

PLAINTIFF'S EXHIBIT

G-569

GARLOCK INC GASKET MATERIALS

A

**COMPARISON OF THE TYNDALL
PHENOMENA TO THE ACTUAL
CONCENTRATION OF ASBESTOS
FIBERS IN THE BREATHING
ZONE OF WORKERS**

**RECEIVED
GARLOCK**

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(REV)**

BACKGROUND:

Sir John Tyndall was a British physicist who lived from 1820 until 1893. His name is generally attached to the phenomena of light scattering of particles or the reflectance of the particles in motion. He first observed and reported the phenomena for particles in fluid suspension, and later in air. The phenomena can be demonstrated simply by observing strong sunlight passing through a pinhole in a window shade. The sunlight impinges upon the particles floating in air and is reflected from them. The situation does not tell anything about the composition of the particles or their relative shape, except flat particles like graphite which form platelets are more reflective than nearly spherical particles. This is because of the broad flat surface which act as tiny mirrors for reflection of the light rays.

The Tyndall effect is a demonstration of particles floating in air but does not in any way relate to the quantity except by visual estimation. Also, the smallest particles that can readily be seen by the naked eye is about 40 microns (micron = micrometer = $1/25,000$ th of an inch). The resolution of the human eye is such that smaller particles are invisible. Very strong light allows anyone to see the particles, but if the particles have an effective diameter less than the wavelength of visible light, then the tiny particles are invisible. If the concentration of tiny particles is very high, the strong light will be refracted which is another phenomena.

The human eye using a strong light is not able to determine the concentration of particles in air other than by guess, or the

distribution of the sizes. What this amounts to is that the tyndall effects, while known for a century, represent little more than a curious phenomena that allows the human eye to detect the presence of large particles floating in air, or in fluids. It is neither a qualitative nor quantitative test that allows estimates of concentration, distribution of sizes, or differentiates between types of particles.

Since this discovery, devices have been built in attempts to use the phenomena to make estimations. The last serious works appear in texts up to about 1936. In fact, one of the best books on the subject of airborne particles was written in 1936 and does not even mention the Tyndall effects as a practical approach (Drinker & Hatch, Industrial Dusts, 1936, rev 1954).

A device known as the Tyndallometer was developed for use in coal mines or other very dusty trades to make gross estimates of the total dust of all types and sizes that could be seen by the human eye. The Germans attempted to use this light scattering device as late as 1970 with little success. No serious scientist would class the Tyndallometer or plastic boxes with strong light shining through them with the current specific phase contrast microscopy, electron microscopy, or laser counting devices now used for the identification and counting of asbestos fibers in air.

Within the last several years some industrial hygienists have attempted to use the Tyndall effects to demonstrate the release of asbestos fibers from asbestos containing products on the market, largely for purposes of litigation. The demonstrations are passed as scientific specific methods that quantify and

and identify asbestos fibers in air. Such arbitrary methods do not represent the actual breathing zone exposure of workers, do not represent the 8 hour time-weighted average exposure, or relate to the epidemiology upon which current Federal and State standards for asbestos are based. This is a strong statement; however, the unnatural release of fibers from products inside of a 2' x 2' x 2' plastic box does not represent the conditions at all. The operation at best suggests an actual intermittent peak exposure which might occur on handling. But, it is known that workers do not do the same repetitive task such as scraping the edge of a gasket for an 8 hour time-weighted average work day. The box then represents an abnormal condition arbitrarily developed and contained inside the box. The supposition is then made that this represents the daily average exposure in the breathing zone of a worker. This is simply not true. Also, the tests that are being conducted as representative are being aggressively distributed in the box by a small fan at 350 linear feet per minute which keeps far more particles airborne to be seen than would be expected in an ordinary work situation where the large particles fall quickly or drift from the breathing zone, or never make it up to the breathing zone during the handling of the product.

Another technique being used by some industrial hygienists using the plastic cube, a strong light, and photography to record the particle release from products is to place the beam of light so that it passes directly below the product being

abraded. The light then shows all the large pieces and particles falling to the bottom of the plastic box. These particles are of no physiological interest because they are too large to enter the upper pharyngeal tract (nose and throat) and the lung. However, it does make a nice demonstration of the reflectance of large particles in the strong light beam. How does this relate to the health standard or threshold limit values? It simply doesn't.

Scraping a gasket edge for three to five minutes, clapping the entry gloves together in the box, and having other types of products in the box during testing all adds to the poor scientific controls on the arbitrary test. Reference (5) relates an actual observation of these acts.

Recent court testimony and depositions have revealed that some industrial hygienists are now collecting air samples from the plastic cube/Tyndall effect experiments and analyzing them by the standard phase contrast microscopy or scanning electron microscopy, or transmission electron microscopy. This is one more clear indication that the Tyndall effects are nothing more than a demonstration of the reflectance of particles in air which are not quantifiable or does it identify fibers by size or morphology. Again, using the current analytical techniques, inferences are made that the tests accurately represent the breathing zone exposure of workers for an 8 hour time-weighted average work day to asbestos fibers of physiological interest. This is a gross error in judgment and interpretation of the current epidemiology and the standards derived from them. The correct technique which is internationally accepted and contained in the U.S.

Federal standard, and offered as a recommendation by both the National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists is to measure the concentration of asbestos fibers greater than 5 micrometers in length in the breathing zone of workers conducted their jobs in a normal fashion during a work shift. Any other technique does not relate to the standards. The epidemiology upon which the standards are based has been determined using the correct sampling technique described above. Also the method of analysis is well defined; the use of phase contrast microscopy at 400X magnification according to the NIOSH PCM 239 or 7400 methods required by the standard. The use of scanning or transmission electron microscopy is useful for identification or more finite examination; however, they do not apply directly to the standard because total fibers are counted. There is no total fiber standard.

The only reason an industrial hygienist would want to use the plastic box is for simple demonstration that the asbestos products can release asbestos fibers on handling or abrasion. However, this has always been known and currently and readily admitted by product manufacturers. The use of the plastic box is a form of dramatism and provides large values of release which make the products appear more hazardous than they are based on the apparent emission data.

There is then a need to place this visual estimation method in perspective with the scientific community and its

knowledge of how asbestos fibers in air in the breathing zone of workers must be sampled and analyzed in order to represent the actual exposure pattern and concentration to be referenced to the Federal standard.

PURPOSE:

The purpose of this experimental design is to examine and compare the notion of the Tyndall effects with the current state-of-the-art methods of sampling, its analysis by prescribed methods and to the breathing zone exposure data derived from similar treatment to the product under typical work conditions.

The use of the plastic cube through which a strong light is passed to produce a Tyndall effect, or reflectance from the particles released from the products, is nothing more than a general subjective device that works for lecturing to those uninformed about the behavior of particles in air. Any other attempts will reduce the subjective demonstration to opinion. The use of precise analytical methods does not validate the box demonstration because the conditions do not represent actual work practices, or breathing zone exposures. It is known that the concentration from a point source of production is rapidly diluted with distance and air currents. It is not uncommon for values to be 1/100th or 1/1000th of the value produced at the point source as contained in the box. Finally, a purpose is to review the data collected by some industrial hygienists using the plastic cube, then calculating the expected breathing zone concentration.

A major purpose is to cast light upon the disinformation developed by the plastic cube/Tyndall experiments.

EXPERIMENTAL DESIGN:

The techniques of some industrial hygienists using the plastic cube experiments were reviewed. The devices used were reproduced as nearly as possible in an attempt to repeat the experiments for validation and comparison to breathing zone data.

A-2' x 2' x 2' acrylic plastic cube was constructed so that it would be air tight. A sample holder was constructed inside the top side and air sampling exit ports were bored on one side of the cube. A small fan was placed inside the cube to provide strong turbulence inside during the tests. One side of the cube was drilled so that sealed gloves could be attached to handle the products inside. A strong spot light was hooded to provide somewhat of a collimated beam through the box was placed outside. The top of the box or cube could be removed between each experiment for purposes of sample placement, cleaning, decontamination and maintenance.

Air samplers were connected to the ports on one side of the cube to collect asbestos and other particles for examination by phase contrast microscopy at 400X magnification.

A second device was constructed of plastic pipe and 4 mil (mil = 1/1000 inch) plastic to form a 10' x 10' x 10' working enclosure. A sealed entry was constructed to allow entry of a workman for tests like those performed in the plastic cube. A small bench was placed in the enclosure for the workman. The purpose was to repeat the experiments conducted in the plastic cube, as reported by some industrial hygienists, inside the 1000 cubic foot enclosure for comparison.

The 1000 cubic foot enclosure would represent the smallest practical enclosure inside ships, buildings, or machinery spaces normally used by workers who may have to handle asbestos containing products. Since the worker would be present, the release reaching the breathing zone is that actually measured there.

The design of this experiment was to compare the results obtained by the plastic box and those obtained by a worker conducting the same actions inside the large enclosure.

Several Garlock Inc. products were selected for test because of their use in industry and because they were named in the plastic box experiments conducted by some industrial hygienists.

The technique was to place a product in the holder in the plastic box, then rub it or scrape it with a wooden tongue depressor, commonly used by the medical industry. The small fan inside the box was turned on. The air samplers were operated for 45 minutes at 2 liters per minute as described in previous published experimental data by some industrial hygienists.

After each experiment the plastic box was washed with warm soapy water, rinsed and dried to effect decontamination. Also products were kept separate and not placed together in the box to prevent cross contamination.

After each experiment inside the 1000 cubic foot enclosure, the plastic was removed, bagged and disposed of as asbestos waste. This was to reduce the possibility of contamination from one trial to the next. Although laborious, such are the requirements

when attempting to measure low level asbestos releases from such products as gaskets. Because of the low concentrations, contamination is always a consideration that must be factored in, or in this case eliminated so that the data represents the actual release potential of the product.

TABLE I

COMPARISON OF PLASTIC CUBE DATA TO THE 1000 CUBIC FOOT ENCLOSURE DATA USING THE SAME PRODUCTS- expressed in Fibers/cc

	PLASTIC BOX	CONVERSION** F = 1/125th	LARGE ENCLOSURE	
Garlock Style 7735-4 900	.25 f/cc	.002 f/cc	.009 f/cc	
	.35	.003	.010	
7021	.42	.003	.010	ly
605	.55	.004	.008	
Guardian Spiral 733	.10	.0008̄	.002	
GS 5862	.15	.0012̄	.004	
10P210	.10	.008	.004	
LOK-GARD encapsulated	.15	.0012̄	.004	

* Fibers/cc, greater than 5 micrometers in length as determined by phase contrast microscopy at 400X magnification according to the NIOSH 7400 method required in the current Federal asbestos standard.

** The factor $F = \frac{1}{125}$ is the ratio between the plastic cube volume of 8 cubic feet and the 1000 cubic foot enclosure. This represents the same concentration from the cube expanded to the larger volume of 1000 cubic feet as might be expected under normal working conditions in the breathing zone of a worker in a small compartment handling asbestos materials.

- This symbol over a number indicates that it is calculated or statistically insignificant.

CONCLUSIONS/DISCUSSIONS:

A comparison of data published by the industrial hygienists using the plastic box/tyndall effects and now internal measurement revealed some difference in data not attributable to technique. Their published testimony indicated that the box was 2 feet on a side that would make 8 cubic feet and which was used for these design experiments. However, experiments observed and reported by others (5) indicate that the box is really 18" on a side or 1.5 feet. The difference in volume is significant. The ratio is $\frac{3.375\text{CF}}{8\text{ CF}} = .42$. This alone accounts for why some of the values reported are consistently higher than those conducted during this design experiment due to the differences in volume of the plastic cube.

The industrial hygienists using the plastic cube have set out to show that encapsulated products including Garlock Inc products can be abraded and release asbestos fibers to the air. This has always been known. However, the nature of the arbitrary experiment allows reporting of large values with the intimation that this is the breathing zone exposure and represents a typical work day. Neither is true.

The users of this visual aid to show the tyndall effects have unwittingly proven what has always been known; that the concentration of the asbestos released at the source of production is diluted rapidly by expansion and air currents by the time it reaches the breathing zone. This experiment shows that the values obtained by the plastic box are realistic and not inconsistent with values obtained using the correct techniques required by

Federal standard and the current state-of-the art air sampling and analytical techniques.

The use of the the newer analytical techniques provided the necessary information to make the comparison to expected ordinary breathing zone exposures.

The use of electron microscopy that reports total fibers is of little use. There is currently no known total standard for all fiber sizes using such techniques. However, the Federal standard recognizes the existence of all of the other fibers by use of the index of .2 fibers/cc, for all fibers greater than 5 micrometers in length according to the NIOSH P&CAM 239 or 7400 methods. It is already known that for every fiber counted greater than 5 micrometers in length about 100 smaller size lengths are present. The electron microscopy serves only to corroborate the existence of particular forms of asbestos present such as chrysotile or amosite.

Another way to calculate the expansion of a contaminant from a point source is to treat it as a point that is expanding spherically symmetrically (like a balloon being blown up). The increasing volume varies as the cube of the radius of the sphere. For example, the volume with a 1 foot radius would be $V = \frac{4}{3} \pi r^3$ or a value of approximately 4 CF. If the radius were 10 feet, the volume would have increased to 4000 CF, or 1000 times. By calculation one can see that if the breathing zone is at least 3 feet away from such a source expanding in that way the dilution factor would be about 1:100. Oddly, this is about what the actual experimental data shows.

These experiments clearly show that the breathing zone exposures

from the handling of Garlock Inc products as shown in Table I are consistant with on-the-job information, special experimental tests where contamination was controlled, and from the knowledge of the encapsulated nature of the products and how they are used in practical applications.

The Tynall experiments should be dismissed as arbitrary experiments that provide disinformation to the uninformed about the exposure to asbestos fibers released by these products, the actual concentration in the breathing zone, and the nature of particles in air under normal work conditions.

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