GENERAL CASUALTY

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Mineral Dusts

There are a wide variety of minerals used in industry and construction. Mining, processing and handling of these materials can cause adverse health effects. The primary health effect from exposure to these materials is fibrosis or scarring of lung tissue but depending on the mineral, health effects may include cancer and other obstructive lung diseases. Loss control staff should have an awareness of these hazards and where exposure to mineral dusts is a potential problem.

Pneumoconiosis make up a class of respiratory diseases attributed solely to occupational exposures. They include the major fibrotic lung diseases such as asbestosis, coal workers' pneumoconiosis or black lung, and silicosis as well as rarer diseases such as siderosis and beryllosis caused by exposure to iron oxide and beryllium. These diseases are caused by the buildup of mineral or metallic dust particles in the lungs and tissue reaction to their presence. Fibrous tissue (fibrosis) replaces normal tissue in the lungs resulting in less uptake of oxygen.

A basic knowledge of the respiratory system and its defensive mechanisms helps us understand how mineral dusts produce disease.

Inhaled particles can be deposited in three regions in the respiratory system. These include the naso-pharyngeal region, the tracheo-bronchial tubes and the alveoli. Turbinates and hairs filter out the largest particles in the naso-pharyngeal section. The smallest particles travel to the alveoli which are the air sacs in the lungs where gas exchange takes place. As particles get smaller and smaller they will be more likely to deposit in the alveoli, making it more difficult for the particles to get trapped by the body's natural defenses.

There are some 300 million alveoli in two adult lungs. These provide a surface area of around 160 m^2 (almost equal to the singles area of a tennis court and 80 times the area of our skin). The most dangerous particles, in terms of mineral exposure, are those that are respirable. Respirable particles are 10 microns or less in size and are deposited in the alveoli where they can evade the lungs defenses. These particles are too small for the human eye to see.

The overall protective defenses of the lungs are very effective and capable of dealing with limited amounts of inhaled particulate matter. The site of particle deposition in the lungs and means of clearance is determined by the size of the particles and where the particles are deposited. Movement of a carpet of mucous by underlying cilia is known as the mucociliary escalator. This moves deposited particles from the middle tracheobronchial region to the upper regions of the respiratory system where they are eventually swallowed.

Macrophage engulfment is the most important removal mechanism in the lower regions of the respiratory system. In this process defensive cells consume particles and carry them out of the lungs. It is thought that pneumoconiosis develops when these cells are ruptured by mineral crystals and the cell's enzymes destroy lung tissue and the body replaces normal tissue with fibrotic scar tissue.

Silica

Two of the most abundant elements on earth are silicon and oxygen; the combination of these two produces silicon dioxide (SiO_2). Silica or silicon dioxide (SiO_2) exists in both crystalline and amorphous forms. Amorphous (noncrystalline) silica occurs in natural glasses (e.g., volcanic tuff) as well as synthetic glasses such as mineral wool.

Amorphous silica is characterized by a random, nonrepeating organization of silicon dioxide molecules. Amorphous forms of silica form when minerals are cooled very quickly and there is not enough time for crystals to develop. Amorphous forms of silica do not pose a health hazard.

Crystalline forms of silicon dioxide are characterized by an organized, repeating pattern of molecules in a three-dimensional array commonly known as quartz. Crystalline forms of silica are produced by increased pressure and heat during formation in the earth's crust.

It is exposure to respirable concentrations of the crystalline form that is associated with the development of disease. Specifically, the crystalline forms of silica are primarily quartz, tridymite, and cristobalite. They have slightly different crystal structure. The most common forms of crystalline silica are found in sand and sandstone. In addition, crystalline silica may exist as minute grains cemented with amorphous silica and these composites include tripoli, flint, chalceony, agate, onyx, and silica flour.

Silica sand is used in many different products. Sand blasting is a common use since it is cheaper than alternatives that are less hazardous. Silica sand and silica flour is a common filler material in many products such as paints and plastics. Some other uses include:

- Abrasives (sand blasting) and polishing agents
- Extenders in paint, wood fillers, rubber, plastics, soaps
- Molding agent if foundries
- Raw material in concrete, bricks, tile, glass

Industries with potential silica exposure include:

- Quarrying & Mining
- Foundries
- Ceramics, Clay & Pottery
- Stone
- Glass
- Abrasives
- Agriculture
- Construction
- Electronics

Silicosis is the fibrotic disease caused by exposure to silica. The hallmark of silicosis is the presence of nodules in the lungs. These nodular lesions contain a central zone with extracellular silica particles surrounded by whorls of collagen and fibrotic tissue. The formation of these nodules is thought to occur because of surface properties of the silica particles that activate lung macrophages with the subsequent release of inflammatory mediators. It is thought that freshly fractured silica is more toxic because of reactive radical groups found on the freshly fractured surface.

Silicosis has a number of manifestations depending on the level of exposure. Chronic or Classic Silicosis occurs after 15–20 years or more of exposure to respirable crystalline silica. The presence of this form of silicosis is recognized by the appearance of the multiple small nodules on a chest radiograph. If the lesions of silica-induced lung disease remain as only individual small nodules (<5 millimeters in size), there is usually minimal if any physiological changes associated with the disease and, therefore, individuals usually have few if any symptoms. In this case, the disease is classified as Simple Silicosis. Chronic silicosis may go undetected for years in the early stages; in fact, a chest X-ray may not reveal an abnormality until after 15 or 20 years of exposure. If there is coalescence of the nodules over time with the formation of large masses (large opacities on the chest radiograph of >10 millimeters in diameter), the disease is then referred to a Progressive Massive Fibrosis or PMF. In this case, individuals with PMF can have reductions in lung function. The worker may have significant respiratory and systemic symptoms of shortness of breath, productive cough, chest discomfort, and weight loss. Silica-induced lung disease can progress once exposure ends. The body's ability to fight infections may be overwhelmed by silica dust in the lungs, making workers more susceptible to certain illnesses, such as tuberculosis. As the lung capacity decreases, the heart works harder trying to make up for the loss of oxygen in the blood. This usually leads to death from heart failure.

In accelerated silicosis the pathologic and radiographic changes of silicosis occur after only 5–10 years of exposure and result from higher concentrations of respirable crystalline silica exposure. Progression occurs in these cases even if the worker is removed from further exposure. Accelerated silicosis is usually fatal.

If the concentrations of respirable crystalline silica are extremely high, disease can occur in only a few months to a few years. Severe, disabling shortness of breath, weakness and weight loss can be seen with Acute Silicosis. An historical example of acute silicosis was the tragic situation of the Hawk's Nest Tunnel construction in the early 1930s near Gauley Bridge, West Virginia. Hundreds of workers died from acute and accelerated silicosis when they were exposed to extremely high concentrations of respirable silica by cutting through three miles of high-quartz sandstone without adequate respiratory protection.

The ACGIH (American Conference of Governmental Industrial Hygienists) has established a TLV (Threshold Limit Value) of 0.025 mg/m³ for respirable silica as an eight-hour time weighted average to prevent silicosis and lung cancer. The OSHA and MSHA PEL (Permissible Exposure Limit) for silica are dependent on the form of silica and the percentage of silica in the respirable dust fraction and follows the formula:

$$\frac{10\ mg/m^3}{\%\ Quartz + 2}$$

The PEL is out of date with the most recent studies and health data relating to silica. It is recommended that the TLV be used as the control level.

Although there is no specific OSHA silica standard at this point OSHA does have a special emphasis program in place with targeted inspections of industries with potential silica exposure. They also recommend a detailed baseline medical examination, pulmonary function testing and evaluation of work and medical history including past silica exposures. OSHA recommends a chest roentgenogram (X-ray), posteroanterior 14" x 17" or 14" x 14", classified according to the 1980 ILO International Classification of Radiographs of Pneumoconiosis (ILO, 1981), and read by a board-certified radiologist or certified class "B" reader (who is qualified to distinguish silicosis from asbestosis, coal miner's pneumoconiosis, and other pneumoconioses).

Asbestos

Asbestos is a term for a group of naturally occurring fibrous magnesium silicate minerals. Asbestos has good insulating properties, is fire resistant and the mineral fibers can be spun and made into fabrics. This lead to widespread use in the past. Asbestos was first used in ancient times but the industry developed in the late 1800s. The development of the auto industry after 1910 coincided with increased use of asbestos in industry and construction. The industry began to decline in the 1970s as health concerns were identified. US consumption decreased from 800,000 tons in 1973 to 4,600 tons in 2003. The low cost, reliability and unsophisticated technology required to make asbestos products were factors leading to its widespread use. About 37% of all asbestos used in the US occurred after 1965. Uses included:

- Flooring
- Pipe insulation
- Roofing products
- Friction products
- Gaskets and packing
- Paper
- Coatings and electrical insulation.

The concentration of asbestos workers were exposed to, the duration of that exposure and the use of respiratory protection are the most important factors in determining the disease risk. Since the latency period is more than 15 years for asbestos related diseases, the way things are now is not as important as the way things were in the past when evaluating potential risk. Controls were largely inadequate in the 1950s, 1960s and early 1970's when many of today's older workers began working. Lack of air monitoring and records in general make evaluation of exposure during this period difficult as well.

Asbestos may be present in many older buildings and building materials. Because asbestos fibers are so small and light, they stay suspended in the air for a long time. Damaged loose asbestos materials like insulation are more likely to release fibers than those bound in a matrix like plastic or cement. Construction and maintenance activities may potentially expose employees to asbestos. EPA has established strict rules regarding asbestos abatement and certification for employers performing abatement of asbestos in buildings.

There are a number of diseases caused by exposure to asbestos. These include:

- Cancers of lungs, colon, stomach, large intestine, esophagus
- Pleural Plaques- Scars on lining of chest walls
- Pleural Effusion- fluid buildup in lungs

Mesothelioma, also known as Asbestos Cancer, is a rare disease characterized by cancer of the pleura (chest cavity lining) or peritoneum (abdomen wall lining). It is caused by small asbestos fibers entering cells causing uncontrolled growth. This puts increased pressure on the lungs, heart and other internal organs.

Lung cancer is the most difficult disease to attribute to asbestos since 90% of lung cancer is caused by cigarette smoking and virtually all lung cancer patients who had asbestos exposure also have a history of smoking. Smoking does not cause asbestosis or mesothelioma but it is thought that smoking affects the lung's natural protection mechanisms making them more vulnerable. Smoking and asbestos exposure together greatly increase the risk for lung cancer through synergistic effects.

The ACGIH has established a TLV of 0.1 f/cc (fiber per cubic centimeter of air) as an eight-hour TWA for asbestos. OSHA's PEL for asbestos is also 0.1 f/cc.

Other Minerals

There are many other minerals that are mined and used in manufacturing and construction. In the pure form most of these minerals are considered nuisance dusts.

Contamination with silica or asbestos can make these minerals hazardous and has been the source of health hazards in the past.

Talc
Talc is a layered magnesium silicate mineral that can occur as platy, granular or fibrous forms or combinations of these forms. Talc is used widely in cosmetics, ceramics, paints, paper, plastics, rubber, roofing, filtration agents, insecticides and other products.

Talc ores vary widely and may contain other minerals including asbestos. Adverse health effects are associated with these other contaminants. Studies have shown that the platy forms of talc free from asbestos represent a small respiratory hazard. Talc dust containing asbestos poses a significant hazard and dust exposures must be controlled in these situations. The ACGIH TLV for talc containing no asbestos and less than 1% silica is 2 mg/m^3 as respirable dust. When talc contains asbestos or silica, the asbestos or silica exposure limits should be applied.

Vermiculite
Vermiculite is a generic term for a group of nonfibrous ferromagnesium aluminum silicate minerals. These minerals have the property of expanding many times their size. When heated very rapidly above 870° C, water between the layers of the mineral flashes into steam which expands the flakes in an accordion-like fashion. This process is called exfoliation and results in a very lightweight chemically inert material that is fire resistant. Vermiculite is used in plaster, concrete, and other applications requiring thermal insulation. Vermiculite is often used as loose-fill insulation in buildings. It can also absorb liquids such as fertilizers, herbicides and insecticides, which can then be transported and used as free-flowing solids.

Pure vermiculite is considered a nuisance dust without significant health concerns. Some vermiculite ores can contain impurities such as asbestos which pose a significant hazard. Vermiculite ore from Libby, Montana was the first commercial mine and produced half the worldwide production from 1925 to 1990. This ore was contaminated with asbestos which caused significant health problems in the mines, mills and with other workers using the material. The mine was closed in 1990 due to these health hazards.

Products containing vermiculite from Libby, Montana should always be presumed to contain asbestos and must be treated accordingly. Respiratory protection should always be worn during construction or renovation of old buildings containing loose-fill vermiculite insulation due to the potential for asbestos contamination.

Perlite
Perlite is a volcanic glass that cooled very rapidly during formation. This prevented crystals from forming and prevented water from escaping. When heated to 870° C, the water is turned to vapor which expands the mineral to as much as 20 times its volume. Because of its very light weight and fire resistant properties, perlite is used in ceiling tiles, roof insulation, refractory bricks, pipe insulation, and noise reduction. It is used as a filter media for pharmaceuticals, chemicals and beverages and as filler in cement and plastics. It is also commonly added to potting soil to increase the amount of air and water retained in the soil.

The ACGIH does not have an exposure limit for perlite. OSHA considers perlite to be a nuisance dust with an exposure limit of 15 mg/m^3 for total dust and 5 mg/m^3 for respirable dust.

Bentonite
Bentonite is a clay mineral formed when very fine volcanic ash was deposited in a lake or ocean millions of years ago. Bentonite takes its name from Fort Benton, Wyoming where it was first mined. Bentonite is mined from open pits, is ground in mills, dried in kilns and then shipped to customers. Bentonite expands when wet and is able to absorb several times its mass in water. These properties make it ideal for sealing wells and its most common use is in water well and oil drilling. Other common uses include filler for paints, as a foundry sand bonding agent, filtering agent for liquids, pharmaceuticals, cosmetics and animal feeds. Cases of pneumoconiosis have been documented among bentonite miners and millers but it is believed to be due to the presence of silica in the clays. There are no exposure limits for bentonite and it should be considered a nuisance dust.

Kaolin
Kaolin is another type of clay also known as China clay. Kaolin is widely used as a filler in ceramics, paper, paint and plastics. It is also used in glass manufacture, pottery, and porcelain, bricks, soap and textile production. High purity kaolin is also used in medicine and cosmetics.

Kaolin often contains crystalline silica and this can be a significant hazard. Studies have shown that kaolin dust has a fibrotic potential even in the absence of silica. Consequently, the ACGIH TLV for Kaolin is 2 mg/m^3 for the respirable fraction. OSHA considers Kaolin to be a nuisance dust but this classification appears to be inadequate due to its fibrotic potential in the lungs.

Diatomaceous Earth

Diatomaceous earth is composed of skeletons of diatoms (a type of algae) deposited millions of years ago. In the natural state the skeletons are composed of an amorphous, nonfibrous silicate. For industrial applications, diatomaceous earth is calcined (incinerated at high temperature) which produces crystalline silica. Natural diatomaceous earth contains about 1% crystalline silica but after calcining it may be 90%. This makes exposure to diatomaceous earth dust extremely hazardous. Diatomaceous earth is used as a filtering agent, in pottery glazes, abrasive lubricants and lining molds in foundries. There are no specific diatomaceous earth exposure limits but due to the silica hazard, the silica exposure limits are applicable.

Gypsum

Gypsum is a mineral composed of calcium sulfate. It occurs naturally bound with water molecules and when it is heated and this water is driven off, it becomes Plaster of Paris. Common uses include drywall, plaster, soil treatment, Portland cement, water clarification, and animal feed. Food and pharmaceutical grade gypsum is used as a source of calcium in foods. The most significant occupational exposure we encounter from a loss control perspective is in construction and drywall work. Pure gypsum containing no asbestos and <1 % silica poses a minimal health hazard and is classified as a nuisance dust.

Loss Control Issues

The most significant issue from a loss control perspective with minerals is dust exposure and the potential for occupational disease claims. Loss controls staff should provide underwriting with a thorough description of the process, the types of raw materials including minerals used in the process and controls in place to protect employees from these hazards. Find out if the company has done any air testing and get copies of the results for review by the Loss Control Technical Lead- EH specialist.

Asbestos has been highly regulated since the 1970s and strict controls are in place regarding asbestos remediation. Contractors renovating old buildings have the most significant potential exposure. Asbestos should be remediated from these buildings by certified remediation contractors before other construction activities begin. Asbestos could still be present if remediation was not completed properly or if sources of asbestos containing materials were not identified. Silica is the most common mineral dust loss control staff will encounter. Dusts associated with quarries and mines, construction, demolition, concrete, masonry work, stone and granite work all have a high potential for containing silica. In these situations, respirators are usually required. Since we cannot perform exposure monitoring for every account we insure and there is a potential for asbestos, silica and other hazards including lead and fiberglass, a good rule of thumb for construction exposures is that employees should at least wear a disposable particulate respirator (dust mask) whenever they are exposed to any type of dust.

In manufacturing operations pay particular attention to bagging stations where dry products like concrete mixes are packaged. In other operations opening bags containing minerals and clays, weighing raw materials and dumping contents into mixers are probably the most significant source of dust exposures. Respiratory protection is usually required for these exposures.

Local exhaust ventilation and dust collection systems are important engineering controls to reduce exposures. Operations can be enclosed and hoods can be placed at sources of dust or on tools to collect dust. Use of water and wet methods of cutting can provide one of the most effective means of dust control. The use of air hoses and dry sweeping should be avoided during clean-up. HEPA equipped vacuums should be used instead. There are also many substitutes for silica sand for abrasive blasting. Aluminum oxide and glass or steel beads can be used instead in most cases.