PIGMENT HANDBOOK

Volume I

PROPERTIES AND ECONOMICS

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Edited by
PETER A. LEWIS

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Magnesium Silicate

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ALLAN M. HARVEY

Director of Environmental Affairs
R. T. Vanderbilt Company, Inc.
Norwalk, Connecticut

TALC

Pigment White 26
Colour Index Number 77718
French Chalk
Hydrous Magnesium Silicate
Pyrophyllite (Aluminum Analog of Talc)
Soapstone
Steatite
Chemical Formula, Theoretical
$Mg_6(Si_8O_{20})(OH)_4$
$3Mg \cdot 4SiO_2 \cdot H_2O$
Chemical Composition, Theoretical (wt %)

Mg	19.2	MgO	31.7
Si	29.6	SiO	63.5
H	0.5	HO	4.8
O	50.7		100.0
	100.0		

The term talc has two meanings. Mineralogically, it means the pure mineral talc corresponding to the chemical formula for hydrous magnesium silicate. Commercially, it means the talc products of commerce, both those of industrial grades and those of pharmaceutical or cosmetic grades. Industrial grades of talc vary widely in talc mineral content from below 50% up to ranges approaching pure talc mineral assay. These grades may contain one or more minerals associated with pure mineral talc such as dolomite, calcite, magnesite, mica, chlorite, quartz, amphiboles, and/or serpentine minerals.

Ordinary usage restricts the term *soapstone* to impure, massive talc rock, while the high-purity, massive talc is called *steatite*. Pyrophyllite is similar to talc in many of its characteristics and has the formula $Al_4[Si_8O_{10}](OH)_4$. French talc is a fine-grained talc used for marking cloth.

Grades of talc are most frequently identified with the end use, such as in ceramics, paint, roofing, insecticides, and paper. The important desirable properties include softness and smoothness, color, luster, high slip tendency, moisture content, oil and grease absorption, chemical inertness, fusion point, heat and electrical conductivity, dielectric strength, and others.

The mineral composition of industrial-grade talcs varies considerably, depending on the geographical location of the ore body. Montana talc production is mostly pure talc or steatite. Texas talcs are high in carbonate content and are generally dark in color. Vermont talcs contain considerable carbonate. New York talcs contain a high amount of associated amphibole minerals. California talcs vary considerably in mineral content depending on the mine location.

PROPERTIES

Both color and purity are important characteristics of talc. They can be partially de-

scribed as *brightness*, which is a measure of reflectance in terms of percent compared with the reflectance of pure magnesium oxide as the standard 100%. The chemical composition of talc found in nature is quite variable. It is an extremely soft mineral and is rated No. 1 on the Mohs scale of hardness (diamond = 10). It varies in color from snow-white to green to greenish gray and various shades of gray. Talc usually forms as a secondary mineral after alteration of high magnesium and silicon-bearing rocks such as those that contain serpentines, pyroxenes, or high silica dolomites.

Talc deposits can be classified into four major categories: steatite, soft platy talc, tremolitic talc, and mixed talc ores. The crystal habit of the talc mineral in these ores can be foliated (leafy), granular, lamellar (platelike), fibrous, or massive, with each form contributing to the particular properties of various industrial grades. Typical properties of an average representative talc pigment are listed below.

TYPICAL PROPERTIES

	Talc
Appearance	White lustrous powder
Density (g/cm^3)	2.7–2.85
(lb/gal)	22.5–23.7
Bulking value (gal/lb)	0.044–0.042
Brightness (GE)	75–95
Index of refraction	1.54–1.59
Melting point (°F)	~2600
(°C)	~1400
pH value	8.8–9.5
Oil absorption (lb/100 lb)	23–52

ECONOMICS OF USE

There are approximately 30 producing talc mines located in 11 states in the United States. In order of volume, the principal mining districts, producing 82% of the yearly total in 1984, were Texas, Montana, New York, and Vermont. Total pyrophyllite production, which is 7% of the total talc plus pyrophyllite, came mostly from North Carolina.

Other talc-producing states include California, Georgia, and North Carolina. Together with the four principal states, the 1984 total of pyrophyllite and talc mined in the United States was 1,230,000 short tons, which is about 15% of total world production. The talc and pyrophyllite sold in the United States in 1984 was valued at $20.8 million. A total of 230,000 short tons of talc were exported by the United States in 1984.

Imports of talc into the United States have increased measurably in the past 5 years because of increased crude from Australia and ground material from Canada. The total of talc imports into the United States for consumption in 1984 was 50,000 short tons. Import sources for the years 1980–1983 were Canada, 34%; Italy, 30%; Australia, 13%; France, 8%; and others, 15%.

U.S. Consumption of ground talc during 1984 was in the following areas: ceramics, 35%; paints, 18%; roofing, 11%; paper, 9%; plastics, 6%; cosmetics, 5%; and rubber, 3%. Consumption of pyrophyllite was mainly in refractories, 26%; ceramics, 24%; insecticides, 19%; and roofing, 10%.

HISTORICAL BACKGROUND

Soapstone for utensils and ornaments was mined by prehistoric Indians on Santa Catalina Island, California. In the mid-1800s, soapstone from deposits along the western foothills of the Sierra Nevada Mountains was used by settlers for building and ornamental stone.

Talc mining in the United States dates back to 1878 when Colonel Henry Palmer opened the first commercial talc mine on the Nelson Freeman farm near Talcville, a small town in St. Lawrence County, New York. In 1893, this operation was sold to the International Pulp Company, which became the International Talc Company in 1940. In 1974, the International Talc Com-

pany ceased operations and sold off some of its ore bodies and mills to the Gouverneur Talc Company, a subsidiary of the R. T. Vanderbilt Company, Inc.

Talc mining in Vermont began in 1902 with the opening of a mine in the town of Johnson. Eastern Magnesia Talc Company opened its talc mine there in 1924, and in the late 1950s, in conjunction with Johnson and Johnson Company, introduced a froth flotation process into the operation to provide the high-purity talc required for cosmetic use. Texas talc was first mined commercially in 1952. Development of the carbonate-derived Montana talc took place in the 1950s.

The commercial uses for talc, soapstone, and pyrophyllite are extensive and growing. World production in 1958 was about 3×10^6 tons, of which the United States produced about 47%. World production is now over 8×10^6 tons/yr. More recently, the use of talc as a filler for thermoplastic and thermosetting plastics has been added to the traditional applications in the ceramic, paint, paper, and pharmaceutical industries.

MAJOR USES

Paper

As a filler, talc is effective as an inexpensive titanium dioxide extender and is outstanding as a pitch control additive. Talc also assists in improvement of gloss, opacity, and brightness. Steatitic talcs are favored over the tremolitic talcs as paper fillers because of the latter's abrasive quality. Research in Finland indicates that the deficiencies of talc as a coating pigment can be overcome and talc may well challenge kaolin in this market segment.

The particle size of talc fillers ranges from 5 μm to less than 0.5 μm, with surface areas of 4–16 m^2/g. When used as an extender or replacement for the white hiding pigment titanium dioxide, talc has a distinct weight advantage (talc density 2.8 versus 4.2 for titanium dioxide). This feature grows in importance as postal rates increase.

The unique property of preferentially wetting oily materials in the presence of water makes talc extremely effective in *pitch control*. Pitch and other oleoresinous components of paper pulps cause serious problems when they deposit on rolls, wire, and other parts of the paper machine. Talc readily adsorbs the pitch particles rendering them less sticky and preventing agglomeration.

Ultrafine particle size talc products can be used along with clay, calcium carbonate, and titanium dioxide pigments to control rheological properties, calendering, gloss, ink holdout, opacity, and brightness.

Paint

Talc is used in many different types of coating. Initially, the primary application for talc was in linseed oil house paints to impart improved durability and resistance to film cracking. Its use in house paints has continued, but as finer and more diversified grades were developed, the application of talc has grown in other solvent-thinned as well as water-thinned coatings. Some examples are primers, undercoaters, traffic paints, industrial coatings, and interior and exterior trade sales paints.

The maximum fineness of talc in a given paint is often determined by the use of a Hegman gauge, which consists of a precision steel block into which a wedge-shaped channel, 0.5–2 in. wide and up to 0.005 in. deep, has been cut and marked with a linear scale. A drop of paint is placed at the deeper end of the channel and scraped toward the shallow end. Fineness is indicated at the point on the scale at which talc particles are seen to protrude above the paint surface. Hegman numbers and approximate particle size, respectively, are 8 = 0 μm, 7 = 13 μm, 6 = 25 μm, 5 = 40 μm, 4 = 50 μm, 3 = 65 μm, and 2 = 76 μm, 1 = 89 μm, and 0 = 100 μm.

Although there are specific differences in the mineralogy of talc from various geographical sources, the reasons for its use may be classified on a general basis. As with other extender pigments, talc has specific properties that make its use advantageous for requirements of particular formulations. Among its features are availability with high brightness, chemical inertness in coatings, good suspension properties, good suspension of other pigments, good brushability and flow, provision of film roughness from coarse grades, good color stability on exterior exposure (does not stain or "brown-off"), and ease of dispersion to its ultimate fineness without requiring high shear. The ease of dispersion property enables simple adjustment of gloss or viscosity of finished coatings by its use as a post-add ingredient.

Just as talcs from various geographical sources have many common effects on paint properties, specific differences exist which are attributable to mineralogy and related to particle shape. Some talcs are highly platy whereas others contain an assortment of particle shapes ranging from platy, to prismatic, blocky, and acicular. Platy talcs render a higher degree of water resistance to paint films than do their assorted particle shape counterparts. In addition, the high degree of impermeability leads to better enamel hold-out properties. Platy talcs are less abrasive and impart good sanding properties to metal primers. Talcs containing assorted particle shapes provide more blister-resistant films by allowing transmission of vapors. Entrapment of volatiles within films is also less likely to occur. Because of their ability to provide higher hardness (on the Mohs scale) and more efficient pigment packing within the film, talcs containing assorted particle shapes aid abrasion resistance of paint films.

Several grades of talc are available to meet its many varied applications. The grades range in Hegman fineness from 0 to 6 or 7 and in oil absorption from about 23 to 55.

Ceramics

Industrial talcs vary widely in their mineralogy and morphology, as indicated previously. Those differences give certain talcs advantages (physical and/or pyrophysical) when considered for specific applications. For example, tremolitic talcs with their blocky morphology are outstanding for use in ceramic wall tile, virtually eliminating laminations, improving product density, and permitting faster pressing. Ceramic bodies that can be fired safely at rapid cycles are produced with high uniform thermal expansion and low moisture expansion. In electrical porcelain, hotelware, and sanitaryware, these talcs can be used as an auxiliary flux, resulting in a tighter and stronger body, with a decrease of moisture expansion and increase in thermal expansion. These properties result in improved resistance to crazing in glazed ceramicware. If controlled for specific resistance or soluble salt content, tremolitic talcs are of value in high-talc, low-temperature casting bodies. Talc can be used as a low-flux replacement for magnesium oxide. Talc also can be used to replace clay in many ceramic bodies, promoting translucency and durability of the finished ware.

Plastics

Talcs are used in plastics predominantly as reinforcing and extender agents, where the platy structure enhances certain physical properties. In the case of polypropylene, talc provides increased stiffness and creep resistance. Plastics using talc for filling and reinforcement include polyester phenolics, polystyrene, HDPE nylon, epoxies, alkyds, and PVC. Examples of uses for talc-filled plastics are PVC floor tile and polyester body patch. Major markets are the automotive, appliance, electronics, flooring, home furnishings, and wire and cable industries.

Cosmetics

Cosmetic talcs normally have a talc mineral assay of 90% or more. A good cosmetic talc

should be reasonably light-colored, have good slip, be free of gritty or hard mineral particles, and conform with certain fragrance-retention standards. In addition, for purposes of health and safety, the bacteria content of cosmetic talcs is monitored carefully to ensure as bacteria-free a product as possible.

Miscellaneous Uses

The uses of talc are many and varied. It finds use as a dusting powder for ceramic sanitaryware and unvulcanized rubber, as a filler in asphalt roofing, pesticides, textiles, upholstery fabric, and rug backings, as well as a number of applications where its lubricating properties are of value.

PIGMENT MANUFACTURE

Most of the domestic talc mining production comes from open pits, but significant quantities are produced from underground mines located throughout the United States.

Talc milling has traditionally involved dry-processing operations. Since high-purity talc products are not demanded by much of the industrial talc market, beneficiation is not usually carried out. However, the talc milling industry is gradually changing from uncomplicated grinding plants to sophisticated processing operations that involve many beneficiation procedures.

The new generation of talc mills includes complex froth flotation, sedimentation, hydrocycloning, centrifugal sizing, dry and wet magnetic separation, spray drying, and new grinding techniques. Since white color is a desirable feature in many applications, the grinding equipment should not discolor the talc during the size reduction operation. For very fine particle size, vertical-shift pulverizing mills and jet-milling equipment are used. The latter uses the fluid energy principle with either compressed air or steam providing the energy. Porcelain-lined flint-pebble mills are used for larger particle size talcs.

PIGMENT GRADES

Because industrial talcs vary widely in their mineral composition, the particular properties demanded by each end use can be realized by a careful evaluation of each manufacturer's grades. In other words, the different combinations of the various minerals that can occur in industrial talcs (see Table 1) can result in widely different properties, with interchangeability between manufacturers' products not necessarily guaranteed.

In addition, the shapes of the different mineral particles in an industrial talc vary with the talc source, resulting in further diversification. These particles can be predominantly acicular, platy, or granular with each type conferring a desirable property on the finished talc product.

Table 1 Minerals Commonly Associated with Talc

Talc	$Mg_6[Si_8O_{20}](OH)_4$
Serpentine	$Mg_3[Si_2O_5](OH)_4$
Anthophyllite[a]	$(Mg, Fe)_7[Si_8O_{22}](OH)_2$
Tremolite[a]	$Ca_2(Mg,Fe)_5[Si_8O_{22}](OH)_2$
Dolomite	$CaMg(CO_3)_2$
Calcite	$CaCO_3$
Magnesite	$MgCO_3$
Mica	$K_2Al_4[Si_6Al_2O_{20}](OH, F)_4$
Chlorite	$(Mg, Al, Fe)_{12}[(Si, Al)_8O_{20}](OH)_{16}$
Quartz[a]	SiO_2

[a] Hard, abrasive minerals.

PIGMENT SPECIFICATIONS AND MANUFACTURERS

Three specifications exist for talc when it is to be used in coatings wherein the raw materials must conform to certain qualities. These specifications are ASTM D 605-82, Military MIL-P-15173A, and Maritime 52-MA-523B. Table 2 lists manufacturer grades conforming to the different specifications.

Table 2 Manufacturers' Products (Trade Names) Meeting ASTM D 605-82, Maritime 52-MA-523b, and Military MIL-P-15173A Specifications for Magnesium Silicate (Talc) Pigments

Cyprus	*Vanderbilt*
Mistron Frost	Nytal 200
Mistron Super Frost	Nytal 300
Mistron Monomix	Nytal 300H
Mistron RCS	Nytal 400
Mistron Ultramix	I.T. X
Mistron 600	I.T. 3X
Mistron Mist	I.T. 5X
Mistron 400	I.T. FT
Beaverwhite 200	I.T. 325
Beaverwhite 325	
Glacier 200	
Glacier 325	

Pfizer	*Whittaker, Clark & Daniels*
Microtalc CP 10-40	
Microtalc CP 14-35	Lo Micron 399
Microtalc CP 20-30	Lo Micron 2610
Microtalc MP 10-52	Talc 499
Microtalc MP 12-50	Magnesium Silicate 971
Microtalc MP 15-38	MicroTalc 1196
Microtalc MP 25-38	Micro 2611
Microtalc MP 30-36	Pioneer 2620
Talcron CP 38-33	Visco XX 2794
Talcron CP 14-31	
Talcron MP 40-27	
Talcron MP 44-26	
Talcron MP 45-26	

Note: Maritime 52-MA-523b and Military MIL-P-15173A specifications each include two types of talc classified on the basis of oil absorption. Grades listed in table conform to one of the two types. Consult manufacturer for further details.

Because of the common association of industrial talc with other minerals, as shown in Table 1, talc specifications allow a broad range in chemical and physical properties. The associated minerals often impart properties that render it more useful than pure talc for many coating applications.

Cosmetic talc grades are defined by the Cosmetic, Toiletry and Fragrance Associations's CTFA Specification, revised October 7, 1976. The American Industrial Hygiene Association has issued (1982) a Hygiene Guide Series specification for talc.

HEALTH AND ENVIRONMENTAL ASPECTS

The only federal government agencies regulating exposure to talc dust are the Occupational Safety and Health Administration (OSHA) and the Mine Safety and Health Administration (MSHA). In OSHA's Z-3 Table of Mineral Dusts, under 29 CFR 1910.1000, the 8 h, time-weighted average limit of exposure for talc is 20×10^6 particles per cubic foot. The limit under MSHA is the same. The latest edition (1985–1986) of Threshold Limit Values recommended by the American Conference of Governmental Industrial Hygienists lists two entries for talc: talc (containing no asbestos fibers)—2 mg/m^3; talc (containing asbestos fibers)—use asbestos TLV. However, very few industrial talcs contain asbestos, and in those cases asbestos occurs only in trace amounts. Magnesium silicate (talc) is listed as GRAS (Generally Regarded as Safe) in indirect food applications according to the limitations listed in Sections 182.90, 175.300, and 177.1210 of Title 21, *Code of Federal Regulations*.

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