

ASBESTOS

The term Asbestos refers to six regulated, naturally occurring fibrous silicate minerals:
Chrysotile, Amosite, Crocidolite, Anthophyllite, Tremolite, Actinolite.

Of the six, **Chrysotile, Amosite and Crocidolite** are the most commonly used.

Asbestos was used even by the ancient Greeks and Romans. In fact the word "asbestos" is derived from the Greek meaning "inextinguishable". When processed (milled), asbestos separates into very thin fibers. These fibers are stronger than steel, making it attractive for a wide range of applications.

When disturbed, asbestos has the potential to release fibers into the air. These fibers, so small that they are typically invisible to the naked eye, can remain airborne for extended periods. When inhaled they pose serious health issues including:

Asbestosis – A disease characterized by pulmonary fibrosis. This is a progressive scarring of the lung tissue. It is associated exclusively with chronic occupational exposure to asbestos. Symptoms are shortness of breath, cough, and fatigue.

Lung Cancer – A malignant tumor of the covering of the bronchi. Early symptom is a persistent cough such as in bronchitis. Chest X-Rays sometimes show shadows that indicate tumors. The definitive test is a biopsy with microscopic analysis. The latency period is typically 20-30 years.

Mesothelioma – Cancer of the lining of the chest or abdominal wall. Few symptoms early on. By the time it is diagnosed it is almost always fatal. As with lung cancer the latency period is extended (typically 30-40 years).

Common Uses:

From 1935 to the mid 1970's asbestos was applied extensively to buildings. Chrysotile and Amosite, both separately and in blends were the predominant asbestos types used. Under the clean air act of 1970, the EPA began regulating asbestos containing materials (ACM) which they defined as >1% asbestos. Although its current use in the U.S. is minimal, there is still a strong international market and imported products may therefore contain asbestos.

- **Spray On Insulation**
- **Flooring Felt (up to 85% asbestos)**
- **Roofing Felt (up to 85% asbestos)**
- **Corrugated sheets for Pipe Wrap (up to 85% asbestos)**
- **Millboard and Roll Board (up to 95% asbestos)**
- **Cooling Tower fill**
- **Auto Brakes, Mufflers and Transmission disks (up to 80% asbestos)**
- **Filters in beverage making**
- **Insulation on wires and appliances**
- **Asbestos Cement pipes (up to 20% asbestos)**
- **Floor Tile (up to 30% asbestos)**
- **Sealants, Adhesives, Mastics and Paints (up to 30% asbestos)**
- **Packings and Gaskets (up to 90% asbestos)**
- **Textiles (curtains, mattresses, gloves, hats)**
- **Road surfacing and pavement**
- **Shotgun shell base wads**

Chrysotile

Chemical formula: $Mg_3Si_2O_5(OH)_2$

Source: Quebec, California, Vermont, Soviet Union, and the Italian Alps

Overview:

Chrysotile, also known as "white asbestos", is one of three main members of the serpentine mineral group. The other two, tremolite and actinolite, although more abundant in nature are not regulated minerals. The serpentines are typically found in metamorphic rock.

Chrysotile is by far the most commonly used asbestos type and accounts for approximately 95% of asbestos found in U.S. buildings. In some asbestos mines the fibers are quite long making it conducive to weaving into fire and heat resistant textiles.

Chrysotile is a hydrous magnesium silicate. It has a layered structure. One layer has linked silica tetrahedra Si_2O_5 which bind to a brucite $Mg(OH)_2$ layer at the apical O and OH groups yielding an overall mineral chemistry of close to $Mg_3Si_2O_5(OH)_2$. Because of a mismatch in size of the two layers a curvature develops resulting in tightly wrapped concentric tubes. The resultant fibers are easily separated, strong, and very flexible. The unique internal structure aids in the identification of chrysotile. Although not as acid resistant as the other asbestos types, it has the highest tensile strength.

Chrysotile chemistry is fairly constant although there can be some substitution by Fe and Ni for Mg and Al for some Si. Magnesium replacement by iron is small but common.

By Polarized Light Microscopy (PLM) chrysotile bundles typically appear curved or even wavy. A common occurrence is the presence of kinks or "knozzles" in the length of the bundle. The split and/or split ends of many bundles give a broomstick appearance. Chrysotile is monodimorphic and has a positive sign of elongation. Its γ (gamma) refractive index value is less than 1.58. Individual fibers and even small bundles are beyond the resolution of light microscopy and TEM is often suggested to reduce the chance of false negatives or under estimation. By TEM, chrysotile fibrils display a characteristic internal tube structure and Electron Diffraction pattern, produced by the scrolling of chrysotile's curved sheets of tetrahedral and octahedral layers.

Uses:

Spray-on insulation, asbestos cement, pipe and boiler insulation, brake linings, fire blankets and other fire proof and fire resistant textiles, roofing felts, mastics, putties and caulks, gaskets and ropes, transite panels and asbestos reinforced plastics (switchboards, insulation boards)

Anthophyllite

Chemical formula: $Mg_2Si_2O_5(OH)_2 \sim Mg_2Fe^{2+}_2Si_2O_5(OH)_2$

Sources: Finland, U.S. and Canada

Overview:

Anthophyllite can be white, gray, green, or brown. It is a non-conductor of electricity. Its fibers are extremely thin and flat and often pointed at one end like a knife blade.

Anthophyllite is an orthorhombic amphibole and is a solid solution mineral so there is some variability in the chemical composition. Anthophyllite chemistry usually contains some Fe and the occurrence of an end member species without Fe is rare. When crystal chemistry exceeds 2 molecular units of Fe, a monoclinic crystal structure forms and the mineral species is called cummingtonite and is part of the cummingtonite-grunerite solid solution.

By Polarized Light Microscopy (PLM) anthophyllite fibers have perfect parallel extinction which helps to distinguish it from the Actinolite-Tremolite series. The refractive indices range from approx. 1.623-1.676. Anthophyllite has moderate birefringence and is a member of the amphibole double chain silicate group. Random orientation SAED of Anthophyllite shows a layline spacing of 5.3 Å. Patterns may show preferred orientation for a zone axis pattern.

Anthophyllite may be found in a variety of materials as cleavage fragments with mean aspect ratios <20:1. The occurrence of these fibers is usually associated with mechanical processes either in the production or in the analysis of the material.

Uses:

This type of asbestos is generally not found in building materials except as a contaminant from its talc component.

Amosite

Chemical formula: $(Mg_{1-x}Fe_x)_2Si_2O_5(OH)_2 \sim Fe_2Si_2O_5(OH)_2$

Source: Predominant source is South Africa

Overview:

Amosite (Grunerite) is also known as "brown asbestos". It is the second most common asbestos type used (about 5% of asbestos found in building materials). Asbestiform grunerite is commercially known as Amosite due to one of its main sources, AMOSA (Asbestos Mines of South Africa). Its true mineralogical name is Grunerite.

Grunerite fibers are thicker and much straighter than chrysotile. The fibers have excellent acid resistance and are a non-conductor of electricity.

Its high iron content characterizes Amosite chemistry. Amosite is a member of the Cummingtonite - Grunerite solid solution and as such does not have a definite chemical formula; any particular occurrence may have a composition anywhere within the grunerite range. Amosite asbestos is typically close to the Mg rich end member of grunerite but not so Mg rich that it would be classified as cummingtonite. Mn substitution exists with most Mn replacing Fe in the M₂ structural site. Grunerite is a member of the amphibole double chain silicates.

By Polarized Light Microscopy (PLM) Amosite fibers tend to be thick and blocky but at times can also appear quite long and thin (needle like). Amosite is monoclinic and has a positive sign of elongation. It is typically non-birefringent. The refractive index ranges are 1.654-1.686 for α and 1.687-1.729 for γ and vary depending on the exact elemental composition. Random orientation SAED of Amosite shows a layline spacing of 5.3 Å with twinning often present.

Uses:

Acid storage battery casings
Asbestos Cement
Spray on Insulation
Ceiling tiles
Asbestos reinforced plastics
Pipe and Boiler insulation
Transite Paneling - along with chrysotile and crocidolite

Actinolite

Chemical formula:

Actinolite: $CaMg_4Fe^{2+}_2Si_8O_{22}(OH)_2 \sim CaMg_3Fe^{2+}_3Si_8O_{22}(OH)_2$

Sources: Actinolite was seldom mined commercially. It is typically found as a contaminant such as in the Vermiculite mines of Libby, MT and the talc mines of Norway and Sweden.

Overview:

Actinolite is part of a complete solid solution series from Tremolite to Ferroactinolite. All members differ by their relative amounts of Magnesium and Iron. Tremolite is at one end of the scale with a higher Mg to Iron ratio. When the total atomic Fe content to total Fe + Mg exceeds 10% the species is no longer called Tremolite and is now Actinolite. As the iron content increases to >50% the mineral is now classified as ferroactinolite. At this solid solution series only Tremolite and Actinolite are regulated.

Actinolite is monoclinic and can exhibit inclined extinction by PLM. Actinolite can exhibit some pleochroism, the strength of which is related to its iron content. Actinolite is pale to dark green in plane polarized light. Random orientation SAED of actinolite shows a layline spacing of 5.3 Å with twinning being uncommon. Actinolite is a member of the amphibole double chain silicate group.

Uses:

Uncommon in building materials except as a contaminant, contaminant in talc and some vermiculites, present in some soils as is the case in California.

Crocidolite

Chemical formula: $NaMg_3Fe^{2+}_3Si_3O_{10}(OH)_2 \sim NaFe^{2+}_3Fe^{3+}_3Si_3O_{10}(OH)_2$

Sources: South Africa and Australia

Overview:

Crocidolite is the name for asbestiform riebeckite. It is also known as "blue asbestos". It is a fairly rare form of asbestos. It has excellent acid resistance and is a non-conductor of electricity. The fibers have greater tensile strength but lower heat resistance than chrysotile.

Crocidolite is a monoclinic solid solution amphibole so there is some variation in the chemical composition. Crocidolite chemistry is characterized by its Sodium content. There can be substitution between Magnesium and Iron.

By Polarized Light Microscopy (PLM) the prismatic crystals of crocidolite fibers tend to be thin and needle like. Crocidolite is monoclinic and has a negative sign of elongation. Its strong pleochroism aids in its identification. Its negative sign of elongation is also characteristic. The refractive indices range from approximately 1.670-1.717. It is a member of the amphibole double chain silicate group. Random orientation SAED of Crocidolite shows a layline spacing of 5.3 Å with twinning sometimes present.

Distinguishing Characteristics:

Distinct pleochroism
Negative sign of elongation
Fibers appear long and straight much like Amosite but much thinner, more like chrysotile

Uses:

Acid storage battery casings
Spray on Insulation
Millboards (commercial ovens and steam pipes)
Transite paneling along with chrysotile and amosite

Tremolite

Chemical formula:

Tremolite: $CaMg_5Si_8O_{22}(OH)_2 \sim CaMg_4Fe^{2+}_1Si_8O_{22}(OH)_2$

Sources: Tremolite is named for the locality, Val Tremola, in Italy.

Overview:

Tremolite is part of a complete solid solution series from Tremolite to Ferroactinolite. All members differ by their relative amounts of Magnesium and Iron. Tremolite is at one end of the scale with a higher Mg to Iron ratio. When the total atomic Fe content to total Fe + Mg exceeds 10% the species is no longer called Tremolite and is now Actinolite. As the iron content increases to >50% the mineral is now classified as ferroactinolite. In this solid solution series only Tremolite and Actinolite are regulated.

Tremolite is monoclinic and can exhibit inclined extinction by PLM. Tremolite's extinction angle may be as high as 15-20°. By PLM Tremolite is non-birefringent. Tremolite is colorless. The refractive index typically varies from 1.60 to 1.65 with moderate birefringence. Random orientation SAED of Tremolite shows a layline spacing of 5.3 Å with twinning being uncommon. Tremolite is a member of the amphibole double chain silicate group.

Uses:

Uncommon in building materials except as a contaminant, contaminant in talc and some vermiculites, present in some soils as is the case in California.



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