perchloroethylene		
Tetrachloromethane, see Carbon tetrachloride		
Tetrachloronaphthalene - Skin	-	2
** Tetraethyl lead (as Pb) - Skin	-	0.075
Tetrahydrofuran	200	590
** Tetramethyl lead (TML) (as Pb) - Skin	-	0.075
Tetramethyl succinonitrile - Skin	0.5	3
Tetranitromethane	1	8
Tetryl (2, 4, 6-trinitrophenyl-methylnitramine) - Skin	-	1.5
Thallium (soluble compounds) - Skin	-	0.1
Thiram	-	5
Tin (inorganic cmpds, except SnH_4 and SnO_2)	-	2
Tin (organic cmpds)	-	0.1
Titanium dioxide	-	15
Toluene (toluol)	200	750
C Toluene-2, 4-diisocyanate	0.02	0.14
o-Toluidine - Skin	5	22
Toxaphene, see Chlorinated camphene		
Tributyl phosphate	-	5
1, 1, 1-Trichloroethane, see Methyl chloroform		
1, 1, 2-Trichloroethane - Skin	10	45
Trichloroethylene	100	535
Trichloromethane, see Chloroform		
Trichloronaphthalene - Skin	-	5
1, 2, 3-Trichloropropane	50	300
1, 1, 2-Trichloro 1, 2, 2-trifluoroethane	1,000	7,600
Triethylamine	25	100
Trifluoromonobromomethane	1,000	6,100
2, 4, 6-Trinitrophenol see Picric acid		
2, 4, 6-Trinitrophenylmethylnitramine, see Tetryl		
Trinitrotoluene - Skin	-	1.5
Triorthocresyl phosphate	-	0.1

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Substance	ppm[a]	mg/M^3 [b]
Triphenyl phosphate	-	3
Tungsten & Compounds, as W		
Soluble	-	1
Insoluble	-	5
Turpentine	100	560
Uranium (natural) sol. & insol. compounds as U	-	0.2
Vanadium (V_2O_5 dust)	-	0.5
(V_2O_5 fume)	-	0.1
Vinyl benzene, see Styrene		
C Vinyl chloride	500	1,300
Vinylcyanide, see Acrylonitrile		
Vinyl toluene	100	480
Warfarin	-	0.1
Xylene (xylol)	100	435
Xylidine - Skin	5	25
Yttrium	-	1
Zinc chloride fume	-	1
Zinc oxide fume	-	5
Zirconium compounds (as Zr)	-	5

Radioactivity: For permissible concentrations of radioisotopes in air, see U.S. Department of Commerce, National Bureau of Standards, Handbook 69, "Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure," June 5, 1959. Also, see U.S. Department of Commerce National Bureau of Standards, Handbook 59, "Permissible Dose from External Sources of Ionizing Radiation," September 24, 1954, and addendum of April 15, 1958.

1969 Addition

MINERAL DUSTS

Substance	m.p.p.c.f.[e]
SILICA	
Crystalline	
** Quartz, Threshold Limit calculated from the formula	$\frac{250}{\%SiO_2 + 5}$ [f]
** Cristobalite " " "	
Amorphous, including natural diatomaceous earth	20
SILICATES (less than 1% crystalline silica)	
** Asbestos	5
Mica	20
Soapstone	20
Talc	20
Tremolite	5
Portland Cement	50
GRAPHITE (natural)	15
"Inert" or Nuisance Particulates see Appendix D	50 (or 15 mg/M^3 whichever is the smaller) of total dust <1% SiO_2

Conversion factors

mppcf x 35.3 = million particles per cubic meter
= particles per c.c.

e) Millions of particles per cubic foot of air, based on impinger samples counted by light-field technics.

f) The percentage of crystalline silica in the formula is the amount determined from air-borne samples, except in those instances in which other methods have been shown to be applicable.

** See Notice of Intended Changes

NOTICE OF INTENDED CHANGES

These substances, with their corresponding values, comprise those for which either a limit has been proposed for the first time, or for which a change in the "Adopted" listing has been proposed. In both cases, the proposed limits should be considered trial limits that will remain in the listing for a period of at least two years. During this time, the previously Adopted Limit will remain in effect. If, after two years no evidence comes to light that questions the appropriateness of the values herein, the values will be placed in the "Adopted" list. Documentation is available for each of these substances.

Substance	ppm[a]	mg/M^3 [b]
+ C Ammonia	50	35
+ + 2-Acetylaminofluorene	-	A[1]
+ + 4-Aminodiphenyl	-	A[1]
+ + Ammonium chloride fume	-	1
+ + Asphalt (Petroleum) fumes	-	2
Butyl mercaptan	0.5	-
C Cadmium oxide fume (as Cd)	-	0.1
C Dichloroacetylene	0.1	-
+ + Dichlorobenzidine	-	A[1]
+ + 4-Dimethylaminoazobenzene	-	A[1]
Endosulfan (Thiodan®) - Skin	-	0.1
Ethyl mercaptan	0.5	-
+ Fibrous glass	g) -	Appendix D
Heptane	500	2,000
+ Hydrogen peroxide	1	1
Indene	10	-
+ Mercury vapor, inorganic and organic cmpds, excluding alkyl Mercury - Skin	-	0.05
+ Methyl 2-cyanoacrylate	2	
+ Methyl demeton - Skin	-	0.5
Methyl isoamyl ketone	100	475
Methyl mercaptan	0.5	-
+ + Methyl parathion - Skin	-	0.2
+ + 4-Dimethylaminoazobenzene	-	A[1]
Octane	400	1,900
Oil mist (particulate)	-	5[h]
Oil vapors	i) A[3]	-
Pentaerythritol (tetramethylomethane)	-	15
Pentane	500	1,500

a) Parts of vapor or gas per million parts of contaminated air by volume at 25°C and 760 mm. Hg pressure.

b) Approximate milligrams of particulate per cubic meter of air.

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Substance	ppm[a]	mg/M^3 [b]	
Petroleum distillates	i) A[3]	-	
Phenothiazine - Skin	-	5	
Stoddard Solvent	200	-	
Styrene	100	-	
Tetraethyl lead (as Pb) - Skin	-	0. 100[j]	
Tetramethyl lead (as Pb) - Skin	-	0. 150[j]	
Trimethyl benzene	25	-	
Vinyl acetate	10	-	
Wood Dust (total dust)	-	10	

g) 5-7 μ Diameter. No TLV for coarse fibrous glass has yet been set.
h) As sampled by method that does not collect vapors.
i) According to analytically determined composition.
j) For control of general room air; biologic monitoring is essential for personnel control.

1969 Revision
1969 Addition

NOTICE OF INTENDED CHANGES (Continued)

MINERAL DUST

	Substance	
	Asbestos	12 fibers/ml - 5μ in length[k], or 2 mppcf[m]
+ +	Coal Dust (bituminous)	3. 5 mg/M^3 (respirable dust)[n]
	Cristobalite	Use one-half the value calculated from the count or mass formulae for quartz.
	Quartz	(1) TLV for respirable dust in mg/M^3:[p] $\frac{10 \text{ mg/M}^3}{\% \text{ Respirable Quartz} + 2}$
		(2) "Total dust" respirable and nonrespirable: $\frac{30 \text{ mg/M}^3}{\% \text{ Quartz} + 2}$
++	Fused Silica	Use quartz formulae.
	Tridymite	Use one-half the value calculated from formulae for quartz.

k) As determined by the membrane filter method at 430 x phase contrast magnification.

m) As counted by the standard impinger, light-field count technique.

n) "Respirable" dust as defined by the British Medical Research Council Criteria (1) and as sampled by a device producing equivalent results (2).

(1) Hatch, T.E. and Gross, P., Pulmonary Deposition and Retention of Inhaled Aerosols, p. 149. Academic Press, New York, New York, 1964.

(2) Interim Guide for Respirable Mass Sampling, AIHA Aerosol Technology Committee. In draft form, to be published in late 1969.

p) Both concentration and per cent quartz for the application of this limit are to be determined from the fraction passing a size-selector with the following characteristics:

Aerodynamic Diameter (μ) (unit density sphere)	% passing selector
≤2	90
2. 5	75
3. 5	50
5. 0	25
10	0

\+ 1969 Revision
++ 1969 Addition

APPENDIX A

A[1] Because of the high incidence of cancer, either in man or in animals, no exposure or contact by any route, respiratory, oral or skin should be permitted for the compounds:

2-Acetylaminofluorene	beta-Naphthylamine
4-Aminodiphenyl	4-Nitrodiphenyl
Benzidine & its salts	N-Nitrodimethylamine
Dichlorobenzidine	beta-Propiolactone
4-Dimethylaminoazobenzene	

Because of the extremely high incidence of bladder tumors in workers handling beta-naphthylamine and the potential carcinogenic activity of the other compounds, the State of Pennsylvania prohibits the manufacture, use and other activities that involve human exposure without express approval by the Department of Health.

A[2] **Polytetrafluoroethylene* decomposition products.** Thermal decomposition of the fluorocarbon chain in air leads to the formation of oxidized products containing carbon, fluorine and oxygen. Because these products decompose in part by hydrolysis in alkaline solution, they can be quantitatively determined in air as fluoride to provide an index of exposure. No TLV is recommended pending determination of the toxicity of the products, but air concentrations should be minimal.

A[3] **Gasoline and/or Petroleum Distillates.** The composition of these materials varies greatly and thus a single TLV for all types of these materials is no longer applicable. In general, the aromatic hydrocarbon content will determine what TLV applies. Consequently the content of benzene, other aromatics and additives should be determined to arrive at the appropriate TLV (Elkins, et al. A.I.H.A.J. 24, 99, 1963).

*Trade Names: Algoflon, Fluon, Halon, Teflon, Tetran

APPENDIX B

B.1 THRESHOLD LIMIT VALUES FOR MIXTURES

When two or more hazardous substances are present, their combined effect, rather than that of either individually, should be given primary consideration. In the absence of information to the contrary, the effects of the different hazards should be considered as additive. That is, if the sum of the following fractions,

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$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \text{-----} \frac{C_n}{T_n}$$

exceeds unity, then the threshold limit of the mixture should be considered as being exceeded. C_1 indicates the observed atmospheric concentration, and T_1 the corresponding threshold limit, (See Example 1A.a.).

Exceptions to the above rule may be made when there is good reason to believe that the chief effects of the different harmful substances are not in fact additive, but independent as when purely local effects on different organs of the body are produced by the various components of the mixture. In such cases the threshold limit ordinarily is exceeded only when at least one member of the series ($\frac{C_1}{T_1}$ or $\frac{C_2}{T_2}$ etc.) itself has a value exceeding unity, (See Example 1A.b.).

Antagonistic action or potentiation may occur with some combinations of atmospheric contaminants. Such cases at present must be determined individually. Potentiating or antagonistic agents are not necessarily harmful by themselves. Potentiating effects of exposure to such agents by routes other than that of inhalation is also possible, e.g. imbibed alcohol and inhaled narcotic (trichloroethylene). Potentiation is characteristically exhibited at high concentrations, less probably at low.

When a given operation or process characteristically emits a number of harmful dusts, fumes, vapors or gases, it will frequently be only feasible to attempt to evaluate the hazard by measurement of a single substance. In such cases, the threshold limit used for this substance should be reduced by a suitable factor, the magnitude of which will depend on the number, toxicity and relative quantity of the other contaminants ordinarily present.

Examples of processes which are typically associated with two or more harmful atmospheric contaminants are welding, automobile repair, blasting, painting, lacquering, certain foundry operations, diesel exhausts, etc. (Example 2.)

THRESHOLD LIMIT VALUES FOR MIXTURES
EXAMPLES

1A. General case, where air is analyzed for each component.

a. ADDITIVE EFFECTS

$$\frac{C_1}{T_1} + \frac{C_2}{T_2} + \frac{C_3}{T_3} + \cdots \frac{C_n}{T_n} = 1$$

Air contains 5 ppm of carbon tetrachloride (TLV, 10), 20 ppm of ethylene dichloride (TLV, 50) and 10 ppm of ethylene dibromide, (TLV, 25).

$$\frac{5}{10} + \frac{20}{50} + \frac{10}{25} = \frac{65}{50} = 1.3$$

Threshold limit is exceeded.

b. INDEPENDENT EFFECTS

Air contains 0.15 mg/M^3 of lead (TLV, 0.2) and 0.7 mg/M^3 of sulfuric acid (TLV, 1).

$$\frac{0.15}{0.20} = 0.75; \qquad \frac{0.7}{1} = 0.7$$

Threshold limit is not exceeded.

1B. Special case when source of contaminant is a mixture and atmospheric composition is assumed similar to that of original material, i.e. vapor pressure of each component is the same at the observed temperature.

a. ADDITIVE EFFECTS, approximate solution.

1. A mixture of equal parts (1) trichloroethylene (TLV, 100), and (2) methyl chloroform (TLV, 350).

$$\frac{C_1}{100} + \frac{C_2}{350} = \frac{C_m}{T_m}$$

Solution applicable to "spot" solvent mixture usage, where all or nearly all, solvent evaporates.

$$C_1 = C_2 = \frac{1}{2} C_m$$

$$\frac{C_1}{100} + \frac{C_1}{350} = \frac{2C_1}{T_m}$$

$$\frac{7C_1}{700} + \frac{2C_1}{700} = \frac{2C_1}{Tm}$$

$$Tm = 700 \times \frac{2}{9} = 155 \text{ ppm}$$

1B. b. General Exact Solution for Mixtures of N Components With Additive Effects and Different Vapor Pressures.

(1) $\frac{C_1}{T_1} + \frac{C_2}{T_2} + \cdots + \frac{C_n}{T_n} = 1;$

(2) $C_1 + C_2 + \ldots + C_n = T;$

(2.1) $\frac{C_1}{T} + \frac{C_2}{T} + \cdots + \frac{C_n}{T} = 1.$

By the Law of Partial Pressures,

(3) $C_1 = ap_1,$

and by Raoult's Law,

(4) $p_1 = F_1 p_1^{\circ}.$

Combine (3) and (4) to obtain

(5) $C_1 = aF_1 p_1^{\circ}.$

Combining (1), (2.1) and (5), we obtain

(6) $\frac{F_1 p_1^{\circ}}{T} + \frac{F_2 p_2^{\circ}}{T} + \ldots + \frac{F_n p_n^{\circ}}{T} = \frac{F_1 p_1^{\circ}}{T_1} + \frac{F_2 p_2^{\circ}}{T_2} + \cdots + \frac{F_n p_n^{\circ}}{T_n}$

and solving for T,

(6.1) $T = \dfrac{F_1 p_1^{\circ} + F_2 p_2^{\circ} + \ldots + F_n p_n^{\circ}}{\frac{F_1 p_1^{\circ}}{T_1} + \frac{F_2 p_2^{\circ}}{T_2} + \cdots + \frac{F_n p_n^{\circ}}{T_n}}$

or $\dfrac{\sum_{i=1}^{i=n} F_1 p_1^{\circ}}{\sum_{i=1}^{i=n} \frac{F_1 p_1^{\circ}}{T_1}}$

(6.2) $T = \dfrac{\sum_{i=1}^{i=n} F_1 p_1^{\circ}}{\sum_{i=1}^{i=n} \frac{F_1 p_1^{\circ}}{T_1}}$

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T = Threshold Limit Value in ppm.
C = Vapor concentration in ppm.
p = Vapor pressure of component in solution.
p^o = Vapor pressure of pure component.
F = Mol fraction of component in solution.
a = A constant of proportionality.
Subscripts 1, 2, . . . n relate the above quantities to components 1, 2, . . . n, respectively.
Subscript i refers to an arbitrary component from 1 to n.
Absence of subscript relates the quantity to the mixture.

Solution to be applied when there is a reservoir of the solvent mixture whose composition does not change appreciably by evaporation.

Exact Arithmetic Solution of Specific Mixture

	Mol. wt.	Density	T	p^o at 25°C	Mol fraction in half-and-half solution by volume
Trichloro-ethylene (1)	131.4	1.46g/ml	100	73mm Hg	0.527
Methylchlo-roform (2)	133.42	1.33g/ml	350	125mm Hg	0.473

$$F_1 p_1^{\ o} = (0.527)\ (73) = 38.2$$

$$F_2 p_2^{\ o} = (0.473)\ (125) = 59.2$$

$$T = \frac{38.2 + 59.2}{\frac{38.2}{100} + \frac{59.2}{350}} = \frac{(97.4)\ (350)}{133.8 + 59.2} = \frac{(97.4)\ (350)}{193.0} = 177$$

T = 177 ppm (Note difference in TLV when account is taken of vapor pressure and mol fraction in comparison with above example where such account is not taken.)

2. A mixture of one part of (1) parathion (TLV, 0.1) and two parts of (2) EPN (TLV, 0.5).

$$\frac{C_1}{0.1} + \frac{C_2}{0.5} = \frac{C_m}{T_m} \qquad C_2 = 2C_1$$

$$C_m = 3C_1$$

$$\frac{C_1}{0.1} + \frac{2C_1}{0.5} = \frac{3C_1}{T_m}$$

$$\frac{7C_1}{0.5} = \frac{3C_1}{T_m}$$

$$T_m = \frac{1.5}{7} = 0.21\ mg/M^3$$

1C. TLV for Mixtures of Mineral Dusts.

For mixtures of biologically active mineral dusts the general formula for mixtures may be used. With the exception of asbestos, pure minerals are assigned TLV of 2.5, 20 or 50.

For a mixture containing 80% talc and 20% quartz, the TLV for 100% of the mixture "C" is given by:

$$TLV = \frac{1}{\frac{0.8}{20} + \frac{0.2}{2.5}} = 8.4\ mppcf$$

Essentially the same result will be obtained if the limit of the more (most) toxic component is used provided the effects are additive. In the above example the limit for 20% quartz is 10 mppcf.

For another mixture of 25% quartz 25% amorphous silica and 50% talc:

$$TLV = \frac{1}{\frac{0.25}{2.5} + \frac{0.25}{20} + \frac{0.5}{20}} = 7.3\ mppcf$$

The limit for 25% quartz approximates 8 mppcf.

APPENDIX C

BASES FOR ASSIGNING LIMITING "C" VALUES

By definition in the Preface, a listed value bearing a "C" designation refers to 'ceiling' value that should not be exceeded; all values should fluctuate below the listed value. In general the bases for asssigning or not assigning a "C" value rest on whether excursions of concentration above a proposed limit for periods up to 15 minutes may result in a) intolerable irritation, b) chronic, or irreversible tissue change, or c) narcosis of sufficient degree to increase accident proneness, impair self rescue or materially reduce work efficiency.

T.L.V. RANGE ppm or mg/M^3	Test T.L.V. Factor	Examples
0 to 1	3	Toluene diisocyanate - T.L.V., 0.02 ppm, if permitted to rise above 0.06 ppm may result in sensitization in a single subsequent exposure. "C" listing recommended on category b.
1 + to 10	2	Manganese - T.L.V., $5mg/M^3$, contains little or no safety factor. All values should fluctuate below $5mg/M^3$. "C" listing recommended on category b.
10 + to 100	1.5	Methyl styrene - T.L.V. 100, if encountered at levels of 150 ppm will prove intensely irritating. "C" listing recommended on category a.
100 + to 1000	1.25	Methyl chloroform - T.L.V. 350 ppm, at 438 ppm for periods not exceeding 15 minutes is not expected to result in untoward effects relating to category c. No "C" listing recommended.

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Exhibit 15-E

PERMISSIBLE EXCURSIONS FOR TIME-WEIGHTED AVERAGE (TWA) LIMITS

The test TLV Factor in the Table serves also as a guide to the magnitude of the permissible excursion above the limit for those substances not given a "C" designation i.e. the TWA limits. Thus for HF, with a TWA limit of 3 ppm, a concentration of 6 ppm is permissible for periods not exceeding 15 minutes, provided an equivalent exposure below the limit is experienced.

APPENDIX D

Some "Inert" or Nuisance Particulates q)

Alundum (Al_2O_3)	Limestone
Calcium carbonate	Magnesite
Cellulose	Marble
Portland Cement	Pentaerythritol
Corundum (Al_2O_3)	Plaster of Paris
Emery	Rouge
Glycerine Mist	Silicon Carbide
Graphite (synthetic)	Starch
Gypsum	Sucrose
Vegetable oil mists (except castor, cashew nut, or similar irritant oils)	Tin Oxide
	Titanium Dioxide

q) When toxic impurities are not present, e.g. quartz < 1%.

APPENDIX E

Some Simple Asphyxiants - "Inert" Gases and Vapors

Acetylene	Hydrogen
Argon	Methane
Ethane	Neon
Ethylene	Nitrogen
Helium	Nitrous Oxide
	Propane

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Documentation of Threshold Limit Values. A separate companion piece to the TLVs is issued by ACGIH under this title. This publication gives the pertinent scientific information and data with reference to literature sources that were used to base each limit. Each documentation also contains a statement defining the type of response against which the limit is safeguarding the worker. For a better understanding of the TLVs it is essential that the Documentation be consulted when the TLVs are being used.

Information concerning the availability of Xerox copies of the 2nd edition of the Documentation of Threshold Limit Values should be directed to the Secretary-Treasurer.

ERRATA

Page 6 — delete separate listing for n-Butyle acetate

Page 7 — the substance diazomethane and the corresponding TLV's of 0.2 ppm and 0.4 mg/M^3 should be listed independently. For the TLV of 1,2 Diaminoethane, see Ethylenediamine.

Page 13 — Teflon® decomposition products, appendix reference should be A^2.

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CIVIL ACTION NO. 6329

S. R. POTTER

VS

FIBREBOARD PAPER PRODUCTS CORPORATION

ANSWERS OF THE DEFENDANT, JOHNS-MANVILLE PRODUCTS CORPORATION, TO INTERROGATORIES PROPOUNDED BY PLAINTIFF

IN THE UNITED STATES DISTRICT COURT FOR THE EASTERN DISTRICT OF TEXAS - BEAUMONT DIVISION

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