NYCO
One Mineral, A World Of Applications

Additional Reading: Physical Properties

About This Document

NYCO has the benefit of many years of experience in the production, handling and marketing of wollastonite products. The purpose of this document is to share some of this accumulated knowledge and experience with NYCO's customers, associates, agents and distributors with a view towards the successful usage and application of NYCO's wollastonite products.

The document provides a basis for understanding and for obtaining more definitive information or advice. This guide in no way represents a definitive reference for wollastonite. In consideration of the peculiarities of wollastonite, NYCO strongly recommends that the appropriate professionals carry out any design of products, processes, installations or modifications. NYCO also recommends that any test work deemed necessary by those involved in these endeavors be carried out on the appropriate NYCO products. NYCO can provide contacts that have had past experience working with wollastonite.

Where specific information is given, this is based on NYCO's experience and as such is offered as an example only. Situations and conditions in other's facilities will be different enough to warrant that a qualified professional makes specific recommendations. NYCO can provide assistance in contacting individuals with past experience.

Feel free to contact NYCO for additional information.

Physical Properties

Specific Gravity

The specific gravity of pure wollastonite (triclinic) can be calculated based on unit cell parameters to be 2.96. Measured specific gravities are typically fall in the following range: 2.87-3.09. This variation is due to trace or minor amounts of various impurity ions such as aluminum, iron, magnesium, manganese, potassium and sodium, which substitute for calcium and distort the crystal lattice. The specific gravity of commercial wollastonite products is also affected by the content of impurity minerals such as calcite (s.g. of 2.70-2.95), garnet (s.g. of 3.5-3.8), diopside (s.g. of 3.2-3.3), etc.

Bulk Density

Mixing, compounding, storing and shipping ground materials requires knowledge of their apparent bulk densities. The bulk density of commercial wollastonite products depends primarily on their fineness and aspect-ratio however, specific gravity, moisture content and test method can also play a role. The volume-weight test consists of measuring the volume of a given weight of material under specified conditions, and then calculating the weight per unit volume. This is done in the ‘loose’ condition (aerated) and in the ‘tapped’ condition (compacted). Typical measured bulk densities for NYCO products are as follows:

Loose Bulk Density, kg/m^3 (lbs./cu.ft.)	products vary from 220 to 1360 (14 to 85)
Tapped Bulk Density, kg/m^3 (lbs./cu.ft.)	products vary from 420 to 1440 (26 to 90)

In a related test, wollastonite is dispersed in water and the resulting suspension is then allowed to stand for a fixed period of time in a glass column. The height of the sediment is recorded. This is commonly referred to as ‘wet volume’ and gives an indication of particle size, aspect-ratio and settling characteristics.

Bulk density can be important in applications where the powder performs certain functions such as in steel casting mold powders, where the powder itself must be thermally insulating.

Color

When pure, the mineral is brilliantly white, but impurities even in trace amounts may color it cream, grey, pink, brown, or red. This color change is related to the presence of iron and other coloring ions. Color may be imparted by impurities on the crystal surface (deposited by the passage of groundwater) or by impurities actually contained in the crystal structure.

The luster is glassy to silky (vitreous to pearly). Luster is important in applications such as plastics, paints and coatings as it in turn imparts luster to surface finishes.

Brightness

The dry brightness and whiteness of wollastonite are important in determining it’s suitability for certain filler and ceramic applications. Brightness is determined by measuring the reflectance of finely ground powder against a standard that is assigned a brightness of 100. Magnesium oxide and barium sulphate are the two standards used. G.E. brightness, a term used in North America, refers to brightness measured with a General Electric reflectometer. Commercial wollastonite products usually have a G.E. brightness ranging from 80 to 95. The Hunter method is also used to measure the brightness of wollastonite.

Optical Properties

Typical values for pure polymorphs of wollastonite are shown below.

Optical Properties of Pure CaO SiO_2

Structure	α	β	γ	δ	**α :z**	**β :y**	**Sign**
a wollastonite - triclinic	1.618	1.630	1.632	0.014	39^O	4^O	(-)
a Parawollastonite - monoclinic	1.618	1.630	1.632	0.014	38^O	0^O	(-)
b Pseudowollastonite	1.610	1.611	1.654	0.044	9^O	-	(+)

The introduction of iron increases the refractive indices and the optic axial angle of wollastonite. In general, the effect of the entry of manganese is similar to that of iron.

Melting Point

The melting point for pure wollastonite is generally accepted as being 1540^{O}C. The fluid temperature for commercially produced wollastonite is generally somewhat lower than this value. NYCO has found that for NYCO's wollastonite products, the fluid temperature can be as low as 1380^{O}C. Melting point is important for end-uses such as ceramics, metallurgical fluxes, and heat or fire-resistance. The actual subject of melting point appears straightforward, however, it can be rather involved and complex including such things as Softening Point, Upper Plastic Deformation Point, Fluid Point, Fusion Range, Melt Rate, etc. Sometimes crystallization characteristics are just as important with a corresponding set of parameters (but generally different values) reached upon cooling. Unfortunately there are few standardized test procedures and test results can be easily influenced by such things as test method, particle size, bulk density, atmosphere, etc.

Thermal Conductivity Thermal conductivity measurements are specific to the application. Wollastonite is normally considered to have low thermal conductivity. Functional fillers for plastics typically have low thermal conductivity however, wollastonite may be advantageous in these applications since relative to other fillers, it can increase thermal conductivity of the polymer matrix without deterioration of electrical insulating properties. In the continuous casting of steel, the steel is very near solidification and the mold powder must have good insulating properties. As liquid flux and partially molten flux are poor insulators, the unmelted layer of powder must provide the majority of the heat retention. Insulating properties of the powder are dependent upon thermal conductivity, bulk density, etc.

Thermal Expansion

A characteristically low coefficient of thermal expansion combined with aspect-ratio, impart high thermal shock resistance and dimensional stability in high temperature applications such as fire-resistant board or refractory linings. The coefficient of linear expansion is generally accepted as being 6.5x10-6 mm/mm/^{O}C.

Mechanical Properties

The limited information regarding the mechanical properties of wollastonite is indicated below.

Mechanical Properties of Wollastonite

Form	Elastic Modulus, GPa	Tensile Strength, MPa
Wollastonite fibers (3-150 m m dia.)	303-530	2700-4100

Electrical Properties

Wollastonite can be considered to be an insulator or non-conductor of electricity. For pure wollastonite, the commonly accepted value for DC electrical conductivity is 1.5E-11 mho/m. The dielectric permittivity of pure wollastonite is generally accepted as 8.60 @ 1MHz. Specific measurements of wollastonite rock samples are as follows:

Relative Dielectric Permittivity & Loss Tangent				
Description	**1 kHz**	**10 kHz**	**100 kHz**	**1 MHz**
Wollastonite (Mexico)	6.9 0.0152	6.8 0.0046	6.8 0.0078	6.9 0.0046

The dielectric value of wollastonite in an epoxy formulation is 4.6, loss factor 10? = 1.0. For use in electrical ceramics, wollastonite provides a low loss dielectric crystalline phase which has proved useful in the production of high frequency electronic equipment.

Being an insulator, wollastonite powders in their dry state are prone to static charge build-up. Static charge can lead to material flow problems. Static discharge is a concern during transfers. Although wollastonite itself is not flammable, the proper grounding of wollastonite handling equipment is advisable particularly in areas containing other materials that may be explosive or flammable.

Fluorescence

It has been reported that some wollastonite fluoresces yellow or orange under short-wave ultraviolet light. Fluorescence may however, suddenly extinguish with some samples. The variation in the color of fluorescence in wollastonite is thought to be due to a variation in the percentage of manganese activator. At a manganese concentration of about 0.1 percent, yellow fluorescence results. At 5 percent, the fluorescence is orange. Intermediate concentrations of manganese produce intermediate colors. Some response is evident in wollastonite under long-wave ultraviolet, but it is usually weak.

Particle Shape

High aspect-ratio is important in filler applications as it has a mechanical reinforcing effect. High aspect-ratio products are used as functional fillers for reinforcing thermoplastic and thermoset polymer compounds. In cement-based products, high aspect wollastonite is also added for it’s reinforcing effect as a replacement for asbestos. Being thermally stable, wollastonite fibers also impart high temperature stability to both organic resin and cement products.

Particle Size

The optimum particle size for wollastonite products is determined primarily by the application. In general, coarse particle sizes are considered undesirable because they detract from mechanical reinforcement, segregate and settle quickly, affect the processing and quality of end-use products, lead to higher abrasion, and affect surface finish. On the other hand, excessive amounts of fines can lead to ineffective mechanical reinforcement, high resin consumption as a filler, and problems with materials handling.

Abrasion

Abrasive wear is a concern for process and handling equipment especially in plastics compounding. The abrasion is influenced largely by the particle size and some of the finer wollastonite products are very low in abrasivity (comparable to ground talc). Coarser grades however, are more abrasive (comparable to glass fiber). Fine wollastonite products can now be used in compounding, injection, and extrusion equipment that has historically not been able to withstand such harsh abrasive fillers as glass fiber and large particle size wollastonite.

Scratch & Mar Resistance

The susceptibility to scratch & mar damage during shipping, assembly, and use of plastic components prevents greater use of some polymer systems. Generally, scratch & mar resistance is related to the wear resistance of a finished surface. Surface hardness is directly related to the wear resistance of a material. Compared to other functional fillers, wollastonite has a higher Mohs hardness (4.5-5.0). For example the hardness of talc is 1.0-1.5 and calcite is 3.0. As a result, wollastonite filled polymers typically have superior scratch & mar resistance.

Plastics

As a functional filler for polymers, acicular wollastonite improves flexural, compressive and impact strength. It also enhances electrical insulating properties, increases heat distortion temperature, adds fire resistance, improves machinability and dimensional stability. In the compounding of plastics, wollastonite’s low plasticizer absorption, high brightness and opaqueness result in lowered polymer and pigment demand. Low viscosity at high loadings can reduce mold cycle time.

Wollastonite’s compatibility with organic polymers is enhanced with surface or chemical treatment with surface coupling agents. This further improves wollastonite dispersion and wetting; mineral-polymer bonding; mechanical and electrical properties. Wollastonite is used in such things as thermosetting plastics including phenolic molding compounds, epoxies, polyurethane, polyurea, BMC polyester and friction products; thermoplastics such as polypropylene, nylon, polyester, polycarbonate, and other engineering plastics and alloys.

High Temperature Products

Wollastonite has found application as a substitute for asbestos in fire-resistant building products used in the construction industry. As a functional additive, wollastonite improves flexural and impact strengths, freeze/thaw resistance and sound deadening properties. Wollastonite’s low thermal conductivity and good aspect-ratio leading to high temperature dimensional stability make wollastonite an attractive addition for applications requiring fire resistance. Wollastonite finds application in such things as interior and exterior construction boards, roof tiles, shaped insulation products, sheets, panels and sidings. In a related application, wollastonite also finds use in calcium silicate linings for high temperature furnaces, vessels, etc.

Paints and Coatings

In coatings, fine acicular particles (-10 microns) act as a good flattening agent and allow paint to settle out after application to produce a dry film of uniform thickness, and the interlocking particles improve toughness and durability of the coating with excellent tint retention, scrub, and weather resistance. High brightness and whiteness reduce pigment load, and typically very low oil absorption reduces the volume of binder required and contributes to reduced pigment costs. As noted earlier, wollastonite can also help to neutralize acidity shift.

Suggested References

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