An Introduction to Mineral Fillers for Paints & Coatings

Vanderbilt Minerals, LLC
Overview

Introduction

General discussion about the function of mineral fillers

Mineral fillers from Vanderbilt Minerals, LLC

Other mineral fillers, not sold by Vanderbilt Minerals, LLC

An example of the effect of different mineral fillers in a low VOC interior latex flat paint

Summary
Vanderbilt Minerals, LLC
Norwalk, CT

R.T. Vanderbilt Company was started in 1916 by Robert T. Vanderbilt.

Started by selling kaolin clay to the Paper Industry.

Began selling minerals and chemicals to the Paints & Coatings Industries in the 1920s.

Paint R & D Laboratory has been in existence since before 1930.

R.T. Vanderbilt Holding Company, Inc. in the 21st Century

Still privately a held company. Hugh B. Vanderbilt, Jr. Chairman of the Board.

Now divided into Vanderbilt Minerals, LLC and Vanderbilt Chemicals, LLC

CMA Responsible Care Company

ISO 9001 Certified
R.T. Vanderbilt Holding Company, Inc. in the 21st Century

Corporate Offices and R & D in Norwalk, CT
Chemical Production in Murray, KY and Bethel, CT
Minerals Production in Gouverneur, NY, Bath, SC, Robbins, NC, Murray, KY, various sites in AZ, NV and CA
Mineral Fillers = something cheap to take up space—not so!

Minerals and other chemical additives in paints & coatings are used to improve properties.
Effects of addition of minerals to paints & coatings depend on:

Mineralogy (chemistry, crystal structure, Mohs hardness, etc)

Oil absorption, brightness, pH, chemical inertness, refractive index, purity, soluble salts, etc

Particle size and particle size distribution

Particle shape and aspect ratio

Volume fraction in the matrix (PVC and CPVC)
Mineralogy

A mineral can’t be defined simply by its chemical formula. The crystal structure must also be considered.

For example, there are many aluminum silicates. Hydrous kaolin \([\text{Al}_2\text{Si}_2\text{O}_5(\text{OH})_4]\), mullite \([\text{Al}_2\text{SiO}_5]\), pyrophyllite \([\text{Al}_2\text{Si}_4\text{O}_{10}(\text{OH})_2]\), kyanite \([\text{Al}_2\text{O}\text{SiO}_4]\) and sillimanite \([\text{Al}_2\text{SiO}_5]\) are all aluminum silicates but are unique minerals. They have different crystal structures and different properties.
Mineral properties that must be considered:

pH is a function of the metallic ions in the structure. Aluminum in the structure makes the mineral acidic. Calcium, potassium, barium or sodium makes the mineral alkaline. Some minerals, such as calcite or serpentine are soluble in acids and can’t be used in coatings that have pH <7.
Mineral properties that must be considered:

Mohs hardness is a relative measure of abrasivity or abrasion resistance of a mineral. Talc is the softest mineral and diamond is the hardness. Harder minerals will have better scrub resistance and better burnish resistance. They also will potentially be more damaging to process equipment than softer minerals.
Mohs Hardness Scale

1. Talc
2. Gypsum
3. Calcite
4. Fluorite
5. Apatite
6. Feldspar
7. Quartz
8. Topaz
9. Corundum
10. Diamond
Mineral properties that must be considered:

The oil absorption of a mineral is a function of the mineral itself and how finely it is ground. The denser the mineral, the lower the oil absorption. The oil absorption relates to how much of the resin the mineral will absorb. The oil absorption affects the viscosity of the paint and the gloss.
Mineral properties that must be considered:

Water-soluble salts in certain minerals can adversely affect corrosion resistance and exacerbate blistering. Exterior paint frosting and chalking also are a result of soluble salts.

Dry brightness and color-in-oil of a mineral will affect how the mineral appears in a coating. A mineral can have excellent dry brightness but turn color when put into a resin. Color-in-oil can vary from cream to gray or even green depending on the mineral. The color is usually an effect of minor impurities.
Mineral properties that must be considered:

Refractive index is a measure of how light is bent when it passes from one medium to another. The higher the refractive index, the more the light is bent and the greater opacity results. Rutile TiO$_2$ has a high refractive index and gives good opacity to coatings.

Most mineral fillers have significantly lower refractive index and don’t give opacity, but they can be used in conjunction with TiO$_2$ to achieve opacity at reduced cost. Some minerals, such as amorphous silica, have refractive index the same or lower than the resin and will be invisible in the dry film. They can be used to reduce gloss of a clear coating without creating haze.
Particle size and particle size distribution

The particle size of a mineral can be expressed in several ways depending on the method by which it is measured.

Common methods of measuring particle size are Hegman fineness, screening, sedimentation methods and laser light scattering methods.

Each method will yield a distinct result.

When comparing data of different minerals, be sure that the particle size distributions are measured the same way.
Particle size by Hegman Fineness

Hegman fineness measurements yield only size of the coarsest particles. This is a good first approximation of the fineness of grind and dispersion of the mineral pigments in the paint.

Hegman fineness does not tell anything about the overall distribution of the minerals.
Screen residues yield the % coarser than some given mesh size. Typical mesh sizes are 100, 200, 325 and 450 mesh. These are equal to 150 μm, 75 μm, 44 μm and 32 μm respectively.

Screenings can be done dry or wet. Wet screenings usually yield smaller quantity retained than dry screenings.
Particle size by screening

The screen residue measures the quantity retained, it does not tell anything about the size of those retained particles except that they are larger than the screen openings.

The screen residue does not tell anything about the sizes of the particles that pass through the screen except that they are smaller than the screen openings.
For acicular particles the process is more challenging.
Particle size and particle size by sedimentation methods

Sedimentation methods, such as measure by SediGraph, measure particle size by Stokes Law and yield results expressed as equivalent spherical diameter.

The median equivalent spherical diameter is often given. The median is the size where 50 % of the particles are larger and 50 % are smaller.
What “size” is this particle?

Equivalent Spherical Diameter

Be careful when:
Comparing the “particle size” of dissimilar minerals
Comparing particle size from different analyzers

These are the same size!
(all have the same equivalent spherical diameter)
Caution when using just the median diameter:
These two distributions that have the same median size but are obviously quite different in overall distribution.

Median Particle Size = Half the particles are larger, half are smaller

See the next slide.....
These two products have the same equivalent spherical diameter but ….
Particle size and particle size by laser diffraction methods

Laser diffraction measurement methods, such as measured by Malvern or Horiba, yield a different particle size and particle size distribution than sedimentation methods.

Particle size is usually expressed as $D_{10}$, $D_{50}$ and $D_{90}$. (the percent finer than the stated micron size)

Laser diffraction methods usually yield a coarser particle size than sedimentation methods.
The various particle size distribution methods described have been compared for two products. Which is finer?

<table>
<thead>
<tr>
<th></th>
<th><strong>VANSIL® W-30</strong></th>
<th><strong>VANSIL W-40</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hegman Fineness</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>325 mesh residue</td>
<td>0.06%</td>
<td>0.03%</td>
</tr>
<tr>
<td>Median particle size by SediGraph</td>
<td>4.5 μm</td>
<td>5.6 μm</td>
</tr>
</tbody>
</table>
Particle shape and aspect ratio

Mineral particles can be in any of several basic shapes. These basic shapes are:

- Sphere
- Cube
- Needle
- Block
- Plate/Flake
- Fiber
Aspect Ratio

Needle/Fiber Aspect Ratio: \( \frac{L}{D} \)
Ratio of mean length to mean diameter

Plate Aspect Ratio: \( \frac{D}{T} \)
Ratio of mean diameter of a circle of the same area as the face of the plate to the mean thickness of the plate
Aspect Ratio

Aspect ratio is a description of the overall shape of the particle. It describes the length to diameter ratio, the face to thickness ratio, etc.

Cubes or spheres have 1:1 aspect ratio

Blocks have 2:1 to 4:1 aspect ratio  
(length:width)

Needles or fibers have 5:1 to 200:1 aspect ratio  
(length:width)

Plates or flakes have 20:1 to 200:1 aspect ratio  
(face:edge)
Volume Fraction in the Matrix
PVC & CPVC

The volume that the mineral occupies in the matrix and its ratio to the volume of binder plays an important part in the properties of the paint.

Pigment volume concentration (PVC) is an important ratio when formulating paints & coatings.

The oil absorption of the minerals must also be accounted for. The amount of resin left after the oil absorption has been satisfied is the “free binder”. The amount of free binder affects factors such as gloss, adhesion, corrosion resistance and durability.
PVC Calculations

\[
\% \text{ PVC} = \frac{\text{volume of mineral}}{\text{volume of mineral} + \text{volume of resin solids}} \times 100
\]

Many basic properties of paints are affected both positively and negatively by the PVC ratio.

Asbeck & Van Loo studied the relationships and coined the term CPVC (Critical Pigment Volume Concentration).
Asbeck & Van Loo Diagram showing relationships between PVC and paint properties

- Blistering
- Gloss
- Film tensile
- Scrub resistance
- Permeability
- Rusting

PVC vs. CPVC
A “maximum-filled” matrix occurs at the Critical Pigment Volume Concentration (CPVC). Film properties change markedly near the CPVC.

CPVC of a solvent-borne coating can be approximated from the oil absorption. It is more difficult to determine the CPVC of a latex coating.
At < CPVC, there is an excess of binder. This results in high gloss, good scrub resistance, good corrosion resistance, good blister resistance and good adhesion.

At > CPVC, there is insufficient binder to completely coat all the mineral particles. This results in low gloss, poor scrub resistance, poor corrosion resistance, poor blister resistance and poor adhesion.

It is recommended that the coating be formulated either below or above CPVC but not at CPVC. As can be seen from the earlier slide, properties change rapidly at CPVC, and very minor differences from batch to batch can result in major differences in properties.
CPVC approximations by Oil Absorption

CPVC can be approximated from oil absorption data. Prepare a dry blend of the minerals and pigments in the coating and measure the oil absorption by ASTM D 281. Calculate the CPVC as follows:

\[
CPVC = \frac{1}{1 + OA}
\]

The above calculation only is valid for solvent borne coatings. The oil absorption must be determined on a mixture of the minerals and pigments in the same proportions as they will be used in the paint. Latex particles do not fill the voids of the minerals in the same fashion as other resins and the CPVC as approximated by the oil absorption will likely be different for a latex paint made with those minerals.
Gloss vs PVC can be used to determine CPVC. Prepare a series of paints with the same minerals but increasing PVC. Measure the gloss of the paints and plot gloss vs PVC. The point of inflection of the curve is the CPVC. The other properties on the Asbeck and Van Loo curve can also be used to determine CPVC but gloss vs PVC is the fastest and easiest method.
Effect of PVC on gloss

Light

Paint film

Substrate

Low PVC Film
(< CPVC)

High Gloss

High PVC Film
(> CPVC)

Low Gloss
Determination of CPVC by gloss

Gloss v PVC

Gloss

CPVC

PVC
Mineral Fillers affect many coatings properties

- Dry Hide
- Dry Film Durability & Flexibility
- TiO₂ Efficiency
- Scrub Resistance
- Color Uniformity
- Substrate & Inter-coat Adhesion
- Weathering Resistance & Tint Retention
- Abrasion Resistance
- Application Rheology
- Gloss Control
- Tannin Blocking
- Stain Resistance
- Corrosion Resistance
- Replacing More Expensive Prime Pigments
Filler and extender minerals from Vanderbilt Minerals, LLC

VANSIL® Wollastonite

PYRAX® and VEECOTE® Pyrophyllite

DIXIE CLAY®, PEERLESS® and BILT-PLATES® Kaolin Clay
Wollastonite
Mohs hardness = 4 ½ - 5, refractive index = 1.63, density = 2.9 g/cc
VANSIL® Wollastonite

Wollastonite is an acicular (needle-like) mineral, calcium silicate. It has low oil absorption.

Vanderbilt Minerals, LLC’s wollastonite is mined and processed in the Gouverneur, NY area.

Uses include corrosion resistance for water-borne DTM primers, tint retention for exterior latex paints and scrub resistance for interior flat paints. Fine ground products are used in powder coatings.

The VANSIL products are available in both powder and acicular grades.
<table>
<thead>
<tr>
<th>Powder grades of VANSIL®</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>VANSIL W-10</td>
</tr>
<tr>
<td>VANSIL W-20</td>
</tr>
<tr>
<td>VANSIL W-30</td>
</tr>
<tr>
<td>VANSIL W-40</td>
</tr>
<tr>
<td>VANSIL W-50</td>
</tr>
</tbody>
</table>
## Acicular Grades of VANSIL®

<table>
<thead>
<tr>
<th></th>
<th>Hegman Fineness</th>
<th>Aspect Ratio</th>
<th>Screen Residue</th>
</tr>
</thead>
<tbody>
<tr>
<td>VANSIL WG</td>
<td>0</td>
<td>15:1</td>
<td>20% + 200 mesh</td>
</tr>
<tr>
<td>VANSIL HR-325</td>
<td>6 +</td>
<td>12:1</td>
<td>&lt;0.1% + 325 mesh</td>
</tr>
<tr>
<td>VANSIL HR-1500</td>
<td>0-1</td>
<td>14:1</td>
<td>2.5% + 325 mesh</td>
</tr>
<tr>
<td>VANSIL HR-2000</td>
<td>0-1</td>
<td>14:1</td>
<td>5% + 325 mesh</td>
</tr>
</tbody>
</table>
Pyrophyllite
Mohs hardness = 1-2, refractive index = 1.59, density = 2.8 g/cc
PYRAX® and VEECOTE® Pyrophyllite

Vanderbilt Minerals, LLC mines and processes pyrophyllite in the Robbins, SC area

Pyrophyllite is a platy aluminum silicate (not to be confused with kaolin clay that is also an aluminum silicate).

Pyrophyllite has a talc-like structure.

Pyrophyllite is a cream colored, coarse filler.

Uses include interior primers, inexpensive flat paints, texture paints and as a mica replacement in joint compounds.
# Grades of PYRAX® and VEECOTE®

<table>
<thead>
<tr>
<th></th>
<th>Hegman Fineness</th>
<th>G. E. Brightness</th>
<th>Oil Absorption</th>
<th>Median PS (SediGraph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VEECOTE</td>
<td>0-1</td>
<td>80</td>
<td>26</td>
<td>10.0 µm</td>
</tr>
<tr>
<td>PYRX B</td>
<td>0</td>
<td>78</td>
<td>24</td>
<td>14.0 µm</td>
</tr>
<tr>
<td>PYRAX WA</td>
<td>0</td>
<td>78</td>
<td>26</td>
<td>10.0 µm</td>
</tr>
</tbody>
</table>
Kaolin Clay

Mohs hardness = 2-2 ½, refractive index = 1.56, density = 2.6 g/cc
Kaolin clay is a platy aluminum silicate mineral.

Vanderbilt Minerals, LLC’s kaolin clay is mined and processed in Bath, SC area, northeast of the main kaolin producing area of central GA.

Kaolin clay forms in two distinct crystal sizes which have the generic designations of hard (finer) and soft (coarser) clay.

DIXIE CLAY and BILT-PLATES are air floated hard clay. PEERLESS and McNAMEE are air floated soft clay.

Uses include fillers for interior primers, interior flat paints
## Grades of Kaolin Clay

<table>
<thead>
<tr>
<th></th>
<th>Hegman Fineness</th>
<th>G. E. Brightness</th>
<th>Oil Absorption</th>
<th>Median PS (SediGraph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DIXIE® Clay</td>
<td>0</td>
<td>70</td>
<td>41</td>
<td>0.25 µm</td>
</tr>
<tr>
<td>BILT-PLATES® 156</td>
<td>4</td>
<td>75</td>
<td>41</td>
<td>0.25 µm</td>
</tr>
<tr>
<td>PEERLESS® 1</td>
<td>0</td>
<td>75</td>
<td>30</td>
<td>1.2 µm</td>
</tr>
<tr>
<td>PEERLESS 3</td>
<td>0</td>
<td>60</td>
<td>33</td>
<td>1.1 µm</td>
</tr>
<tr>
<td>MCNAMEE®</td>
<td>0</td>
<td>71</td>
<td>39</td>
<td>1.1 µm</td>
</tr>
</tbody>
</table>
Other Filler Minerals
(not sold by Vanderbilt Minerals, LLC)

Calcium Carbonate (natural calcite & synthetic precipitated calcium carbonate)

Talc

Nepheline Syenite

Silica (natural quartz, amorphous synthetics)

Barium Sulfate (natural barite & blanc fixe)

Mica

Diatomite
Calcium Carbonate

Mohs hardness = 3, refractive index = 1.70, density = 2.7 g/cc

Natural Ground (GCC)  Synthetic (PCC)
Natural Calcium Carbonate

Natural calcium carbonate (GCC) is one of the most abundant filler minerals.

It forms in several crystal habits (different shapes). Shapes include blocky (chalk), scalenohedral (calcite), short needle acicular (aragonite).

Calcium carbonate has high brightness, low oil absorption, can be ground to ultra fineness, and is relatively inexpensive.

It is widely used in all kinds of paints and coatings especially interior and exterior architectural.

Calcium carbonate is unstable in acidic conditions & soft (poor abrasion resistance).
Synthetic Calcium Carbonate

Synthetic precipitated calcium carbonate (PCC) is made by calcining poor quality calcite or lime, dissolving in water to make slaked lime, reacting with CO$_2$ then precipitating a fine high brightness product. Many different crystal structures are available and can be tailored to the specific end use.

PCC is used where higher brightness, finer particle size, lower abrasivity and higher purity are required than for GCC.

PCC is used in water borne traffic paints and as TiO$_2$ extenders and opacifiers in latex paint.
Platy Talc
Mohs hardness = 1, refractive index = 1.59, density = 2.75 g/cc
Platy Talc

Talc is a platy magnesium silicate mineral. Its properties include high oil absorption, softness and high brightness.

Talc is found all over the world. Large deposits are located in China, France, Italy, Brazil, Norway, India, Canada, and USA.

The use of talc in coatings contributes to gloss control, TiO\textsubscript{2} spacing, anti-settle, sandability of primers, inter-coat adhesion and corrosion/blistering resistance.
Nepheline Syenite

Mohs hardness = 5-6, refractive index = 1.53, density = 2.57
Nepheline syenite is an irregular shaped natural mineral mix of feldspars and nepheline. Its crystal structure is deficient in silica.

It is used in various kinds of paints and coatings where it imparts good scrub resistance to flat paint and good exterior weatherability (tint and gloss retention and resistance to chalking and frosting).
Silica
Mohs hardness = 7, refractive index = 1.54, density = 2.65

quartz

sand
Silica

Natural silica is the most abundant mineral family on earth.

Common varieties include quartz, sandstone, silica sand, tripoli, opal and novaculite (microcrystalline quartz).

It has low oil absorption, good brightness, high purity, and excellent abrasion resistance.

Caution must be observed in its use because crystalline silica exposure may cause lung cancer and similar illnesses.
Synthetic Silica

Synthetic silica products are made in several forms.

Precipitated amorphous silica has high brightness, high oil absorption and low refractive index.

Because of low refractive index, these products can be used for gloss control of clear coatings. Because of the hardness, these products can be used for scrub resistance of latex paints.
Barium Sulfate

Mohs hardness = 3-3 ½, refractive index = 1..64, density = 4.5 g/cc

Natural Barite  Blanc Fixe
Barium Sulfate

Natural barium sulfate, known as barite, is a high brightness, high specific gravity, low oil absorption inert filler. It finds use in powder coatings because of its high specific gravity, good brightness and low oil absorption.

Synthetic barium sulfate, known as blanc fixe, is used for photographic paper coatings and in industrial and automotive primers.
Mica

Mohs hardness = 2-3, refractive index = 1.60,

density = 2.8 g/cc
Mica

Mica is a platy mineral. There are several different forms of mica: muscovite, phlogopite, biotite, etc.

Fine dry ground mica is used in joint compounds and texture paints for mud crack resistance.

Fine wet ground mica is used in exterior latex paints for tint retention and weatherability.

Mica is used as the base for special effect pigments.
Diatomaceous Earth

Mohs hardness = 4 ½-5, refractive index = 1.41, density = 2.0 g/cc
Diatomaceous earth is a form of silica formed from skeletons of microscopic plants and animals (diatoms) which yields a wide range of interesting shapes and sizes.

It has very high surface area, high pore volume and is very hard.

Its uses include gloss control and scrub resistance of interior flat paints. One must be careful when using diatomite as over grinding will destroy the unique crystal shapes, defeating the purpose of using it. Addition late in the paint preparation with low shear mixing is recommended.
An example of the effect of using different mineral fillers in an interior latex flat paint.

A study was done comparing several mineral fillers in a low VOC 65 PVC interior flat paint. The following mineral fillers were compared at equal volume loading:

- Platy Talc
- Wollastonite
- Pyrophyllite
- Nepheline Syenite
- Calcium Carbonate (GCC)
- 50/50 Platy Talc & Wollastonite
An example of the effect of using different mineral fillers in an interior latex flat paint.

The following paint properties were compared:

- Hegman Fineness
- Viscosity
- Dry film brightness
- Gloss
- Opacity
- Sag & Leveling
- Scrub Resistance
## Low VOC 65 PVC Interior Flat Latex Paint

<table>
<thead>
<tr>
<th>Dispersion</th>
<th>Pounds</th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>340.0</td>
<td>40.8</td>
</tr>
<tr>
<td>HEC</td>
<td>6.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Propylene Glycol</td>
<td>10.0</td>
<td>1.2</td>
</tr>
<tr>
<td>In can preservative</td>
<td>2.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Dispersant</td>
<td>9.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Wetting agent</td>
<td>2.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Defoamer</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>NH₄OH</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>TiO₂ R 706</td>
<td>145.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Mineral filler</td>
<td>Variable</td>
<td>11.5</td>
</tr>
<tr>
<td>Calcined clay</td>
<td>75.0</td>
<td>4.1</td>
</tr>
</tbody>
</table>

*Mix at high speed for 15 minutes. Reduce speed for let down.*
## Low VOC 65 PVC Interior Flat Latex Paint

<table>
<thead>
<tr>
<th>LET DOWN</th>
<th>Pounds</th>
<th>Gallons</th>
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</thead>
<tbody>
<tr>
<td>Vinyl acrylic latex</td>
<td>210.0</td>
<td>23.5</td>
</tr>
<tr>
<td>Water</td>
<td>95.0</td>
<td>11.4</td>
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<tr>
<td>Coalescent</td>
<td>7.0</td>
<td>0.8</td>
</tr>
<tr>
<td>Rheology Modifier</td>
<td>1.5</td>
<td>0.2</td>
</tr>
<tr>
<td>Defoamer</td>
<td>2.0</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Mix at slow speed for 10 minutes.*

Totals                  | variable | 100.0   |
## Paint Properties

<table>
<thead>
<tr>
<th></th>
<th>Talc</th>
<th>Wollastonite</th>
<th>Pyrophyllite</th>
<th>Nepheline Syenite</th>
<th>GCC</th>
<th>50/50 Talc/Wollastonite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hegman</td>
<td>$3\frac{1}{2}$</td>
<td>4</td>
<td>$2\frac{1}{2}$</td>
<td>4</td>
<td>$3\frac{1}{2}$</td>
<td>4</td>
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<tr>
<td>KU viscosity</td>
<td>92</td>
<td>77</td>
<td>80</td>
<td>79</td>
<td>90</td>
<td>88</td>
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<tr>
<td>Dry Brightness</td>
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<td>90</td>
<td>87</td>
<td>89</td>
<td>90</td>
<td>89</td>
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<td>60° Gloss</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
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<tr>
<td>85° Gloss</td>
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<td>2</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Opacity</td>
<td>0.98</td>
<td>0.97</td>
<td>0.98</td>
<td>0.95</td>
<td>0.97</td>
<td>0.98</td>
</tr>
<tr>
<td>Scrub Resistance (cycles)</td>
<td>80</td>
<td>170</td>
<td>110</td>
<td>220</td>
<td>160</td>
<td>120</td>
</tr>
<tr>
<td>Sag Rating (mils)</td>
<td>24</td>
<td>22</td>
<td>12</td>
<td>14</td>
<td>22</td>
<td>22</td>
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<tr>
<td>Leveling Rating</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td>4</td>
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</tbody>
</table>
The previous slide showed how the properties of a paint can be affected by the mineral filler. Mineral fillers cannot be just substituted for each other without testing to determine if the performance properties will change when the substitution is made. Blending of two or more minerals may yield the best properties of each and minimize their deficiencies.
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Summary

There are many kinds of minerals used in paints & coatings.

Each mineral is unique in its function.

For additional information on products offered by Vanderbilt Minerals, LLC visit:

www.vanderbiltminerals.com

or

www.innovadex.com

Additional reading: *Industrial Minerals and Their Uses*, Edited by Peter A. Ciullo (Noyes Publications)