[Template:Very long](/wiki/Template:Very_long" \o "Template:Very long) [Template:Other uses](/wiki/Template:Other_uses) [Template:Use dmy dates](/wiki/Template:Use_dmy_dates) [Template:Infobox mineral](/wiki/Template:Infobox_mineral) [right|thumb|Asbestos](/wiki/File:Asbestos2USGOV.jpg) [thumb|Asbestos](/wiki/File:Asbestos3USGOV.jpg) [thumb|](/wiki/File:Blue_asbestos.jpg)[Blue asbestos](/wiki/Blue_asbestos) (crocidolite) from [Wittenoom, Western Australia](/wiki/Wittenoom,_Western_Australia). The ruler is 1 cm. [thumb|](/wiki/File:Blue_asbestos_(teased).jpg)[Blue asbestos](/wiki/Blue_asbestos), teased to show the fibrous nature of the mineral (from mine at [Wittenoom, Western Australia](/wiki/Wittenoom,_Western_Australia)) **Asbestos** (pronounced [Template:IPAc-en](/wiki/Template:IPAc-en), [Template:IPAc-en](/wiki/Template:IPAc-en) or [Template:IPAc-en](/wiki/Template:IPAc-en)) is a set of six naturally occurring [silicate minerals](/wiki/Silicate_minerals),<ref name=Alleman&Mossman1997/> which all have in common their [eponymous](/wiki/Eponymous) [asbestiform](/wiki/Asbestiform) [habit](/wiki/Crystal_habit): long (roughly 1:20 [aspect ratio](/wiki/Aspect_ratio)), thin [fibrous](/wiki/Fibrous) [crystals](/wiki/Crystal), with each visible fiber composed of millions of microscopic "fibrils" that can be released by [abrasion](/wiki/Abrasion_(mechanical)) and other processes.[[1]](#cite_note-1) They are commonly known by their colors, as *blue asbestos*, *brown asbestos*, *white asbestos*, and *green asbestos*.

Asbestos mining existed more than 4,000 years ago, but large-scale mining began at the end of the 19th century, when manufacturers and builders began using asbestos for its desirable physical properties:<ref name=Alleman&Mossman1997/> [sound absorption](/wiki/Absorption_(acoustics)), average [tensile strength](/wiki/Tensile_strength), [resistance to fire](/wiki/Flame-retardant), heat, electricity, and affordability. It was used in such applications as [electrical insulation](/wiki/Electrical_insulation) for hotplate wiring and in [building insulation](/wiki/Building_insulation). When asbestos is used for its resistance to fire or heat, the fibers are often mixed with cement or woven into fabric or mats. These desirable properties made asbestos very widely used. Asbestos use continued to grow through most of the 20th century until public knowledge (acting through courts and legislatures) of the health hazards of asbestos dust outlawed asbestos in mainstream construction and [fireproofing](/wiki/Fireproofing) in most countries.

Prolonged [inhalation](/wiki/Inhalation) of asbestos fibers can cause serious and fatal illnesses including [lung cancer](/wiki/Lung_cancer), [mesothelioma](/wiki/Mesothelioma), and [asbestosis](/wiki/Asbestosis) (a type of [pneumoconiosis](/wiki/Pneumoconiosis)).[[2]](#cite_note-2)[[3]](#cite_note-3) Illness from asbestos exposure can be found in records dating back to [Roman times](/wiki/Roman_Britain). Concern in modern times began in the 20th century and escalated during the 1920s and 1930s. By the 1980s and 1990s, asbestos trade and use were heavily restricted, phased out, or banned outright in an increasing number of countries.

The severity of asbestos-related diseases, the material's extremely widespread use in many areas of life, its continuing long-term use after harmful health effects were known or suspected, and the slow emergence of symptoms decades after exposure ceased, made [asbestos litigation](/wiki/Asbestos_and_the_law) the longest, most expensive mass [tort](/wiki/Tort) in [U.S. history](/wiki/History_of_the_United_States) and a much lesser legal issue in most other countries involved.[[4]](#cite_note-4) Asbestos-related [liability](/wiki/Legal_liability) also remains an ongoing concern for many manufacturers, [insurers and reinsurers](/wiki/Insurance_industry).

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## Etymology[[edit](/index.php?title=(none)&action=edit&section=1)]

Asbestos derives from the Greek *asbeston*, meaning unquenchable.[[5]](#cite_note-5)

## Types and associated fibers[[edit](/index.php?title=(none)&action=edit&section=2)]

[thumb|left|Chrysotile asbestos](/wiki/File:Asbestos1USGOV.jpg) [thumb|left|Asbestos fibers](/wiki/File:Asbestos_fibres.jpg) Six mineral types are defined by the [United States Environmental Protection Agency](/wiki/United_States_Environmental_Protection_Agency) as "asbestos" including those belonging to the serpentine class and those belonging to the amphibole class. All six asbestos mineral types are known to be human [carcinogens](/wiki/Carcinogens).[[6]](#cite_note-6)[[7]](#cite_note-7) The visible fibers are themselves each composed of millions of microscopic "fibrils" that can be released by [abrasion](/wiki/Abrasion_(mechanical)) and other processes.[[1]](#cite_note-1)

### Serpentine[[edit](/index.php?title=(none)&action=edit&section=3)]

Serpentine class fibers are curly. [Chrysotile](/wiki/Chrysotile) is the only member of the serpentine class.

#### Chrysotile[[edit](/index.php?title=(none)&action=edit&section=4)]

[Chrysotile](/wiki/Chrysotile), [CAS No.](/wiki/CAS_registry_number) 12001-29-5, is obtained from [serpentinite](/wiki/Serpentinite) rocks which are common throughout the world. Its idealized [chemical formula](/wiki/Chemical_formula) is [Mg](/wiki/Magnesium)[Template:Sub](/wiki/Template:Sub)([Si](/wiki/Silicon)[Template:Sub](/wiki/Template:Sub)[O](/wiki/Oxygen)[Template:Sub](/wiki/Template:Sub))([OH](/wiki/Hydroxide))[Template:Sub](/wiki/Template:Sub).[[8]](#cite_note-8) Chrysotile appears under the microscope as a white fiber.

Chrysotile has been used more than any other type and accounts for about 95% of the asbestos found in buildings in America.<ref name=wdnr>[Template:Cite web](/wiki/Template:Cite_web)</ref> Chrysotile is more flexible than amphibole types of asbestos, and can be spun and woven into fabric. The most common use was corrugated asbestos cement roofing primarily for outbuildings, warehouses and garages. It may also be found in sheets or panels used for ceilings and sometimes for walls and floors. Chrysotile has been a component in [joint compound](/wiki/Joint_compound) and some plasters. Numerous other items have been made containing chrysotile including brake linings, fire barriers in fuseboxes, pipe insulation, floor tiles, residential shingles, and gaskets for high temperature equipment.[Template:Citation needed](/wiki/Template:Citation_needed)

### Amphibole[[edit](/index.php?title=(none)&action=edit&section=5)]

Amphibole class fibers are needle-like. [Amosite](/wiki/Amosite), [crocidolite](/wiki/Crocidolite), [tremolite](/wiki/Tremolite), [anthophyllite](/wiki/Anthophyllite) and [actinolite](/wiki/Actinolite) are members of the amphibole class.

#### Amosite[[edit](/index.php?title=(none)&action=edit&section=6)]

[Amosite](/wiki/Amosite), CAS No. 12172-73-5, often referred to as brown asbestos, is a [trade name](/wiki/Trade_name) for the amphiboles belonging to the [cummingtonite](/wiki/Cummingtonite)-[grunerite](/wiki/Grunerite) [solid solution](/wiki/Solid_solution) series, commonly from South Africa, named as a partial [acronym](/wiki/Acronym) for "Asbestos Mines of South Africa". One formula given for amosite is [Fe](/wiki/Iron)7Si8O22(OH)2. Amosite is seen under a microscope as a grey-white vitreous fiber. It is found most frequently as a fire retardant in thermal insulation products, [asbestos insulating board](/wiki/Asbestos_insulating_board) and ceiling tiles.[[9]](#cite_note-9)

#### Crocidolite[[edit](/index.php?title=(none)&action=edit&section=7)]

[Crocidolite](/wiki/Crocidolite), CAS No. 12001-28-4, is the fibrous form of the amphibole [riebeckite](/wiki/Riebeckite), found primarily in southern Africa, but also in Australia and Bolivia. One formula given for crocidolite is [Na](/wiki/Sodium)2Fe2+3Fe3+2Si8O22([OH](/wiki/Hydroxyl))2. Crocidolite is seen under a microscope as a blue fiber.

[Crocidolite](/wiki/Crocidolite) commonly occurs as soft [friable](/wiki/Friability) fibers. Asbestiform amphibole may also occur as soft friable fibers but some varieties such as amosite are commonly straighter. All forms of asbestos are fibrillar in that they are composed of fibers with breadths less than 1 [micrometer](/wiki/Micrometre) in bundles of very great widths. Asbestos with particularly fine fibers is also referred to as "amianthus".

#### Other materials[[edit](/index.php?title=(none)&action=edit&section=8)]

Other regulated asbestos minerals, such as tremolite asbestos, CAS No. 77536-68-6, [Ca](/wiki/Calcium)2Mg5Si8O22(OH)2; actinolite asbestos, CAS No. 77536-66-4, Ca2(Mg, Fe)5(Si8O22)(OH)2; and anthophyllite asbestos, CAS No. 77536-67-5, (Mg, Fe)7Si8O22(OH)2; are less commonly used industrially but can still be found in a variety of construction materials and insulation materials and have been used in a few [consumer products](/wiki/Product_(business)).

[thumb|Size of asbestos fibers compared to other particles (USEPA, March 1978)](/wiki/File:Epa_450_2-78-014_march_1978_asbestos_comparison.JPG) Other natural asbestiform minerals, such as [richterite](/wiki/Richterite), Na(CaNa)(Mg, Fe++)5(Si8O22)(OH)2, and [winchite](/wiki/Winchite), (CaNa)Mg4(Al, Fe3+)(Si8O22)(OH)2, though not regulated, are said by some to be no less harmful than tremolite, amosite, or crocidolite.[[10]](#cite_note-10) They are termed "asbestiform" rather than asbestos. Although the U.S. [Occupational Safety and Health Administration](/wiki/Occupational_Safety_and_Health_Administration) (OSHA) has not included them in the asbestos standard, NIOSH and the American Thoracic Society have recommended them for inclusion as regulated materials because they may also be hazardous to health.[[10]](#cite_note-10)

## Producing nations[[edit](/index.php?title=(none)&action=edit&section=9)]

In 2009, 2 million [tonnes](/wiki/Tonne) of asbestos were mined worldwide. The Russian Federation was the largest producer with about 50% world share followed by China (14%), Brazil (12.5%), Kazakhstan (10.5%) and Canada (9%).[[11]](#cite_note-11) In late 2011, Canada's remaining two asbestos mines, both located in the [Province of Quebec](/wiki/Province_of_Quebec), halted operations.[[12]](#cite_note-12) In September 2012, the government in the Province of Quebec halted asbestos mining.[[13]](#cite_note-13)

## History of use[[edit](/index.php?title=(none)&action=edit&section=10)]

[Template:Refimprove](/wiki/Template:Refimprove)

### Early uses[[edit](/index.php?title=(none)&action=edit&section=11)]

Asbestos use dates back at least 4,500 years, when the inhabitants of the Lake [Juojärvi](/wiki/Juojärvi) region in East [Finland](/wiki/Finland) strengthened earthenware pots and cooking utensils with the asbestos mineral anthophyllite (see [Asbestos-ceramic](/wiki/Asbestos-ceramic)).<ref name=Ross&Nolan2003>[Template:Cite book](/wiki/Template:Cite_book)</ref> The word *asbestos* comes from the [ancient Greek](/wiki/Ancient_Greece) ἄσβεστος, meaning "unquenchable" or "inextinguishable".<ref name=Alleman&Mossman1997>[Template:Cite journal](/wiki/Template:Cite_journal)</ref><ref name=Bostock&Riley1856>[Template:Cite book](/wiki/Template:Cite_book)</ref> One of the first descriptions of a material that may have been asbestos is in [Theophrastus](/wiki/Theophrastus), *On Stones*, from around 300 BC, although this identification has been questioned.[[14]](#cite_note-14) In both modern and ancient [Greek](/wiki/Greek_language), the usual name for the material known in English as "asbestos" is *amiantos* ("undefiled", "pure") whence the term for it in, *e.g.*, French *amiante* and Portuguese *amianto*. In [modern Greek](/wiki/Modern_Greek), the word ἀσβεστος or ασβέστης stands consistently and solely for [lime](/wiki/Lime_(mineral)).

The term *asbestos* is traceable to Roman naturalist [Pliny the Elder's](/wiki/Pliny_the_Elder) manuscript [*Natural History*](/wiki/Natural_History_(Pliny)), and his use of the term *asbestinon*, meaning "unquenchable".<ref name=Alleman&Mossman1997/><ref name=Ross&Nolan2003/><ref name=Bostock&Riley1856/> While Pliny is popularly credited with recognising the detrimental effects of asbestos on human beings,[[15]](#cite_note-15) it has been said that examination of the primary sources reveals no support for that claim.<ref name=Maines2005>[Template:Cite book](/wiki/Template:Cite_book)</ref>

Wealthy [Persians](/wiki/Persian_people) amazed guests by cleaning a cloth by exposing it to fire. For example, according to [Tabari](/wiki/Muhammad_ibn_Jarir_al-Tabari), one of the curious items belonging to [Khosrow II](/wiki/Khosrow_II) Parviz, the great [Sassanian](/wiki/Sassanian) king (r. 531–579), was a napkin ([Template:Lang-fa](/wiki/Template:Lang-fa)) that he cleaned simply by throwing it into fire. Such cloth is believed to have been made of asbestos imported over the [Hindu Kush](/wiki/Hindu_Kush).[[16]](#cite_note-16) According to [Biruni](/wiki/Biruni#ref-16) in his book, *Gems*, any cloths made of asbestos ([Template:Lang-fa](/wiki/Template:Lang-fa), *āzarshost*) were called *shostakeh* ([Template:Lang-fa](/wiki/Template:Lang-fa)).[[17]](#cite_note-17) Some Persians believed the fiber was the fur of an animal, called the [*samandar*](/wiki/Salamander_(legendary_creature)) ([Template:Lang-fa](/wiki/Template:Lang-fa)), which lived in fire and died when exposed to water,[[18]](#cite_note-18)[[19]](#cite_note-19) whence the former belief that the [salamander](/wiki/Salamander) could tolerate fire.[[20]](#cite_note-20) [Charlemagne](/wiki/Charlemagne), the first [Holy Roman Emperor](/wiki/Holy_Roman_Emperor) (800–814), is said to have had a tablecloth made of asbestos.[[21]](#cite_note-21) [Marco Polo](/wiki/Marco_Polo) recounts having been shown, in a place he calls *Ghinghin talas*, "a good vein from which the cloth which we call of salamander, which cannot be burnt if it is thrown into the fire, is made ..."[[22]](#cite_note-22) Some archeologists believe that ancients made shrouds of asbestos, wherein they burned the bodies of their kings, in order to preserve only their ashes, and prevent them being mixed with those of wood or other combustible materials commonly used in funeral pyres.<ref name=histsci>[History of science](http://digicoll.library.wisc.edu/cgi-bin/HistSciTech/HistSciTech-idx?type=turn&entity=HistSciTech000900240192&isize=L) This article incorporates content from the 1728 Cyclopaedia, a publication in the public domain.</ref>[Template:Page needed](/wiki/Template:Page_needed)[Template:Unreliable source?](/wiki/Template:Unreliable_source?)[[23]](#cite_note-23) Others assert that the ancients used asbestos to make perpetual wicks for [sepulchral](/wiki/Sepulchre) or other lamps.[[18]](#cite_note-18) In more recent centuries, asbestos was indeed used for this purpose. Although asbestos causes skin to itch upon contact, [ancient literature](/wiki/Ancient_literature) indicates that it was prescribed for diseases of the skin, and particularly for the itch. It is possible that they used the term *asbestos* for [soapstone](/wiki/Soapstone), because the two terms have often been confused throughout history.<ref name=histsci/>[Template:Page needed](/wiki/Template:Page_needed)

### Industrial era[[edit](/index.php?title=(none)&action=edit&section=12)]

[thumb|right|Industrial scale asbestos mining began in 1878 in](/wiki/File:Asbestos_mining_1876.jpg) [Thetford township](/wiki/Thetford_Mines), [Quebec](/wiki/Quebec). By 1895, mining was increasingly mechanized. The large scale asbestos industry began in the mid-19th century. Early attempts at producing asbestos paper and cloth in Italy began in the 1850s, but were unsuccessful in creating a market for such products. Canadian samples of asbestos were displayed in London in 1862, and the first companies were formed in England and Scotland to exploit this resource. Asbestos was first used in the manufacture of yarn, and German industrialist Louis Wertheim adopted this process in his factories in Germany. [[24]](#cite_note-24) In 1871, the Patent Asbestos Manufacturing Company was established in Glasgow, and within the following decades, the [Clydebank](/wiki/Clydebank) area became a centre for the nascent industry.[[25]](#cite_note-25) Industrial scale mining began in the [Thetford hills](/wiki/Thetford_Mines), [Quebec](/wiki/Quebec) from the 1870s. Sir [William Edmond Logan](/wiki/William_Edmond_Logan) was the first to notice the large deposits of [chrysotile](/wiki/Chrysotile) in the hills in his capacity as head of [Geological Survey of Canada](/wiki/Geological_Survey_of_Canada). Samples of the minerals from here were displayed in London, and excited much interest.[[24]](#cite_note-24) With the opening up of the [Quebec Central Railway](/wiki/Quebec_Central_Railway) in 1876, mining entrepreneurs, such as [Andrew Stuart Johnson](/wiki/Andrew_Stuart_Johnson) established the asbestos industry in the province.[[26]](#cite_note-26) The 50 ton output of the mines in 1878 rose to over 10,000 tons in the 1890s with the adoption of machine technologies and expanded production.[[24]](#cite_note-24)[[27]](#cite_note-27) For a long time, the world's largest asbestos mine was the Jeffrey mine in the town of [Asbestos, Quebec](/wiki/Asbestos,_Quebec).[[28]](#cite_note-28) [thumb|left|The applications of asbestos multiplied at the end of the 19th century. This is an advertisement for an asbestos-lined](/wiki/File:Asbestos_iron_ad.jpg) [clothes iron](/wiki/Clothes_iron) from 1906. Asbestos production began in the [Urals](/wiki/Urals) of the [Russian Empire](/wiki/Russian_Empire) in the 1880s, and in the [Alpine regions](/wiki/Alps) of [Northern Italy](/wiki/Northern_Italy) with the formation in [Turin](/wiki/Turin) of the Italo-English Pure Asbestos Company in 1876, although this was soon swamped by the greater production levels from the Canadian mines. Mining also took off in [South Africa](/wiki/South_Africa) from 1893 under the aegis of the British businessman Francis Oates, the Director of the [De Beers](/wiki/De_Beers) company.[[29]](#cite_note-29) It was in South Africa that the production of amosite began in 1910. The U.S. asbestos industry had an early start in 1858, when fibrous anthophyllite was mined for use as asbestos insulation by the Johns Company, a predecessor to the current Johns Manville, at a quarry at Ward's Hill on Staten Island, New York.[[30]](#cite_note-30) US production began in earnest in 1899, with the discovery of large deposits in the [Belvidere Mountain](/wiki/Eden,_Vermont#Belvidere_Mountain).

The use of asbestos became increasingly widespread towards the end of the 19th century, when its diverse applications included fire retardant coatings, concrete, bricks, pipes and fireplace cement, heat, fire, and acid resistant gaskets, pipe insulation, ceiling insulation, fireproof drywall, flooring, roofing, lawn furniture, and drywall joint compound. In 2011 it was reported that over 50% of UK houses still contained asbestos, despite a ban on asbestos products some years earlier.[[31]](#cite_note-31) In Japan, particularly after [World War II](/wiki/World_War_II), asbestos was used in the manufacture of [ammonium sulfate](/wiki/Ammonium_sulfate) for purposes of rice production, sprayed upon the ceilings, iron skeletons, and walls of railroad cars and buildings (during the 1960s), and used for energy efficiency reasons as well. Production of asbestos in Japan peaked in 1974 and went through ups and downs until about 1990, when production began to drop dramatically.[[32]](#cite_note-32)

### Discovery of toxicity[[edit](/index.php?title=(none)&action=edit&section=13)]

*For additional chronological citations, see also,* [*List of asbestos disease medical articles*](/wiki/List_of_asbestos_disease_medical_articles)

[Pliny the Younger](/wiki/Pliny_the_Younger) wrote in AD 61–114 that slaves who worked with the mineral asbestos became ill.[[33]](#cite_note-33)<ref name=Garfinkel>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> Much later in 1899, Dr. Montague Murray noted the negative health effects of asbestos.<ref name=nih\_mp>[Template:Cite journal](/wiki/Template:Cite_journal)</ref> The first documented death related to asbestos was in 1906.<ref name=svdell\_hist>[Template:Cite web](/wiki/Template:Cite_web)</ref>

In the early 1900s researchers began to notice a large number of early deaths and lung problems in asbestos-mining towns. The first such study was conducted by Dr. H. Montague Murray at the [Charing Cross Hospital](/wiki/Charing_Cross_Hospital), [London](/wiki/London), in 1900, in which a postmortem investigation of a young man who had died from [pulmonary fibrosis](/wiki/Pulmonary_fibrosis) after having worked for 14 years in an asbestos textile factory, discovered asbestos traces in the victim's lungs. [Adelaide Anderson](/wiki/Adelaide_Anderson), the Inspector of Factories in Britain, included asbestos in a list of harmful industrial substances in 1902. Similar investigations were conducted in France and Italy, in 1906 and 1908, respectively.[[34]](#cite_note-34) [thumb|](/wiki/File:Nellie_Kershaw.jpg)[Nellie Kershaw](/wiki/Nellie_Kershaw), factory worker, whose death from [pulmonary asbestosis](/wiki/Asbestosis) was the first such case to be described in medical literature. [thumb|Fire-resistant asbestos fabric.](/wiki/File:Heat-resistant_asbestos_fabric.jpg) The first diagnosis of asbestosis was made in the UK in 1924.[[35]](#cite_note-35)[[36]](#cite_note-36) [Nellie Kershaw](/wiki/Nellie_Kershaw) was employed at [Turner Brothers Asbestos](/wiki/Turner_&_Newall) in [Manchester](/wiki/Manchester), [England](/wiki/England) from 1917, spinning raw asbestos fibre into yarn.[[36]](#cite_note-36)[[37]](#cite_note-37) Her death in 1924 led to a formal inquest. [Pathologist](/wiki/Pathology) Dr William Edmund Cooke testified that his examination of the lungs indicated old scarring indicative of a previous, healed, tuberculosis infection, and extensive [fibrosis](/wiki/Fibrosis), in which were visible "particles of mineral matter ... of various shapes, but the large majority have sharp angles."[[35]](#cite_note-35) Having compared these particles with samples of asbestos dust provided by Dr S.A. Henry, His Majesty's Medical Inspector of Factories, Cooke concluded that they "originated from asbestos and were, beyond a reasonable doubt, the primary cause of the fibrosis of the lungs and therefore of death".[[36]](#cite_note-36)[[38]](#cite_note-38) As a result of Cooke's paper, [parliament](/wiki/Parliament_of_the_United_Kingdom) commissioned an inquiry into the effects of asbestos dust by Dr E. R. A. Merewether, Medical Inspector of Factories, and [Template:Nowrap](/wiki/Template:Nowrap), a [factory inspector](/wiki/History_of_labour_law_in_the_United_Kingdom#Factory_and_Workshop_Act_1901) and pioneer of dust monitoring and control.[[1]](#cite_note-1) Their subsequent report, *Occurrence of Pulmonary Fibrosis & Other Pulmonary Affections in Asbestos Workers*, was presented to parliament on 24 March 1930.[[39]](#cite_note-39) It concluded that the development of asbestosis was irrefutably linked to the prolonged inhalation of asbestos dust, and included the first health study of asbestos workers, which found that 66% of those employed for 20 years or more suffered from asbestosis.[[1]](#cite_note-1) The report led to the publication of the first Asbestos Industry Regulations in 1931, which came into effect on 1 March 1932.<ref name=sb\_classpap>[Template:Cite web](/wiki/Template:Cite_web)</ref> These regulated ventilation and made [asbestosis](/wiki/Asbestosis) an excusable work-related disease.[[8]](#cite_note-8) The term [mesothelioma](/wiki/Mesothelioma) was first used in medical literature in 1931; its association with asbestos was first noted sometime in the 1940s. Similar legislation followed in the U.S. about ten years later.

Approximately 100,000 people in the United States have died, or are terminally ill, from asbestos exposure related to ship building. In the [Hampton Roads](/wiki/Hampton_Roads) area, a shipbuilding center, mesothelioma occurrence is seven times the national rate.[[40]](#cite_note-40) Thousands of tons of asbestos were used in World War II ships to insulate piping, boilers, steam engines, and steam turbines. There were approximately 4.3 million shipyard workers in the United States during WWII; for every 1,000 workers about 14 died of mesothelioma and an unknown number died from asbestosis.<ref name=hamptonroads>Burke, Bill (6 May 2001) ["Shipyards, a Crucible for Tragedy: Part 1: How the war created a monster"](http://www.asbestos-attorney.com/pilot3-1.htm) *Virginian-Pilot* Norfolk, Virginia (newspaper)</ref>

The United States government and asbestos industry have been criticized for not acting quickly enough to inform the public of dangers, and to reduce public exposure. In the late 1970s, court documents proved that asbestos industry officials knew of asbestos dangers since the 1930s and had concealed them from the public.<ref name=hamptonroads/>

In Australia, asbestos was widely used in construction and other industries between 1946 and 1980. From the 1970s there was increasing concern about the dangers of asbestos, and its use was phased out. Mining ceased in 1983. The use of asbestos was phased out in 1989 and banned entirely in December 2003. The dangers of asbestos are now well known in Australia and there is help and support for sufferers from asbestosis or mesothelioma.[[41]](#cite_note-41)

### Usage by industry and product type[[edit](/index.php?title=(none)&action=edit&section=14)]

#### Serpentine group[[edit](/index.php?title=(none)&action=edit&section=15)]

Serpentine minerals have a sheet or layered structure. Chrysotile is the only asbestos mineral in the serpentine group. In the United States, chrysotile has been the most commonly used type of asbestos. According to the U.S. EPA Asbestos Building Inspectors Manual, chrysotile accounts for approximately 95% of asbestos found in buildings in the United States.[Template:Citation needed](/wiki/Template:Citation_needed) Chrysotile is often present in a wide variety of products and materials, including:

* Chlor Alkali diaphragm membranes used to make chlorine (currently in the USA) [[42]](#cite_note-42)\*[Drywall](/wiki/Drywall) and joint compound
* [Plaster](/wiki/Plaster)
* Gas mask filters pre 1960s
* Mud and texture coats
* Vinyl floor tiles, sheeting, adhesives
* Roofing tars, felts, siding, and shingles[[43]](#cite_note-43)\*"[Transite](/wiki/Transite)" panels, siding, countertops, and pipes
* [Popcorn ceilings](/wiki/Popcorn_ceiling), also known as acoustic ceilings
* [Fireproofing](/wiki/Fireproofing)

[thumb|Fire-resistant asbestos glove.](/wiki/File:Heat-resistant_asbestos_glove.jpg)

* [Caulk](/wiki/Caulk)
* Industrial and marine [gaskets](/wiki/Gasket)
* [Brake](/wiki/Brake) pads and shoes
* Stage curtains
* Fire blankets
* Interior fire doors
* Fireproof clothing for firefighters
* Thermal pipe insulation
* Filters for removing fine particulates from chemicals, liquids and wine
* Dental cast linings
* HVAC flexible duct connectors
* [Drilling fluid](/wiki/Drilling_fluid) additives

[thumb|A household heat spreader for cooking on gas stoves, made of asbestos (probably 1950s; "Amiante pur" is French for "Pure Asbestos")](/wiki/File:AsbestosHeatSpreaderForCooking.jpg) In the European Union and Australia it has recently been banned as a potential health hazard[[44]](#cite_note-44) and is not used at all. Japan is moving in the same direction, but at a slower pace.

#### Amphibole group[[edit](/index.php?title=(none)&action=edit&section=16)]

Amphiboles including [amosite](/wiki/Amosite) (brown asbestos) and [crocidolite](/wiki/Crocidolite) (blue asbestos) were formerly used in many products until the early 1980s. [Template:Citation needed](/wiki/Template:Citation_needed) [Tremolite](/wiki/Tremolite) asbestos constituted a contaminant of many if not all naturally occurring chrysotile deposits. The use of all types of asbestos in the amphibole group was banned in much of the Western world by the mid-1980s, and in Japan by 1995. [Template:Citation needed](/wiki/Template:Citation_needed) Some products that included amphibole types of asbestos included the following:

* Low density insulating board (often referred to as AIB or asbestos insulating board) and ceiling tiles;
* Asbestos-cement pipe (made until the early 1990s by at least one manufacturer);
* [Asbestos-cement](/wiki/Eternit) sheets and pipes for construction, casing for water and electrical/telecommunication services;
* Thermal and chemical insulation (e.g., fire rated doors, limpet spray, lagging and gaskets).

Cigarette manufacturer [Lorillard](/wiki/Lorillard) ([Kent's](/wiki/Kent_(cigarette)) [filtered cigarette](/wiki/Cigarette_filter)) used crocidolite asbestos in its "Micronite" filter from 1952 to 1956.[[45]](#cite_note-45) While mostly chrysotile asbestos fibers were once used in automobile [brake pads](/wiki/Brake_pads), shoes, and [clutch discs](/wiki/Clutch), contaminants of amphiboles were present. Since approximately the mid-1990s, brake pads, new or replacement, have been manufactured instead with linings made of ceramic, carbon, metallic and [aramid fiber](/wiki/Aramid) ([Twaron](/wiki/Twaron) or [Kevlar](/wiki/Kevlar)—the same material used in [bulletproof vests](/wiki/Bulletproof_vest)).

Artificial Christmas snow, known as flocking, was previously made with asbestos.[[46]](#cite_note-46) It was used as an effect in films including [*The Wizard of Oz*](/wiki/The_Wizard_of_Oz_(1939_film)) and department store window displays and it was marketed for use in private homes under brand names that included "Pure White", "Snow Drift" and "White Magic".<ref name=ems>[Asbestos in Fake Snow Wizard of Oz](http://www.ems-asbestos.co.uk/asbestos-in-fake-snow-wizard-of-oz-1939/). Retrieved 19 December 2014</ref>

### Asbestos in construction[[edit](/index.php?title=(none)&action=edit&section=17)]

#### Asbestos construction in developed countries[[edit](/index.php?title=(none)&action=edit&section=18)]

[thumb|right|Older decorative ceilings, similar to this one, may contain small amounts of](/wiki/File:Asbestos_ceiling.jpg) [white asbestos](/wiki/White_asbestos). [thumb|right|1929 newspaper advertisement from Perth, Western Australia, for](/wiki/File:Durabestos_advertisement.jpg) [asbestos sheeting](/wiki/Asbestos_sheeting) for residential building construction. The use of asbestos in new construction projects has been banned for health and safety reasons in many developed countries or regions, including the European Union, Australia, Hong Kong, Japan, and New Zealand. A notable exception is the United States, where asbestos continues to be used in construction such as cement asbestos pipes. The 5th Circuit Court prevented the EPA from banning asbestos in 1991 because EPA research showed the ban would cost between $450 and 800 million while only saving around 200 lives in a 13-year timeframe, and that the EPA did not provide adequate evidence for the safety of alternative products.[[47]](#cite_note-47) Until the mid-1980s, small amounts of white asbestos were used in the manufacture of [Artex](/wiki/Artex), a decorative stipple finish,[[48]](#cite_note-48) however, some of the lesser-known suppliers of Artex were still adding white asbestos until 1999.[[49]](#cite_note-49) Removing or disturbing Artex is not recommended, as it may contain white asbestos.

Prior to the ban, asbestos was widely used in the construction industry in thousands of materials. Some are judged to be more dangerous than others due to the amount of asbestos and the material's friable nature. Sprayed coatings, pipe insulation and Asbestos Insulating Board (AIB) are thought to be the most dangerous due to their high content of asbestos and friable nature. Many older buildings built before the late 1990s contain asbestos. In the United States, there is a minimum standard for asbestos surveys as described by [ASTM](/wiki/ASTM) Standard E 2356–04. The U.S. Environmental Protection Agency includes some but not all asbestos-contaminated facilities on the Superfund National Priorities list (NPL). Renovation and demolition of asbestos contaminated buildings is subject to EPA [NESHAP](/wiki/NESHAP) and OSHA Regulations. Asbestos is not a material covered under [CERCLA's](/wiki/CERCLA) innocent purchaser defense. In the UK, the removal and disposal of asbestos and of substances containing it are covered by the [Control of Asbestos Regulations 2006](/wiki/Control_of_Asbestos_Regulations_2006).[[50]](#cite_note-50) U.S. asbestos consumption hit a peak of 804,000 tons in 1973; world asbestos demand peaked around 1977, with 25 countries producing nearly 4.8 million metric tons annually.[[51]](#cite_note-51) In older buildings (e.g. those built prior to 1999 in the UK, before white asbestos was banned), asbestos may still be present in some areas e.g. old bath panels, concrete [water tanks](/wiki/Water_tanks) and many other places. Being aware of asbestos locations reduces the risk of disturbing asbestos.[[52]](#cite_note-52) See the [asbestos image gallery (external link)](http://www.hse.gov.uk/asbestos/gallery.htm) to see some common asbestos locations.

Removal of asbestos building components can also remove the fire protection they provide, therefore fire protection substitutes are required for proper fire protection that the asbestos originally provided.[[52]](#cite_note-52)[[53]](#cite_note-53)

#### Asbestos in construction outside Europe and North America[[edit](/index.php?title=(none)&action=edit&section=19)]

Some countries, such as [India](/wiki/India), Indonesia, China, Russia and [Brazil](/wiki/Brazil), have continued widespread use of asbestos. The most common is corrugated asbestos-cement sheets or "A/C sheets" for roofing and for side walls. Millions of homes, factories, schools or sheds and shelters continue to use asbestos. Cutting these sheets to size and drilling holes to receive 'J' bolts to help secure the sheets to roof framing is done on-site. There has been no significant change in production and use of A/C sheets in [developing countries](/wiki/Developing_country) following the widespread restrictions in developed nations[Template:Citation needed](/wiki/Template:Citation_needed).

#### Asbestos and the 11 September 2001 attacks[[edit](/index.php?title=(none)&action=edit&section=20)]

[Template:See also](/wiki/Template:See_also) As [New York City's](/wiki/New_York_City) [twin towers](/wiki/World_Trade_Center_(1973-2001)) collapsed following the [9/11](/wiki/9/11) attacks, [Lower Manhattan](/wiki/Lower_Manhattan) was blanketed in a mixture of building debris and combustible materials. This complex mixture gave rise to the concern that thousands of residents and workers in the area would be exposed to known hazards in the air and in the dust, such as asbestos, lead, glass fibers, and pulverized concrete.[[54]](#cite_note-54) More than 1,000 tons of asbestos are thought to have been released into the air during the destruction of the [World Trade Center](/wiki/World_Trade_Center_(1973-2001)) in New York on [9/11](/wiki/9/11).[[55]](#cite_note-55) Inhalation of a mixture of asbestos and other [toxicants](/wiki/Toxic) is thought to be linked to the unusually high death rate of emergency service workers from cancer since the disaster.[[55]](#cite_note-55) Many thousands more are now thought to be at risk of developing cancer due to this exposure with those who have died so far being only the 'tip of the iceberg'.[[55]](#cite_note-55) Some commentators have criticised authorities for using asbestos in the Towers' construction (see 'Other criticism' below).

In May 2002, after numerous cleanup, dust collection, and air monitoring activities were conducted outdoors by EPA, other federal agencies, New York City and New York State, New York City formally requested federal assistance to clean and/or test residences in the vicinity of the WTC site for airborne asbestos.[[54]](#cite_note-54) However, the impact of short term exposure in such instances has sparked much skepticism as to health risks. Up to this point most research can only associate long term exposure to high levels with reduced lung functioning.[[56]](#cite_note-56)

### Asbestos contaminants in other products[[edit](/index.php?title=(none)&action=edit&section=21)]

#### Vermiculite[[edit](/index.php?title=(none)&action=edit&section=22)]

[Vermiculite](/wiki/Vermiculite) is a hydrated laminar magnesium-aluminum-iron silicate which resembles [mica](/wiki/Mica). It can be used for many industrial applications and has been used as insulation. Some deposits of vermiculite have been found to be contaminated with small amounts of asbestos.[[57]](#cite_note-57) One vermiculite mine operated by [W. R. Grace and Company](/wiki/W._R._Grace_and_Company) in [Libby, Montana](/wiki/Libby,_Montana) exposed workers and community residents to danger by mining vermiculite contaminated with asbestos, typically [richterite](/wiki/Richterite), [winchite](/wiki/Winchite), [actinolite](/wiki/Actinolite) or [tremolite](/wiki/Tremolite).[[58]](#cite_note-58) Vermiculite contaminated with asbestos from the Libby mine was used as insulation in residential and commercial buildings through Canada and the United States. W. R. Grace and Company's loose-fill vermiculite was marketed as [Zonolite](/wiki/Zonolite) but was also used in sprayed-on products such as [Monokote](/wiki/Monokote).

In 1999 the EPA began cleanup efforts in Libby and now the area is a [Superfund](/wiki/Superfund) cleanup area.[[59]](#cite_note-59) The EPA has determined that harmful asbestos is released from the mine as well as through other activities that disturb soil in the area.[[60]](#cite_note-60)

#### Talc[[edit](/index.php?title=(none)&action=edit&section=23)]

[thumb|A laboratory heat spreader made of asbestos, on tripod over Teclu burner](/wiki/File:A_laboratory_heat_spreader_made_of_asbestos,_over_Teclu_burner.jpg) [Talc](/wiki/Talc) is sometimes contaminated with asbestos.[[61]](#cite_note-61) In 2000, tests in a certified asbestos-testing laboratory found the tremolite form of amphibole asbestos in three out of eight bigger brands of children's [crayons](/wiki/Crayon) that are made partly from talc: [Crayola](/wiki/Crayola), Prang, and RoseArt.[[62]](#cite_note-62) In Crayola crayons, the tests found asbestos levels from 0.05% in *Carnation Pink* to 2.86% in *Orchid*; in Prang crayons, the range was from 0.3% in *Periwinkle* to 0.54% in *Yellow*; in Rose Art crayons, it was from 0.03% in *Brown* to 1.20% in *Orange*. Overall, 32 different types of crayons from these brands contained more than trace amounts of asbestos, and eight others contained trace amounts. The [Art and Creative Materials Institute](/wiki/Art_and_Creative_Materials_Institute), a [trade association](/wiki/Trade_association) which tests the safety of crayons on behalf of the makers, initially insisted the test results must be incorrect, although they later said they do not test for asbestos.[[62]](#cite_note-62) In May 2000, Crayola said tests by Richard Lee, a materials analyst whose testimony on behalf of the asbestos industry has been accepted in lawsuits over 250 times, found two of its crayons tested negative for asbestos.[[63]](#cite_note-63) In June 2000, Binney & Smith, the maker of Crayola, and the other makers agreed to stop using talc in their products, and changed their product formulations in the United States.[[63]](#cite_note-63) The mining company, R T Vanderbilt Co of [Gouverneur, New York](/wiki/Gouverneur_(town),_New_York), which supplied the talc to the crayon makers, states that "to the best of our knowledge and belief" there is no asbestos in its talc.[[64]](#cite_note-64) However media reports claim that the [United States Mine Safety and Health Administration](/wiki/United_States_Mine_Safety_and_Health_Administration) (MSHA) had found asbestos in four talc samples tested in 2000.[[62]](#cite_note-62) The Assistant Secretary for Mine Safety and Health subsequently wrote to the news reporter, stating that "In fact, the abbreviation ND (non detect) in the laboratory report – indicates no asbestos fibers actually were found in the samples",[[65]](#cite_note-65) and multiple studies by both mineral studies laboratories[[66]](#cite_note-66)[[67]](#cite_note-67)[[68]](#cite_note-68)[[69]](#cite_note-69)[[70]](#cite_note-70)[[71]](#cite_note-71)[[72]](#cite_note-72)[[73]](#cite_note-73)[[74]](#cite_note-74) and biological cell studies[[75]](#cite_note-75)[[76]](#cite_note-76)[[77]](#cite_note-77) do not report asbestos. These findings have been rejected by other health reports and studies which advocate a "same as" asbestos risk.[[78]](#cite_note-78)[[79]](#cite_note-79)

## Health impact[[edit](/index.php?title=(none)&action=edit&section=24)]

[thumbnail|right|Asbestos warning label.](/wiki/File:Asbestos_warning_label.jpg) [thumb|right|Figure A shows the location of the lungs, airways, pleura, and diaphragm in the body. Figure B shows lungs with asbestos-related diseases, including pleural plaque, lung cancer, asbestosis, plaque on the diaphragm, and mesothelioma.](/wiki/File:Asbestos_effect.jpg) [thumb|right|Left-sided](/wiki/File:MesotheliomaCT.jpg) [mesothelioma](/wiki/Mesothelioma) (seen on the right of the picture): chest [CT](/wiki/X-ray_computed_tomography)

### Toxicity of different types of asbestos[[edit](/index.php?title=(none)&action=edit&section=25)]

All types of asbestos fibers are known to cause serious health hazards in humans.[[80]](#cite_note-80)[[81]](#cite_note-81)[[82]](#cite_note-82) Amosite and crocidolite are considered the most hazardous asbestos fiber types;[Template:Citation needed](/wiki/Template:Citation_needed) however, chrysotile asbestos has also produced tumors in animals and is a recognized cause of asbestosis and malignant mesothelioma in humans,[[83]](#cite_note-83) and mesothelioma has been observed in people who were occupationally exposed to chrysotile, family members of the occupationally exposed, and residents who lived close to asbestos factories and mines.[[84]](#cite_note-84) During the 1980s and again in the 1990s it was suggested at times that the process of making asbestos cement could "neutralize" the asbestos, either via chemical processes or by causing cement to attach to the fibers and changing their physical size; subsequent studies showed that this was untrue, and that decades-old asbestos cement, when broken, releases asbestos fibers identical to those found in nature, with no detectable alteration.[[85]](#cite_note-85)

### Risk and epidemiology[[edit](/index.php?title=(none)&action=edit&section=26)]

Exposure to asbestos in the form of fibers is always considered dangerous. Working with, or exposure to, material that is [friable](/wiki/Friable), or materials or works that could cause release of loose asbestos fibers, is considered high risk. However, in general, people who become ill from inhaling asbestos have been regularly exposed in a job where they worked directly with the material.

According to the [National Cancer Institute](/wiki/National_Cancer_Institute), "A history of asbestos exposure at work is reported in about 70 percent to 80 percent of all cases. However, mesothelioma has been reported in some individuals without any known exposure to asbestos."[[86]](#cite_note-86) A paper published in 1998, in the American Journal of Respiratory and Critical Care Medicine, concurs, and comments that asbestosis has been reported primarily in asbestos workers, and appears to require long-term exposure, high concentration for the development of the clinical disease. There is also a long latency period (the time taken between harmful contact and emergence of the actual resulting illness) of about 12 to 20 years,[[87]](#cite_note-87) and potentially up to 40 years.

The most common diseases associated with chronic exposure to asbestos are [asbestosis](/wiki/Asbestosis) and [mesothelioma](/wiki/Mesothelioma).[[88]](#cite_note-88) According to OSHA,[[89]](#cite_note-89) "there is no 'safe' level of asbestos exposure for any type of asbestos fiber.[[90]](#cite_note-90)[[91]](#cite_note-91) Asbestos exposures as short in duration as a few days have caused mesothelioma in humans. Every occupational exposure to asbestos can cause injury or disease; every occupational exposure to asbestos contributes to the risk of getting an asbestos related disease."[[89]](#cite_note-89)[[92]](#cite_note-92)[[93]](#cite_note-93)

### Safety and exposure prevention[[edit](/index.php?title=(none)&action=edit&section=27)]

Asbestos exposure becomes an issue if asbestos containing materials become airborne, such as due to deterioration or damage. Building occupants may be exposed to asbestos, but those most at risk are persons who purposely disturb materials, such as maintenance or construction workers. Housekeeping or custodial employees may be at an increased risk as they may potentially clean up damaged or deteriorated asbestos containing materials without knowing that the material contains asbestos. Asbestos abatement or remediation workers and emergency personnel such as firefighters may also become exposed.[[94]](#cite_note-94) Asbestos-related diseases have been diagnosed in asbestos workers' family members, and in residents who live close to asbestos mines or processing plants.[[95]](#cite_note-95)

#### Common building materials containing asbestos[[edit](/index.php?title=(none)&action=edit&section=28)]

Today, in the United States, several thousand products manufactured and/or imported today still contain asbestos. In many parts of the industrialized world, particularly the European Union, asbestos was phased out of building products beginning in the 1970s with most of the remainder phased out by the 1980s. Even with an asbestos ban in place, however, asbestos may be found in many buildings that were built and/or renovated from the late 1800s through the present day.

Residential building materials containing asbestos include a variety of products, such as: stipple used in textured walls and ceilings; [drywall joint filler compound](/wiki/Drywall_joint_filler_compound); asbestos contaminated [vermiculite](/wiki/Vermiculite), [vinyl floor tile](/wiki/Vinyl_floor_tile); vinyl sheet flooring; window [putty](/wiki/Putty); mastic; [cement board](/wiki/Cement_board); asbestos cement pipes and flues; furnace tape; and [stucco](/wiki/Stucco). Asbestos is widely used in roofing materials, mainly corrugated asbestos cement roof sheets and asbestos shingles sometimes called [transite](/wiki/Transite). Other sources of asbestos-containing materials include [fireproofing](/wiki/Fireproofing) and [acoustic materials](/wiki/Architectural_acoustics).[[96]](#cite_note-96)

#### Identification and assessment[[edit](/index.php?title=(none)&action=edit&section=29)]

A fiber cannot be identified or ruled out as asbestos, either using the naked eye or by simply looking at a fiber under a regular microscope. The most common methods of identifying asbestos fibers are by using [polarized light microscopy (PLM)](/wiki/Polarized_light_microscopy) or [transmission electron microscopy (TEM)](/wiki/Transmission_electron_microscopy). PLM is less expensive, but TEM is more precise and can be used at lower concentrations of asbestos.

If asbestos abatement is performed, completion of the abatement is verified using visual confirmation and may also involve air sampling. Air samples are typically analyzed using [phase contrast microscopy (PCM)](/wiki/Phase_contrast_microscopy). PCM involves counting fibers on a filter using a microscope. Airborne occupational exposure limits for asbestos are based on using the PCM method.

The [American Conference of Governmental Industrial Hygienists](/wiki/American_Conference_of_Governmental_Industrial_Hygienists) has a recommended Threshold Limit Value (TLV) for asbestos of 0.1 fibers/mL over an 8-hour shift. OSHA in the United States and occupational health and safety regulatory jurisdictions in Canada use 0.1 fibers/mL over an 8-hour shift as their exposure limits.[[97]](#cite_note-97)

#### Environmental asbestos[[edit](/index.php?title=(none)&action=edit&section=30)]

Asbestos can be found naturally in the air outdoors and in some drinkable water, including water from natural sources.[[98]](#cite_note-98) Studies have shown that members of the general (nonoccupationally exposed) population have tens of thousands to hundreds of thousands of asbestos fibers in each gram of dry lung tissue, which translates into millions of fibers and tens of thousands of asbestos bodies in every person's lungs.[[99]](#cite_note-99) Asbestos from natural geologic deposits is known as "naturally occurring asbestos" (NOA). Health risks associated with exposure to NOA are not yet fully understood, and current US federal regulations do not address exposure from NOA. Many populated areas are in proximity to shallow, natural deposits which occur in 50 of 58 California counties and in 19 other US states. In one study, data was collected from 3,000 mesothelioma patients in California and 890 men with [prostate cancer](/wiki/Prostate_cancer), a malignancy not known to be related to asbestos. The study found a correlation between the incidence of mesotheliomas and the distance a patient lived from known deposits of rock likely to include asbestos; the correlation was not present when the incidence of prostate cancer was compared with the same distances. The risk of mesothelioma declined by 6% for every [Template:Convert](/wiki/Template:Convert) that an individual had lived away from a likely asbestos source.<ref name=Raloff>[Template:Cite journal](/wiki/Template:Cite_journal)</ref>

Portions of [El Dorado County, California](/wiki/El_Dorado_County,_California) are known to contain natural amphibole asbestos formations at the surface.<ref name=Raloff/>[[100]](#cite_note-100) The [USGS](/wiki/USGS) studied amphiboles in rock and soil in the area in response to an EPA sampling study and subsequent criticism of the EPA study. The EPA study was refuted by its own peer reviewers and never completed or published. The study found that many amphibole particles in the area meet the counting rule criteria used by the EPA for chemical and morphological limits, but do not meet morphological requirements for commercial-grade-asbestos. The executive summary pointed out that even particles that do not meet requirements for commercial-grade-asbestos may be a health threat and suggested a collaborative research effort to assess health risks associated with "Naturally Occurring Asbestos."

However, the main criticism pointed at EPA was that their testing was conducted in small isolated areas of El Dorado where there were no amphibole asbestos deposits, thus the language regarding amphibole, nonfibrous "particles". Actual surface amphibole deposits in residential areas were ignored for testing purposes. Because of this, no final findings were published by ATSDR.[[101]](#cite_note-101) A great deal of [Fairfax County, Virginia](/wiki/Fairfax_County,_Virginia) was also found to be underlaid with tremolite. The county monitored air quality at construction sites, controlled soil taken from affected areas, and required freshly developed sites to lay [Template:Convert](/wiki/Template:Convert) of clean, stable material over the ground.<ref name=Raloff/>

Globally, collected samples from Antarctic ice indicate chrysotile asbestos has been a ubiquitous contaminant of the environment for at least 10,000 years. Snow samples in Japan have shown ambient background levels are one to two orders of magnitude higher in urban than in rural areas. Higher concentrations of airborne asbestos fibers are reported in urban areas where there is more ACM (asbestos containing materials) and mechanisms of release (vehicles braking and weathering of asbestos cement materials); concentrations in the range of 1–20 ng/m3 have been reported. Fibers longer than 5μm are rarely found in rural areas. Ambient concentrations using [TEM](/wiki/Transmission_electron_microscopy) analysis have been based on mass measurements.[[102]](#cite_note-102)

### Biological interactions of asbestos[[edit](/index.php?title=(none)&action=edit&section=31)]

#### Possible mechanisms of carcinogenicity[[edit](/index.php?title=(none)&action=edit&section=32)]

Stanton and Layard hypothesized in 1977–78 that toxicity of fibrous materials is *not* initiated by *chemical* effects;[[103]](#cite_note-103) that is, any trigger-effects of asbestos must presumably be *physical*, such as mechanical damage which might disrupt normal cell activity—especially [mitosis](/wiki/Mitosis).

There is experimental evidence that very slim fibers (<60 nm, <0.06 μm in breadth) do tangle destructively with chromosomes (being of comparable size).[[104]](#cite_note-104)[[105]](#cite_note-105) This is likely to cause the sort of mitosis disruption expected in cancer.

#### Chemistry[[edit](/index.php?title=(none)&action=edit&section=33)]

[thumb|right|Asbestos fibers (](/wiki/File:Anthophyllite_asbestos_SEM.jpg)[SEM](/wiki/Scanning_electron_microscope) micrograph) Individual asbestos fibers are invisible to the unaided [human eye](/wiki/Human_eye) because their size is about 3–20 µm wide and can be as slim as 0.01 µm. [Human hair](/wiki/Human_hair) ranges in size from 17 to 181 µm in breadth.[[106]](#cite_note-106) Fibers ultimately form because when these minerals originally cooled and crystallized, they formed by the polymeric molecules lining up parallel with each other and forming oriented [crystal lattices](/wiki/Crystal_structure). These crystals thus have three [cleavage planes](/wiki/Cleavage_(crystal)), and in this case, there are two cleavage planes which are much weaker than the third. When sufficient force is applied, they tend to break along their weakest directions, resulting in a linear fragmentation pattern and hence a fibrous form. This fracture process can keep occurring and one larger asbestos fiber can ultimately become the source of hundreds of much thinner and smaller fibers.

When fibers or asbestos structures from asbestos containing materials (ACM) become airborne, the process is called primary release. Primary release mechanisms include [abrasion](/wiki/Abrasion_(mechanical)), [impaction](/wiki/Wikt:Special:Search/impaction), fallout, air [erosion](/wiki/Erosion), vibration, and fire damage. Secondary release occurs when settled asbestos fibers and structures are resuspended as a result of human activities. In unoccupied buildings or during unoccupied periods, fiber release typically occurs by fallout or is induced by vibration or air erosion.[[102]](#cite_note-102) Friability of a product containing asbestos means that it is so soft and weak in structure that it can be broken with simple finger crushing pressure. Friable materials are of the most initial concern because of their ease of damage. The forces or conditions of usage that come into intimate contact with most non-friable materials containing asbestos are substantially higher than finger pressure.

#### Smoking and asbestos[[edit](/index.php?title=(none)&action=edit&section=34)]

Smoking has a supra-additive effect in increasing the risk of lung cancer in those exposed to asbestos.[[107]](#cite_note-107) Studies have shown an increased risk of lung cancer among [smokers](/wiki/Tobacco_smoking) who are exposed to asbestos compared to nonsmokers.[[108]](#cite_note-108)

### Known asbestos-related diseases[[edit](/index.php?title=(none)&action=edit&section=35)]

[Template:Main](/wiki/Template:Main) Diseases commonly associated with asbestos include:

* **Asbestosis**: Progressive fibrosis of the lungs of varying severity, progressing to bilateral fibrosis, honeycombing of the lungs on radiological view with symptoms including rales and wheezing. Individuals who have been exposed to asbestos via home, environment, work should notify their doctors about exposure history.
* **Asbestos warts**: caused when the sharp fibers lodge in the skin and are overgrown causing benign [callus](/wiki/Callus)-like growths.
* **Pleural plaques**: discrete fibrous or partially calcified thickened area which can be seen on [X-rays](/wiki/X-ray) of individuals exposed to asbestos. Although pleural plaques are themselves asymptomatic, in some patients this develops into pleural thickening.
* **Diffuse pleural thickening**: similar to above and can sometimes be associated with asbestosis. Usually no symptoms shown but if exposure is extensive, it can cause [lung](/wiki/Lung) impairment.
* [**Pneumothorax**](/wiki/Pneumothorax): Some reports have also linked the condition of pneumothorax to asbestos related diseases.

It is important to consult a doctor, particularly if the following symptoms develop: shortness of breath, wheezing or hoarseness, persistent cough that worsens over time, blood in fluid coughed up, pain or tightening in chest, difficulty swallowing, swelling of neck or face, decreased appetite, weight loss, fatigue or [anemia](/wiki/Anemia).[[109]](#cite_note-109)

## History of health concerns and regulation[[edit](/index.php?title=(none)&action=edit&section=36)]

*For additional chronological citations, see also,* [*List of asbestos disease medical articles*](/wiki/List_of_asbestos_disease_medical_articles)

### Until 1900[[edit](/index.php?title=(none)&action=edit&section=37)]

By the 1st century AD, Greeks and Romans are claimed to have observed that slaves involved in the weaving of asbestos cloth were afflicted with a sickness of the lungs,[[110]](#cite_note-110) although this is not confirmed by examination of primary sources.<ref name=Maines2005/>

Early concern in the modern era on the health effects of asbestos exposure can be found in several sources. Among the earliest were reports in Britain. The annual reports of the Chief Inspector of Factories in 1898 included a report from [Lucy Deane](/wiki/Lucy_Deane_Streatfeild) which stated that asbestos had "easily demonstrated" health risks.[[111]](#cite_note-111)<ref name=DeaneReport>[Template:Cite book](/wiki/Template:Cite_book)</ref>

At about the same time, what was probably the first study of mortality among asbestos workers was reported in France.[[112]](#cite_note-112) While the study describes the cause of death as [chalicosis](/wiki/Chalicosis), a generalized pneumoconiosis, the circumstances of the employment of the fifty workers whose death prompted the study suggest that the root cause was asbestos or mixed asbestos-cotton dust exposure.

### 1900s–1910s[[edit](/index.php?title=(none)&action=edit&section=38)]

[thumb|right|](/wiki/File:Ferruginous_body.jpg)[Micrograph](/wiki/Micrograph) demonstrating [asbestosis](/wiki/Asbestosis) of the lung ([ferruginous bodies](/wiki/Ferruginous_bodies)). [H&E stain](/wiki/H&E_stain). Further awareness of asbestos-related diseases can be found in the early 1900s, when London doctor H. Montague Murray conducted a post mortem exam on a young asbestos factory worker who died in 1899. Dr. Murray gave testimony on this death in connection with an industrial disease compensation hearing. The post-mortem confirmed the presence of asbestos in the lung tissue, prompting Dr. Murray to express as an expert opinion his belief that the inhalation of asbestos dust had at least contributed to, if not actually caused, the death of the worker.[[113]](#cite_note-113) The record in the United States was similar. Early observations were largely anecdotal in nature and did not definitively link the occupation with the disease, followed by more compelling and larger studies that strengthened the association. One such study, published in 1918, noted:

All of these processes unquestionably involve a considerable dust hazard, but the hygienic aspects of the industry have not been reported upon. It may be said, in conclusion, that in the practice of American and Canadian [life insurance](/wiki/Life_insurance) companies, asbestos workers are generally declined on account of the assumed health-injurious conditions of the industry.[[114]](#cite_note-114)

### 1920s–1930s[[edit](/index.php?title=(none)&action=edit&section=39)]

Widespread recognition of the occupational risks of asbestos in Britain was reported in 1924 by a Dr. Cooke, a pathologist, who introduced a case description of a 33-year-old female asbestos worker, [Nellie Kershaw](/wiki/Nellie_Kershaw), with the following: "Medical men in areas where asbestos is manufactured have long suspected the dust to be the cause of chronic bronchitis and fibrosis ..."[[115]](#cite_note-115) Dr. Cooke then went on to report on a case in 1927 involving a 33-year-old male worker who was the only survivor out of ten workers in an asbestos [carding](/wiki/Carding) room. In the report he named the disease "asbestosis".[[116]](#cite_note-116) Dr. Cooke's second case report was followed, in the late 1920s, by a large public health investigation (now known as the Merewether report after one of its two authors) that examined some 360 asbestos-textile workers (reported to be about 15% of the total comparable employment in Britain at the time) and found that about a quarter of them suffered from pulmonary fibrosis.[[117]](#cite_note-117) This investigation resulted in improved regulation of the manufacturing of asbestos-containing products in the early 1930s. Regulations included industrial hygiene standards, medical examinations, and inclusion of the asbestos industry into the British Workers' Compensation Act.[[118]](#cite_note-118) The first known U.S. workers' compensation claim for asbestos disease was in 1927. In 1930, the first reported autopsy of an asbestosis sufferer was conducted in the United States and later presented by a doctor at the [Mayo Clinic](/wiki/Mayo_Clinic), although in this case the exposure involved mining activities somewhere in South America.[[119]](#cite_note-119) In 1930, the major asbestos company Johns-Manville produced a report, for internal company use only, about medical reports of asbestos worker fatalities.[[120]](#cite_note-120) In 1932, a letter from U.S. Bureau of Mines to asbestos manufacturer [Eagle-Picher](/wiki/Eagle-Picher) stated, in relevant part, "It is now known that asbestos dust is one of the most dangerous dusts to which man is exposed."<ref name=Brodeur>[Template:Cite book](/wiki/Template:Cite_book)</ref>

In 1933, Metropolitan Life Insurance Co. doctors found that 29% of workers in a Johns-Manville plant had asbestosis.[[120]](#cite_note-120) Likewise, in 1933, Johns-Manville officials settled lawsuits by 11 employees with asbestosis on the condition that the employees' lawyer agree to never again "directly or indirectly participate in the bringing of new actions against the Corporation."<ref name=Brodeur/> In 1934, officials of two large asbestos companies, Johns-Manville and Raybestos-Manhattan, edited an article about the diseases of asbestos workers written by a Metropolitan Life Insurance Company doctor. The changes downplayed the danger of asbestos dust.<ref name=Brodeur/> In 1935, officials of Johns-Manville and Raybestos-Manhattan instructed the editor of *Asbestos* magazine to publish nothing about asbestosis.<ref name=Brodeur/> In 1936, a group of asbestos companies agreed to sponsor research on the health effects of asbestos dust, but required that the companies maintain complete control over the disclosure of the results.[[120]](#cite_note-120)

### 1940s[[edit](/index.php?title=(none)&action=edit&section=40)]

In 1942, an internal Owens-Corning corporate memo referred to "medical literature on asbestosis ... scores of publications in which the lung and skin hazards of asbestos are discussed."[[120]](#cite_note-120) Testimony given in a federal court in 1984 by Charles H. Roemer, formerly an employee of Unarco, described a meeting in the early 1940s between Unarco officials, J-M President [Lewis H. Brown](/wiki/Lewis_H._Brown) and J-M attorney Vandiver Brown. Roemer stated, "I'll never forget, I turned to Mr. Brown, one of the Browns made this crack (that Unarco managers were a bunch of fools for notifying employees who had asbestosis), and I said, 'Mr. Brown, do you mean to tell me you would let them work until they dropped dead?' He said, 'Yes. We save a lot of money that way.'"[[121]](#cite_note-121) In 1944, a Metropolitan Life Insurance Company report found 42 cases of asbestosis among 195 asbestos miners.[[120]](#cite_note-120)

### 1950s[[edit](/index.php?title=(none)&action=edit&section=41)]

In 1951, asbestos companies removed all references to cancer before allowing publication of research they sponsored.[[122]](#cite_note-122) In 1952, Dr. Kenneth Smith, Johns-Manville medical director, recommended (unsuccessfully) that warning labels be attached to products containing asbestos. Later, Smith testified: "It was a business decision as far as I could understand ... the corporation is in business to provide jobs for people and make money for stockholders and they had to take into consideration the effects of everything they did and if the application of a caution label identifying a product as hazardous would cut into sales, there would be serious financial implications."[[123]](#cite_note-123) In 1953, National Gypsum's safety director wrote to the Indiana Division of Industrial Hygiene, recommending that [acoustic plaster](/wiki/Acoustic_plaster) mixers wear respirators "because of the asbestos used in the product." Another company official noted that the letter was "full of dynamite" and urged that it be retrieved before reaching its destination. A memo in the files noted that the company "succeeded in stopping" the letter, which "will be modified."[[124]](#cite_note-124)

### 1960s–1980s[[edit](/index.php?title=(none)&action=edit&section=42)]

Through the 1970s, asbestos was used to fireproof roofing and flooring, for heat insulation, and for a variety of other purposes. The material was used in fire-check partitioning and doors on North Sea Oil Production Platforms and Rigs.

During the mid-to late 1980s, public health concern focused on potential asbestos fiber exposures of building occupants and workers in buildings containing asbestos containing building materials (ACBM) and their risks of developing lung cancer or mesothelioma. As a consequence, the Health Effects Institute (Cambridge, MA) convened a panel to evaluate the lifetime cancer risk of general building occupants as well as service workers.[[125]](#cite_note-125)

### Modern regulation[[edit](/index.php?title=(none)&action=edit&section=43)]

[Template:Main](/wiki/Template:Main)

#### United States[[edit](/index.php?title=(none)&action=edit&section=44)]

[thumb|320px|right|Researcher using a fiber length classifier to produce length-selected fibers of asbestos for toxological studies.](/wiki/File:Researching_Asbestos-Related_Disease.jpg) The United States remains one of the few [developed countries](/wiki/Developed_countries) to not completely ban asbestos[[126]](#cite_note-126) which is legal and still widely used in such commonly used products as clothing, pipeline wraps, vinyl floor tiles, millboards, cement pipes, disk brake pads, gaskets and roof coatings.[[127]](#cite_note-127) In 1989 the EPA issued the Asbestos Ban and Phase Out Rule but in 1991, asbestos industry supporters challenged and overturned the ban in a landmark lawsuit: *Corrosion Proof Fittings v. the Environmental Protection Agency*. Although the case resulted in several small victories for asbestos regulation, the EPA ultimately did not put an end to asbestos use. This ruling leaves many consumer products that can still legally contain trace amounts of asbestos. For a clarification of products which legally contain asbestos, read the EPA's clarification statement.[[128]](#cite_note-128) In 2010, Washington State banned asbestos in automotive brakes starting in 2014.[[129]](#cite_note-129) The [Occupational Safety and Health Administration](/wiki/Occupational_Safety_and_Health_Administration) (OSHA), has set limits of 100,000 fibers with lengths greater than or equal to 5 µm per cubic meter of workplace air for eight-hour shifts and 40-hour work weeks.[[130]](#cite_note-130)

#### Canada[[edit](/index.php?title=(none)&action=edit&section=45)]

In Canada, asbestos is not banned,[[131]](#cite_note-131) though its use has declined since the mid-1970s and early 1980s. Products containing asbestos are regulated by the Asbestos Products Regulation (SOR 2007/260).[[132]](#cite_note-132)

#### United Kingdom[[edit](/index.php?title=(none)&action=edit&section=46)]

In the United Kingdom, blue and brown asbestos materials were banned outright in 1985 while the import, sale and second hand reuse of white asbestos was outlawed in 1999. The 2012 Control of Asbestos Regulations state that owners of non-domestic buildings (e.g., factories and offices) have a "duty to manage" asbestos on the premises by making themselves aware of its presence and ensuring the material does not deteriorate, removing it if necessary. Employers, e.g. construction companies, whose operatives may come into contact with asbestos must also provide annual asbestos training to their workers.[[133]](#cite_note-133)

#### New Zealand[[edit](/index.php?title=(none)&action=edit&section=47)]

In 1984, the import of raw amphibole (blue and brown) asbestos into [New Zealand](/wiki/New_Zealand) was banned. In 2002 the import of chrysotile (white) asbestos was also banned.[[134]](#cite_note-134) In 2015 the government announced that the importation of asbestos would be completely banned with very limited exceptions (expected to be applied to replacement parts for older machines) that would be reviewed on a case-by-case basis.[[135]](#cite_note-135) North-west of Nelson, in the Upper Takaka Valley is New Zealand's only commercially harvested asbestos mine. A low-grade Chrysotile was mined here from 1908 to 1917 but only 100 tons was washed and taken out by packhorse. A new power scheme enabled work to renew and between 1940 and 1949, 40 tons a month was mined by the Hume Company. This continued to 1964, when, due to the short length of its fibre, the limited commercial viability forced mining to cease.[[136]](#cite_note-136)[[137]](#cite_note-137)

#### Australia[[edit](/index.php?title=(none)&action=edit&section=48)]

[thumb|Asbestos Products Ltd exporting asbestos](/wiki/File:SLNSW_20132_Asbestos_Products_Ltd_exporting.jpg) The use of crocidolite (blue) asbestos was banned in 1967, while the use of amosite (brown) asbestos continued in the construction industry until the mid-1980s. It was finally banned from building products in 1989, though it remained in gaskets and brake linings until 31 December 2003, and cannot be imported, used or recycled.[[138]](#cite_note-138)[[139]](#cite_note-139) Asbestos continues to be a problem. Two out of three homes in Australia built between World War II and the early 1980s still contain asbestos.[[140]](#cite_note-140) The union that represents workers tasked with modifying electrical meter boxes at residences stated that workers should refuse to do this work until the boxes have been inspected for asbestos,[[141]](#cite_note-141) and the head of the Australian Council of Trade Unions ([ACTU](/wiki/Australian_Council_of_Trade_Unions)) has called on the government to protect its citizens by ridding the country of asbestos by 2030.[[142]](#cite_note-142) Handlers of asbestos materials must have a B-Class license for bonded asbestos and an A-Class license for friable asbestos.

The town of [Wittenoom](/wiki/Wittenoom,_Western_Australia), in Western Australia was built around a (blue) asbestos mine. The entire town continues to be contaminated, and has been disincorporated, allowing local authorities to remove references to Wittenoom from maps and roadsigns.

#### Brazil[[edit](/index.php?title=(none)&action=edit&section=49)]

Despite the mining and use of asbestos reaching the country’s Supreme Court, Brazil is the world’s third-largest producer and exporter of chrysotile (white) asbestos.[[143]](#cite_note-143) São Paulo State law 12.684/07 prohibits the use of any product which utilizes asbestos but many buildings are still constructed of products containing asbestos. As a result, it is estimated that up to 15,000 Brazilians die each year of exposure to asbestos.[[144]](#cite_note-144)

#### Japan[[edit](/index.php?title=(none)&action=edit&section=50)]

Revelations that hundreds of workers had died in Japan over the previous few decades from diseases related to asbestos sparked a scandal in mid-2005.<ref name=Iceberg>[Japanese Asbestos Scandal](http://www.amrc.org.hk/alu_article/occupational_safety_and_health_in_asia/japanese_asbestos_scandal). Asia Monitor Resource Center. 28 September 2007</ref> Tokyo had, in 1971, ordered companies handling asbestos to install ventilators and check health on a regular basis; however, the Japanese government did not ban crocidolite and amosite until 1995, and a near complete ban with a few exceptions on asbestos was implemented in 2006, with the remaining exceptions being removed in March 2012 for a full-fledged ban.[[145]](#cite_note-145)

#### South Korea[[edit](/index.php?title=(none)&action=edit&section=51)]

In May 1997, the manufacture and use of [crocidolite](/wiki/Crocidolite) and [amosite](/wiki/Amosite), commonly known as blue and brown asbestos, were fully banned in [South Korea](/wiki/South_Korea).[[146]](#cite_note-146) In January 2009, a full-fledged ban on all types of asbestos occurred when the government banned the manufacture, import, sale, storage, transport or use of asbestos or any substance containing more than 0.1% of asbestos.[[147]](#cite_note-147) In 2011, South Korea became the world's sixth country to enact an asbestos harm aid act, which entitles any Korean citizen to free lifetime medical care as well as monthly income from the government if he or she is diagnosed with an asbestos-related disease.[[148]](#cite_note-148)

#### Singapore[[edit](/index.php?title=(none)&action=edit&section=52)]

Use of all types of asbestos has been banned in Singapore since 1989. Currently, only *removal* of asbestos-containing materials is allowed in Singapore and the Ministry of Manpower must be notified before work commences.

#### Turkey[[edit](/index.php?title=(none)&action=edit&section=53)]

A complete ban on asbestos in Turkey went into effect in 2011.[[149]](#cite_note-149)

### Issues contributing to delayed recognition and legislative activity in the 20th century[[edit](/index.php?title=(none)&action=edit&section=54)]

[thumb|Soviet made asbestos, after 1983. No EHS information.](/wiki/File:Russian_made_asbestos,_after_1983.jpg) In a 1998 paper, medical historian Peter Bartrip examines why awareness and legislation appear to have lagged unduly, compared to evidence of the risks of asbestos.[[38]](#cite_note-38) The paper concludes by agreeing with a previous paper ('Asbestos: a chronology of its origins and health effects', British Journal of Independent Medicine, 1990) and the 1930 report of Edward Mereweather (a factory medical inspector involved in the legislative investigations of the time), that despite theories suggesting a [coverup](/wiki/Coverup) and historical evidence that could be cobbled together after the fact, it is more likely that the issue was one of [hindsight](/wiki/Hindsight).

According to Bartrip, Mereweather's 1930 report identified six relevant issues:[[38]](#cite_note-38)[Template:Rp](/wiki/Template:Rp)

1. Significant commercial exploitation of asbestos was still relatively new.
2. The industry was small and employed comparatively few workers, particularly in dusty processes.
3. The disease developed slowly and unobtrusively.
4. The disease was easily confused with tuberculosis.
5. Affected workers left the industry and therefore fell out of sight of Factory Inspectors.(Gee, below, states that studies "focused on factories, rather than users")
6. Medical research had concentrated on dusts containing free silica.

There had been earlier discussion, notably a few brief comments by Factory Inspectors Adelaide Anderson and Edgar Collis during 1898–1911, described by Bartrip as minor reports of no great substance in otherwise very large reports about factory workers.[[38]](#cite_note-38)[Template:Rp](/wiki/Template:Rp) As a result, he concludes that between 1898 and the late 1920s, all that can be said is that, "the dangers of the material were slowly beginning to be appreciated".[[38]](#cite_note-38)[Template:Rp](/wiki/Template:Rp) As of 1927, the Senior Medical Inspector had reported that the effect of asbestos dust inhalation "was as yet imperfectly understood".[[38]](#cite_note-38)[Template:Rp](/wiki/Template:Rp)

A second paper, by Gee & Greenberg, noted additional factors:[[1]](#cite_note-1)# The discovery of carcinogenicity of [smoking](/wiki/Smoking) at approximately the same time as the 1950s asbestos studies, had made it far harder to prove a proposed [causative](/wiki/Causative) link for asbestos.

1. [Anecdotal evidence](/wiki/Anecdotal_evidence) and [hearsay](/wiki/Hearsay) noted by local doctors and inspectors, was not pursued or taken seriously.
2. "Negative" cancer studies were used, which are poor at detecting statistically significant pathology rates unless they include follow-up for around 30 years.
3. A "latency lacuna" exists and contributes to complacency (also reported by Knox 1965) – as the consequences of exposure take decades to arise, by the time they occur it is possible to argue convincingly that "standards have improved" and that therefore the risk is eliminated; however this in turn is not confirmed for another 30 years by which time the same argument can be raised again. Compared to short-term needs, a "speculative" risk not yet confirmed may carry less weight, until long after the time when action could be taken.
4. Long term surveys and sanction regimes failed to match short term pressures within politics, nor those within industry; in the case of asbestos they were inadequate.
5. [Fallacious](/wiki/Fallacy) arguments were used, such as the observation that many asbestos workers remained healthy into old age as evidence of lack of risk or lack of harm. As even the most harmful occupation can have numerous apparent healthy survivors this is an example of "absence of evidence" being interpreted as "evidence of absence".
6. As late as 1967, even [*The Lancet*](/wiki/The_Lancet) was capable of writing that "it would be ludicrous to outlaw this valuable and often irreplaceable material in all circumstances (as) asbestos can save more lives than it can possibly endanger".

## Litigation[[edit](/index.php?title=(none)&action=edit&section=55)]

[Template:Globalize](/wiki/Template:Globalize) [Template:Main](/wiki/Template:Main) Litigation related to asbestos is regarded as one of the largest litigation cases in legal history in terms of duration, claim size, and scope. Factors responsible for this include:

1. *Asbestos use was extremely widespread:* It was used across many sectors, countries, industries and uses. It was also widespread in society itself, being used not in limited "niche" areas but within many everyday products, in housing, fire protection, and even decorative material such as [Artex](/wiki/Artex), as well as numerous other ways. Over 50% of homes in some countries contained asbestos even after its ban there.[[31]](#cite_note-31) So it was somewhat ubiquitous;
2. *Knowledge or suspicion of health issues existed for a long time:* The health issues related to asbestos were known, suspected, or reported, for decades, with modern medical coverage dating back to the 19th century.
3. *Impact was severe, and included factors that tend to lead to high claims:* serious and fatal disease; also apart from death the costs include long term care and disability, care costs, lifetime loss of income, and other high value compensations.
4. *Relatively easy to be at risk:* asbestos-related diseases are caused by inhaling tiny airborne fibers, therefore any activity related to asbestos that led to loose dust or fibers could potentially cause disease (*Secondary asbestosis*). As a result, illness occurred not only in the widespread primary industries using asbestos, such as the asbestos mining and processing businesses, but also across industries that might handle their products (construction and demolition, repairs, fire safety), persons who disturbed asbestos products in their homes or workplaces, and even those who laundered clothing used by asbestos workers.[[150]](#cite_note-150)# *Illnesses arise long after exposure:* asbestos related diseases can arise decades after actual exposure.
5. *Asbestos industry alleged misconduct:* alleged concealing, distorting, and suppressing of risk related information, by asbestos related businesses.

[Template:As of](/wiki/Template:As_of), trends indicate that the worldwide rate at which people are diagnosed with asbestos-related diseases will likely increase through the next decade.[[151]](#cite_note-151)[[152]](#cite_note-152) Analysts have estimated that the total cost of asbestos litigation in the USA alone is over $250 billion.[[153]](#cite_note-153) In the [UK](/wiki/UK), more people died in 2011 from asbestos-related causes (4721) than in all types of traffic and transport accidents combined, and new reported cases were estimated at 2126.[[154]](#cite_note-154) In the United States, asbestos litigation is the longest, most expensive mass [tort](/wiki/Tort) in [U.S. history](/wiki/History_of_the_United_States), involving more than 8,400 defendants and 730,000 claimants as of 2002 according to the [RAND Corporation](/wiki/RAND_Corporation),[[155]](#cite_note-155) and at least one defendant reported claim counts in excess of $800,000 in 2006.[[156]](#cite_note-156) The federal legal system in the United States has dealt with numerous counts of asbestos-related suits, which often included multiple plaintiffs with similar symptoms. In 1999 there were 200,000 related cases pending in the federal court system of the United States.[[157]](#cite_note-157) Further, it is estimated that within the next 40 years, the number of cases may increase to 700,000. These numbers help explain how there are thousands of current pending cases. Litigation of asbestos materials has been slow. Companies sometimes counter saying that health issues do not currently appear in their worker or workers, or sometimes are settled out of court.[[158]](#cite_note-158) The volume of the asbestos liability has concerned manufacturers and [insurers and reinsurers](/wiki/Insurance_industry).[[159]](#cite_note-159) The amounts and method of allocating compensation have been the source of many court cases, and government attempts at resolution of existing and future cases.

In 1999 the United States considered but did not enact the Fairness in Asbestos Compensation Act.[[160]](#cite_note-160) Between 1981 and the present, many asbestos companies have filed for bankruptcy.[[161]](#cite_note-161) While companies filed for bankruptcy, this limited payouts to those who were actually affected by the material. [Christopher Edley, Jr.](/wiki/Christopher_Edley,_Jr.) commented what the 1999 act ultimately would have done if passed would be to "limit punitive damages that seek retribution for the decisions of long-dead executives for conduct that took place decades ago."[[160]](#cite_note-160) Litigation exists outside the United States in [England](/wiki/England), [Scotland](/wiki/Scotland), [Ireland](/wiki/Ireland), the [Netherlands](/wiki/Netherlands), [France](/wiki/France), [Italy](/wiki/Italy), and [Japan](/wiki/Japan) among other nations (though the amounts awarded in these countries are not as large as in the US). See the [companion article](/wiki/Asbestos_and_the_law) for further information.

In Australia a significant and controversial case was brought against the industrial building materials company [James Hardie](/wiki/James_Hardie), which had mined and sold asbestos related products for many years.

## Criticisms of asbestos regulation[[edit](/index.php?title=(none)&action=edit&section=56)]

Asbestos regulation critics include the asbestos industry[[162]](#cite_note-162) and JunkScience.com owner [Steven Milloy](/wiki/Steven_Milloy). Critics argue that the outright banning of dangerous products by [government regulation](/wiki/Government_regulation) is inferior to keeping the products while innovating ways to prevent the lethal effects. They argue that the product benefits are too important to ignore; instead of banning the products, ways should be found to eliminate risks to those who work with the products.

Some criticisms were subsequently discredited. An example is the discredited suggestion by [Dixy Lee Ray](/wiki/Dixy_Lee_Ray) and others[Template:Who](/wiki/Template:Who) that the [Space Shuttle *Challenger*](/wiki/Space_Shuttle_Challenger) disintegrated because the maker of [O-ring](/wiki/O-ring) putty was pressured by the EPA into ceasing production of asbestos-laden putty.[[163]](#cite_note-163)<ref name=Challenger>[Template:Cite web](/wiki/Template:Cite_web)</ref> However, the putty used in *Challenger*[Template:'s](/wiki/Template:') final flight contained asbestos, and failures in the putty were not responsible for the failure of the O-ring that led to loss of the shuttle.<ref name=Challenger/>[[164]](#cite_note-164) Asbestos was also used in the first forty floors of the World Trade Center north tower causing an airborne contamination among lower Manhattan after the towers collapsed in [the attacks on 11 September 2001](/wiki/September_11,_2001_attacks), causing [Steven Milloy](/wiki/Steven_Milloy) of the [libertarian](/wiki/Libertarian) [Cato Institute](/wiki/Cato_Institute) to suggest that the World Trade Center towers could still be standing or at least would have stood longer had a 1971 ban not stopped the completion of the asbestos coating above the 64th floor.[[165]](#cite_note-165)[[166]](#cite_note-166) This was not considered in the [National Institute of Standards and Technology's](/wiki/National_Institute_of_Standards_and_Technology) report on the towers' collapse, on the basis that all fireproofing materials, regardless of their construction, are required to obtain a [fire-resistance rating](/wiki/Fire-resistance_rating) prior to installation, and all fiber-based lightweight commercial spray fireproofing materials are vulnerable to the [dispersive](/wiki/Wikt:dispersion) effects of [high speed/high energy impacts](/wiki/Kinetic_energy), as these are outside the [fire testing](/wiki/Fire_test) upon which all ratings are based. Therefore, asbestos would have made little or no difference in preventing the towers' collapse, if used as fireproofing, and upon collapse any asbestos, however used, would still have been largely dispersed into the air within the massive dust cloud.[[167]](#cite_note-167)[[168]](#cite_note-168)[[169]](#cite_note-169)

## Substitutes for asbestos in construction[[edit](/index.php?title=(none)&action=edit&section=57)]

[Fiberglass](/wiki/Glass_wool) insulation was invented in 1938 and is now the most commonly used type of [insulation material](/wiki/Building_insulation_materials). The safety of this material is also being called into question due to similarities in material structure.[[170]](#cite_note-170) However, the [International Agency for Research on Cancer](/wiki/International_Agency_for_Research_on_Cancer) removed fiberglass from its list of possible human carcinogens in 2001[[171]](#cite_note-171) and a scientific review article from 2011 claimed epidemiology data was inconsistent and concluded that the IARC's decision to downgrade the carcinogenic potential of fiberglass was valid (however, this study was funded by sponsored research contract from the North American Insulation Manufacturer’s Association).[[172]](#cite_note-172) In 1978, a highly texturized fiberglass fabric was invented by [Bal Dixit](/wiki/Bal_Dixit), called [Zetex](/wiki/Zetex_(fabric)). This fabric is lighter than asbestos, but offers the same bulk, thickness, hand, feel, and abrasion resistance as asbestos. The fiberglass was texturized to eliminate some of the problems that arise with fiberglass, such as poor abrasion resistance and poor seam strength.[[173]](#cite_note-173) In Europe [mineral wool](/wiki/Mineral_wool) and [glass wool](/wiki/Glass_wool) are the main insulators in houses.

Many companies that produced asbestos-cement products that were reinforced with asbestos fibers have developed products incorporating organic fibers. One such product was known as "[Eternit](/wiki/Eternit)" and another "Everite" now use "[Nutec](/wiki/Nutec)" fibers which consist of organic fibers, [portland cement](/wiki/Portland_cement) and [silica](/wiki/Silica). [Cement-bonded wood fiber](/wiki/Cement-bonded_wood_fiber) is another substitute. Stone fibers are used in gaskets and friction materials.

Another potential fiber is [polybenzimidazole](/wiki/Polybenzimidazole) or PBI fiber. [Polybenzimidazole fiber](/wiki/Polybenzimidazole_fiber) is a [synthetic fiber](/wiki/Synthetic_fiber) with high [melting point](/wiki/Melting_point) of [Template:Convert](/wiki/Template:Convert) that also does not ignite. Because of its exceptional thermal and chemical stability, it is often used by [fire departments](/wiki/Fire_station) and [space agencies](/wiki/List_of_space_agencies).

## Recycling and disposal[[edit](/index.php?title=(none)&action=edit&section=58)]

[right|thumb|Old](/wiki/File:AsbestosContainment.JPG) [Wailuku](/wiki/Wailuku) Post Office sealed off for [asbestos removal](/wiki/Asbestos_removal) Asbestos alternatives for industrial use include sleeves, rope, tape, fabric, textiles and [insulation batt materials](/wiki/Insulation_batt_materials) made from [fiberglass](/wiki/Fiberglass) and silica.

In most developed countries, asbestos is typically disposed of as [hazardous waste](/wiki/Hazardous_waste) in [landfill sites](/wiki/Landfill_site).

The [demolition](/wiki/Demolition) of buildings containing large amounts of asbestos based materials pose particular problems for builders and property developers – such buildings often have to be deconstructed piece by piece, or the asbestos has to be painstakingly removed before the structure can be razed by mechanical or explosive means. One such example is the [Red Road Flats](/wiki/Red_Road_Flats) in [Glasgow](/wiki/Glasgow), Scotland which used huge amounts of asbestos cement board for wall panelling – here British health and safety regulations stipulate that asbestos material has to be removed to a landfill site via an approved route at certain times of the day in specially adapted vehicles.

Asbestos can be recycled by transforming it into harmless [silicate glass](/wiki/Silicate_glass). A process of thermal decomposition at 1000–1250 °C produces a mixture of non-hazardous silicate phases, and at temperatures above 1250 °C it produces silicate glass.[[174]](#cite_note-174) Microwave thermal treatment can be used in an industrial manufacturing process to transform asbestos and asbestos-containing waste into porcelain stoneware tiles, porous single-fired wall tiles, and ceramic bricks.[[175]](#cite_note-175) The combination of [oxalic acid](/wiki/Oxalic_acid) with [ultrasound](/wiki/Ultrasound) fully degrades chrysotile asbestos fibers.[[176]](#cite_note-176)

## See also[[edit](/index.php?title=(none)&action=edit&section=59)]

### Mineralogy[[edit](/index.php?title=(none)&action=edit&section=60)]

* [Asbestine](/wiki/Asbestine)
* [List of minerals](/wiki/List_of_minerals)

### Other asbestos-related topics[[edit](/index.php?title=(none)&action=edit&section=61)]

[Template:Div col](/wiki/Template:Div_col)

* [Ambler, Pennsylvania](/wiki/Ambler,_Pennsylvania#Legacy_of_asbestos)
* [Asbestos abatement](/wiki/Asbestos_abatement)
* [Asbestos and the law](/wiki/Asbestos_and_the_law)
* [Asbestos Disease Awareness Organization](/wiki/Asbestos_Disease_Awareness_Organization)
* [Asbestos-ceramic](/wiki/Asbestos-ceramic)
* [Avondale Landfill](/wiki/Avondale_Landfill) (in [Polmont](/wiki/Polmont) in Scotland)
* [Brominated flame-retardant](/wiki/Brominated_flame-retardant)
* [Cemesto](/wiki/Cemesto)
* [Chloralkali process](/wiki/Chloralkali_process) (see diaphragm process)
* [Fibro](/wiki/Fibro)
* [*Hunt v. T&N plc*](/wiki/Hunt_v._T&N_plc)
* [Institute of Occupational Medicine](/wiki/Institute_of_Occupational_Medicine)
* [James Hardie](/wiki/James_Hardie)
* [Medical geology](/wiki/Medical_geology)
* [Red List building materials](/wiki/Red_List_building_materials)
* [Owens-Illinois](/wiki/Owens-Illinois)
* [Turner & Newall](/wiki/Turner_&_Newall)
* [Wittenoom, Western Australia](/wiki/Wittenoom,_Western_Australia)

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## References[[edit](/index.php?title=(none)&action=edit&section=62)]

[Template:Research help](/wiki/Template:Research_help) [Template:Reflist](/wiki/Template:Reflist)

## Bibliography[[edit](/index.php?title=(none)&action=edit&section=63)]

* [Template:Cite book](/wiki/Template:Cite_book)

## Further reading[[edit](/index.php?title=(none)&action=edit&section=64)]

* George B. Guthrie and Brooke T. Mossman, editors, *Health Effects of Mineral Dusts*, [Mineralogical Society of America](/wiki/Mineralogical_Society_of_America) *Reviews in Mineralogy* v. 28, 584 pages (1993) ISBN 0-939950-33-2.
* [Deaths and major morbidity from asbestos-related diseases in Asia likely to surge in next 20 years](http://makedifferences.org/Articles/Details/46)
* [Asbestos: an introduction](http://www.iom-world.org/asbestos/index.php) by JW Cherrie
* [Template:Cite book](/wiki/Template:Cite_book)

## External links[[edit](/index.php?title=(none)&action=edit&section=65)]

[Template:Sister project links](/wiki/Template:Sister_project_links)

Independent links

* [The Asbestos Information Centre](http://www.aic.org.uk/) Independent site with information about asbestos and its use in buildings

Regulatory and government links

* [U.S. EPA Asbestos Home Page](http://www.epa.gov/asbestos/index.html)
* [ATSDR Case Studies in Environmental Medicine: Asbestos Toxicity](https://web.archive.org/web/20110606012916/http://www.atsdr.cdc.gov/csem/asbestos/cover2.html) U.S. [Department of Health and Human Services](/wiki/Department_of_Health_and_Human_Services)
* [British Government Health and Safety Executive (HSE)](http://www.hse.gov.uk/asbestos/)
* [National Institute for Occupational Safety and Health: Asbestos](http://www.cdc.gov/niosh/topics/asbestos/)
* [World Health Organization – Asbestos page](http://www.who.int/ipcs/assessment/public_health/asbestos/en/)
* [Asbestos general article](http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+511) and [chrysotile specifically](http://toxnet.nlm.nih.gov/cgi-bin/sis/search/a?dbs+hsdb:@term+@DOCNO+2966): comprehensive coverage of all aspects of chemistry, biological interactions, destruction, and social/clinical scientific knowledge related to Asbestos, on the Toxicology Data Network, with full library of cites on many aspects and sub-topics].

Mineral and mining links

* [Parachrysotile (asbestos)](http://webmineral.com/data/Parachrysotile.shtml) at the webmineral.com Mineral Database
* [Univ. of Minn.: Asbestos](https://web.archive.org/web/20050501105904/http://www1.umn.edu/eoh/hazards/hazardssite/asbestos/asbestosintro.html)
* [White Gold Pioneers: Asbestos Mining](http://www.mccord-museum.qc.ca/en/keys/webtours/VQ_P3_11_EN.html)—The origins of asbestos mining, illustrated with many early photographs

Health and the environment

* [About Your House – General Series – Asbestos](http://www.cmhc-schl.gc.ca/en/co/maho/yohoyohe/inaiqu/inaiqu_001.cfm)
* [British Government Health and Safety Executive (HSE) essential guides](http://www.bulkanalysis.co.uk/asbestos/essential-guides/)
* [Hazards magazine's comprehensive asbestos resource pages](http://hazards.org/asbestos/)
* [The Miracle Mineral Fiber – Asbestos](https://web.archive.org/web/20110706183950/http://kohc.ca/blog/archives/2005/07/asbestos.html)
* [Asbestos: Magic mineral or deadly dust?](http://www.cbc.ca/archives/categories/health/public-health/asbestos-magic-mineral-or-deadly-dust/topic---asbestos-magic-mineral-or-deadly-dust.html), CBC Digital Archives
* [About Asbestos (2006)](http://osha.europa.eu/campaigns/asbestos), [European Agency for Safety and Health at Work](/wiki/European_Agency_for_Safety_and_Health_at_Work) (OSHA)
* [A USGS map of "Naturally Occurring Asbestos" in Eastern America](http://pubs.usgs.gov/of/2005/1189/pdf/Plate.pdf)
* [Occupational exposure to asbestos and man-made vitreous fibres and risk of lung cancer: a multicenter case-control study in Europe](http://lamtreatmentalliance.org/lta_summits/IARC_asbestos.pdf), Rafael Carel et al.

[Template:Fibers](/wiki/Template:Fibers) [Template:Occupational safety and health](/wiki/Template:Occupational_safety_and_health)

[Template:Authority control](/wiki/Template:Authority_control)

[Category:Asbestos](/wiki/Category:Asbestos) [Category:Hazardous air pollutants](/wiki/Category:Hazardous_air_pollutants) [Category:Carcinogens](/wiki/Category:Carcinogens) [Category:IARC Group 1 carcinogens](/wiki/Category:IARC_Group_1_carcinogens) [Category:Occupational safety and health](/wiki/Category:Occupational_safety_and_health)