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GLASS FIBER AND HEALTH COMPLAINTS

What is Glass Fiber?

> ***"Glass Fiber" is any rigid, vitreous fiber, mineral or organic. To cause health complaints it must be large enough to be captured in the upper respiratory system.***

The term "glass fiber" as used here refers to any rigid, vitreous fiber, mineral or organic. "Glass" is a physically defined state of matter and not a product with a specific chemical composition[1]. To cause health complaints it must be large enough to be trapped by the upper respiratory system[2]. Crystalline fibers, such as the asbestos minerals and other fibrous minerals and vitreous fibers that are small enough to penetrate deeply into the lung are not included here because they do not result in complaints at the time of exposure. All "glass fibers" function the same way on the body but the response of any given individual will differ from that of other individuals for a variety of reasons that include medical condition, sensitivity, and other recent or associated exposures. Environmental glass fiber is often associated with other materials, such as allergens, whose adverse effects may be enhanced by the association with glass fiber.

There are many different names for commercial glass fiber. Some of these names indicate chemical composition and some indicate the manner of manufacture, but in the upper respiratory system they are all the same. These names include Rock Wool, Mineral Wool, Glass Wool, Slag Wool, Navy Wool, Man Made Vitreous Fiber (MMVF), Ceramic Fiber, Glass Fiber, Synthetic Vitreous Fibers (SVF), Silica Fiber, Mineral Fiber, Glass Silk, E-Glass, S-Glass, Glass Mat, Banrock, Rocktex, Fiberfrax, Dyna-Flex, and many others. They are all "glass" fiber and they are all irritants to the respiratory system and the eyes. Many of these terms are very loosely defined and they are often applied arbitrarily. When a supplier is ask if their product contains glass fiber they may answer that it does not because they don't call it glass fiber. Asking for the types of fiber in their product can be more helpful. The types of fiber can then be compared to the list presented above. Aspect ratio is not a critical consideration with regard to how glass fiber irritates the nasal passages or eyes. Aspect ratios, length to diameter, as low as 1.5 seem to be as irritating as much longer fibers.

What are Its Sources?

> ***Sources:***
> - ***Thermal insulation***
> - ***Sound-Proofing***
> - ***Office Dividers***
> - ***Reinforcement***
> - ***Manufacturing Processes***

Thermal Insulation Glass fiber is used widely in construction, as thermal insulation, as sound-proofing, for filters, and as reinforcing. As thermal insulation it is commonly used in walls and ceilings. It has also been used inside large ventilation ducts as thermal insulation. It is either in "blankets"--glass fiber mats bound in a loose, open pattern by a phenolic resin—or as blown-in insulation—short glass fiber wool without binder. Only the blanket form is use in ventilation systems as thermal insulation. It is also used in a spray-on form in which the glass fiber is mixed with vermiculite or perolite, calcite, and other materials with a gypsum binder and sprayed onto steel I-beams. In this application its primary function is as a reinforcement to hold the thermal insulation together.

Sound-Proofing As a sound-proofing agent it is used in acoustic ceiling tile, office or cubicle dividers, hallway liners, and in ventilation systems as "soundboard" just down stream from the main fans. Much more binder is applied to the glass fiber in these applications than in the case of thermal insulation. Acoustic ceiling tiles come in many formulations. Visually they are typically either a grayish mat or a yellow mat panel in a standard 2 by 4 foot size. These panels are suspended in a T-bar network over the classroom or office space. The yellow mat panel is covered on the front face by a plastic film and the mat itself is an open network of resin bonded glass fiber. The panel is somewhat rigid with open, unprotected edges. The gray mat tiles come in much greater variety, from very rigid ceramic formulations to very loose, airy mats that crack easily. The gray mats are often a blend of many different materials along with the glass fiber. The edges of these gray mat panels are generally unprotected. Vibration of the T-bar framework or sudden changes in room pressure cause the tile to rub against the T-bar. Glass fibers are broken free from the tile and then rain down onto the occupants and surfaces below. Any movement of the tiles in the T-bar frame creates glass fiber.

The soundboard in ventilation systems is typically a stiff glass fiber mat bound with a phenolic resin and often painted black on the open side facing the air stream. These materials breakdown over time and begin releasing glass fiber into the air stream. The soundboard panels cover only a small part of the air duct down stream of the fans.

Office Dividers The panels used as office or cubical dividers and as hall liners are often glass fiber mats covered with cloth in a metal frame. The glass fiber is typically bound with a phenolic resin and is similar in composition to the yellow mat acoustic ceiling tile. The cloth covering acts as a filter, but over time the phenolic resin begins breaking down and the glass fibers can begin working through the cloth. Penetration of the cloth by pins or mechanical damage to the divider can increase the rate of glass fiber release from these surfaces.

Reinforcement Glass fiber is used in gypsum wall board, in drywall tape and joint compound, in fiberglass/resin construction, and in plaster. Construction or remodeling activities often release glass fiber from these materials and introduce it into the environment. The glass fiber from these sources tends to be uniform in diameter and straight.

Manufacturing Processes Plastic molding processes may use inorganic glass fiber as a raw product that can be released into the environment and/or may create plastic glass fibers in the process that can then be released. Many molded plastic parts are reinforced with short glass fiber. These glass fibers can be released into the environment prior to their being mixed with the plastic or may be released during the trimming of a plastic part. Recycling of the plastic may also release glass fiber. There are a number of cases where the "glass fiber" involved in the health complaint is in fact a stiff plastic fiber. One extensively studied case involve the use of a thermoplastic molding process in which the excess plastic bleed out onto surfaces that had not been treated with mold release. Fine "strings" of clear plastic were created when the mold pulled apart. These fine strings broke into short stiff fibers that traveled with the molded parts and airborne, resulting in health complaints over a large area of the factory and the adjoining office areas. Controlling these plastic fibers eliminated all complaints. A brief relaxation of controls resulted in a new outbreak of complaints even though those complaining were not aware of the revised practice that increased exposure to these fibers. Over a three year study a consistent correlation of complaints to fiber concentration on surfaces was established.

How Does Glass Fiber Affect Environmental Perception?

Glass Fiber Implicated As a Major Cause of the Sick Building Syndrome (SBS)

Glass fiber irritation has been implicated as a significant agent correlated to the sick building syndrome and to health complaints[3,4,5,6,7,8,9,10,11,12,13,14,15,16,17,18]. The complaints associated with exposure to short glass fiber (less than five hundred micrometers in length) includes sinus congestion, sinus headache, dry-irritated eyes, sore throat, tight lungs, nausea, and skin rashes. The Finish study[18], conducted over a period of four years, added a number of subjective complaints to this list of physical symptoms that correlated to glass fiber exposure, which included dry air, unpleasant odor, and perception of dust and dirt. A general fatigue often accompanies this body of symptoms. The documented correlation of health complaints to low levels of short glass fiber exposure goes back to at least the early 1960's[13]. This laboratory has extensive records and case histories correlating the relationship between glass fiber on surfaces and health complaints going back to 1973. All of this data is "clinical", symptoms were present when glass fiber was present above a certain concentration, disappeared when the glass fiber dropped to low levels, and reappeared when the glass fiber increased above a certain level. These "clinical" observation are now supported by much more controlled studies[18,] in terms of the causality but in all cases the analytical method used for quantification has been poor done.

Symptoms That May be Caused by Glass Fiber Exposure:

- ***Eye Irritation***
- ***Contact Dermatitis***
- ***Rashes***
- ***Bloody Nasal Discharges***
- ***Sinus Congestion***
- ***Sinus Headache***
- ***Sore Throat***
- ***Chest Tightness***
- ***Nausea***
- ***Fatigue***
- ***Phantom Malodor***
- ***Dry Air Sensation***

Glass fiber longer than five hundred micrometers has long been associated with contact dermatitis[9]. This is also a common problem with carbon fiber composite debris. In the three year study mentioned above the likelihood of complaints of contact dermatitis increased rapidly after a concentration of 4 fibers per square inch of surface area was reached. This level has seemed to be a reliable predictor of complaints over a broad range of environments in the twenty-five years since that study. The correlation to glass fiber has been often demonstrated by visually observing the fiber protruding from the skin at the site of irritation.

Short glass fiber complaints are less obviously related to the symptoms but a consistent pattern has emerged over the last forty-plus years of observation. Short glass fibers have been collected from irritated eyes of individuals known to be exposed to glass fiber. The Materials Safety Data Sheet (MSDS) for glass fiber products warn that breathing dust from these materials "may cause a scratchy throat, congestion coughing, eye irritation, and rashes". Brief publications by NAIMA (North American Insulation Manufacturers Association) in 2003 and 2004 correctly assessed current data as to the lack of evidence for a correlation to cancer but acknowledged the problem of "irritation" [19,20,21]. The studies by Thriene, et al[14] and Hedges[6] document case histories similar to hundreds of others not documented in the literature that the author is personally familiar with. In many of these cases the "official" explanation was mold or volatile organic compounds (VOC's) but the complaints didn't stop until the glass fiber in the environment disappeared.

Lower respiratory complaints are also mentioned on occasion and there has been some concern regarding those who suffer from asthma. A link between nasal irritation and lower respiratory response may be related to the release of neuropeptides in the nasal passages due to the stimulation of the fifth cranial nerve[22,23]. The neuropeptides are aerosolized by breathing and then constrict the lung in an effort to reduce the inhalation of the irritant. This can trigger an asthmatic episode or a "tightness" of the chest in a non-asthmatic individual.

The inevitable question is 'at what exposure level might health complaints be expected?' Data suggests that this is a moving target[24,25]. The recognition of the effect of sensory clues on perception and physiological responses suggests a learned physiological response on a sub-conscious level, the body actually becomes sensitive to lower levels of exposure. Perception of the exposure not only becomes more sensitive on the cognitive level but also triggers a physiological preparation for those consequences. In a different sensory environment the same level of exposure may not trigger the same physiological response. The level that in this laboratory's experience tracks best with the initial complaints is 13 short glass fibers per square inch (2 per square centimeter) of relevant surface. A relevant surface is any surface representative of those that the individual in question contacts in association with the symptoms. A detailed discussion of these surfaces is the subject of another article to be written in the future[26]. T. Schneider, using a similar analytical technique in Denmark, suggests that 19 per square inch (3 per square centimeter) may indicate a glass fiber problem[29].

How is Exposure to Glass Fiber Measured and Why?

Repeated studies of surface concentration and airborne concentration of glass fiber in the environment have shown that health complaints correlate well with surface concentrations but not with airborne concentrations[6,12,27]. That has also been the experience of this author over more than 30 years and many thousands of investigations. Some who have failed to find that correlation have failed because they failed to collect a proper surface sample or to analyze the sample correctly after sampling. Adhesive tape has been a standard collection technique for surface particles since the 1920's. It was a standard technique for collecting crime scene evidence from the 1930's on. In the 1960's it was demonstrated to be the most effective surface sampling technique for radioactive particles. It has been a standard for assessing cleanliness in the Aerospace industry since at least the early 1970's and was finally made into an ASTM standard, as E 1216-87, in 1987. It has been documented as being at least six times better than any other standard current method as recently as 1998[28]. It is essential to sample using a tape having a plastic film that can be easily removed after sampling without significantly altering the particles collected or their relative position with respect to one another. One tape that satisfies these requirements is Scotch 3M Brand Magic Tape. There is a more detailed

Only tapelifts of surface particles correlate to health complaints.

discussion of surface sampling in PARTICLES AND HEALTH: ENVIRONMENTAL FORENSIC ANALYSIS[26].

The path from surfaces to the upper respiratory system seems to involve both resuspension and mechanical transfer. The unique airflow pattern over the body and the way the nose samples that volume contribute to the concentration of these particles in the upper respiratory system. This pattern can not be duplicated by any combination of air sampling techniques other than direct sampling of the nasal cavity itself[26]. Particles on surfaces are resuspended by mechanical disruption of the surface or by transference to the hands or clothing of the individual or individuals affected. Convective flow and the Coanda effect over the body combine to focus particles into the tidal airflow of the upper respiratory system. Direct contact between the hands and face carry glass fiber into the nasal airflow. All currently standard air sampling techniques are intentionally designed to eliminate the glass fibers that cause health complaints from the sample stream because the techniques are designed to eliminate particles that are effectively trapped in the upper respiratory system.

Quantification requires oblique, polarized, light microscopy.

The quantification of the glass fiber requires polarized light microscopy and the scanning of at least one square inch of the sampled surface. This involves the scanning of tens of thousands of particles per sample to identify the few glass fibers that may be present. That requires the use of oblique illumination in order to create the contrast necessary for rapid discrimination of the glass fibers among the background of often thousands of other non-glass fibers. No other analytical technique is capable of examining thousands of particles and reliably identifying the glass fibers within a reasonable time frame. Analyzing a smaller surface area will not result in reliable results. Electron microscopy has been used in many studies in the literature[18,27]. This is not an acceptable method because the glass fibers can not be characterized elementally and the examination of thousands of fibers in a square inch area by electron microscopy would be economically prohibitive.

What is the "Normal" Exposure (Baseline)?

The urban environment background is about 1 glass fiber per square inch of surface or less.

Glass fiber has become ubiquitous in the environment at large. Urban environments have a background of about 1 glass fiber per square inch of surface are with a total particle loading (obscuration) of 15%. Total surface obscuration is a measure of time since last surface cleaning. There are some interesting parallels between formaldehyde exposure and glass fiber exposure. The formaldehyde in a "New Car" is an enjoyable experience for many people who respond differently to formaldehyde in the home. The same is true with the "New Home" experience and exposure to glass fiber in the office. Glass fiber levels in a new home are often above the 13 per square inch of surface area. That level often drops to less than 1 per square inch over a couple of years without any complaint. If the level of glass fiber stays high over a couple of years complaints become more common. The same high level of glass fiber is often true of other new buildings but the occupants tend not to be tolerant of the exposure.

How Can Exposure be Controlled?

Exposure to glass fiber in the environment is a function of the rate of accumulation and the frequency of cleaning. Exposure can be controlled either by increasing the frequency of cleaning or by decreasing the rate of generation. Literally millions of offices and classrooms are full of glass fiber sources but do not have a glass fiber exposure problem. The difference between problem areas and non-problem areas is the result of these two parameters. Vibration is the most frequent cause for problems with acoustic ceiling tile. In the absence of vibration the rate of generation is so low that standard cleaning frequencies remove the accumulating glass fibers before they become a problem. In many schools where acoustic ceiling tile glass fiber has become a problem, it has been because of the use of the T-bar as hangers for school art work. The added load on the T-bar resulted in vibration between the T-bar and the acoustic ceiling tile. In these schools the problem is often isolated to only a few classrooms. In many offices and classroom the problems appear only after the cleaning frequencies were extended as a budget cutting item.

Glass fiber can be controlled by reducing the generation rate or by increasing the cleaning frequency.

There is a limit to the ability of an increase in the cleaning frequency to mediate the problem. If the rate of generation is too great the only acceptable approach is to reduce the source. That generally requires the removal and replacement of the source material. The replacement should not be a source of glass fiber though it may contain glass fiber. There are many glass fiber containing materials that are sealed and should not cause an exposure problem.

Are There Long Term Health Consequences?

There do not seem to be any long term health consequences resulting from exposure to glass fibers in the upper respiratory system other than a possible increased sensitivity to glass fiber exposure. This is an assumption based on very limited data. Though the author has been involved in many hundreds of these cases and has been able to follow up on some of them there have been a few individuals that report an increased in sensitivity to a number of other environmental factors. They attributed this “new” sensitivity to the glass fiber exposure. That has not been supported by any reliable objective measurements. The medical data prior to exposure to glass fiber is always missing. There is so little understanding of the complex response to environmental factors that it is difficult to characterize these sensitivities in any objective fashion.

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There are many more references to be added. They will be added on a "time available" basis.

Signed: ____________________________
E. R. Crutcher, Author