

# Using functional fillers in coating powder formulation

Douglas S. Richart

*D.S. Richart Associates*

*Although fillers are used in coating powder formulation to control cost and to extend prime pigments, they are also used to improve or modify many functional properties of a coating powder. This article examines three popular fillers—barium sulfate, calcium carbonate, and wolastonite—as well as a few other fillers used in coating powder formulation. It also looks at how the fillers are made and how they affect the functional characteristics of a coating, specifically gloss.*

**F**illers are widely used in coating powder formulations to modify functional properties, such as hardness; modulus; permeability; corrosion, abrasion, and chip resistance; gloss; texture; flammability; and electrical characteristics. The term *filler* comes from liquid paint technology, where it refers to materials that are included in a coating composition to take up space and to reduce cost. The term has a similar meaning in powder coating technology, which is unfortunate because fillers for coating powders can actually improve or modify the functional characteristics of the coating.

Many in the powder coating industry also refer to fillers as *extenders*. In the paint industry, extenders, or extender pigments, show some degree of wet or dry hiding and extend the hiding of titanium dioxide (TiO<sub>2</sub>). This distinction isn't usually made in the powder coating industry.

Manufacturers use fillers to ensure that all powders of a formula type cost about the same and offer consistent coverage. For example, many suppliers offer a standard coating powder formulation that comes in many colors. The white powder in this formula class may need a level of 35 to 40 parts of TiO<sub>2</sub> per hundred parts of resin (PHR) for adequate hiding at a nominal thickness of 2

mils (50 microns). But the black powder of the same formula class may need only 2 to 3 PHR of carbon black to get complete opacity at the same thickness. If the powders were formulated and sold on this basis, the black powder would have a lower specific gravity, higher flow, higher cost per pound, and a higher gloss than the white powder.

By adding the appropriate type and amount of filler to the black powder, the white and black formulations will be about equal in cost, coverage, and gloss.

## Filler makeup and properties

Most fillers used in coating powders are inorganic and are usually based on naturally occurring mined minerals that are beneficiated—in some cases—and ground to a fine particle size. Particle size varies with the filler's specific grade, but can range from relatively coarse particles—a median particle size of 15 microns or more with 1 to 2 percent retained on a 325-mesh screen—to very fine particles with a median particle size of less than 1 micron.

Some fillers are made synthetically, usually by precipitation from a solution of soluble salts. For example, barium sulfate is precipitated from a solution of barium chloride and sodium sulfate (see Table 1). The precipitated fillers usually have a finer and more narrow distribution of particle size than the ground fillers. Ground fillers are prepared by mechanically grinding—either wet or dry—and by classifying to a consistent particle-size distribution.

Most fillers are inorganic, usually in their fully oxidized state. They are heat stable, resist ultraviolet degradation and chemical attack, and don't interact with the binder system. Table 2 shows the characteristics of an

ideal filler. Other important characteristics that affect the smoothness, texture, and gloss of a coating powder are as follows:

- Particle shape, which also affects gloss, smoothness, texture, and permeability of a coating powder
- Oil absorption, which has a significant affect on flow and smoothness of a coating powder
- Specific gravity, which affects the coverage and applied cost of a coating powder

### Three popular fillers

Because different fillers have different properties, powder manufacturers use many types of fillers in their powders. Table 3 shows the most widely used fillers: cal-

**TABLE 2**

**Characteristics of an ideal filler**

**Inert**

- Noninteraction with binder system
- Lightfast and colorfast
- Resistant to solvents, acids and alkalis, chemicals, and stains
- Heat stable
- Insoluble in water and organic solvents

Constant properties, such as composition, particle size, and distribution

Low specific gravity

Nontoxic and nonhazardous

Nonabrasive

Low cost

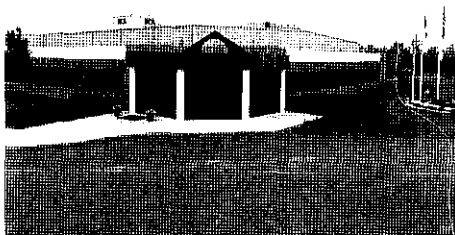
**TABLE 1**

**The synthetic preparation of barium sulfate by precipitation from a solution of barium chloride and sodium sulfate**



# Introducing **HOLCORES PC**

## organic pigment dispersions for powder coating manufacturers



- Compatible with major thermoset resin systems.
- Increased productivity by reducing extrusion time (single pass results in full color development).
- Reduced dust and contamination.
- Easy incorporation due to low melting point.
- No color drift.
- Increased gloss.
- Maximum color strength compared to using raw pigment.

The Holland Colours Group has been supplying innovative products in technically demanding markets around the world since 1979. We are proud to introduce **HOLCORES PC** to the North American powder coating industry. Let us show you what **HOLCORES PC** can do to optimize your coloring system.



**HOLLAND COLORS AMERICAS INC.**  
 Phone: (765) 935-0329  
 Toll Free: (800) 723-0329  
 Fax: (765) 966-3376

**HOLLAND COLOURS CANADA INC.**  
 Phone: (416) 449-4344  
 Toll Free: (800) 361-3967  
 Fax: (416) 449-3587

TABLE 3

## Properties of typical fillers used in coating powders

Common name	Barytes	Calcite	Wollastonite	Clays
Chemical type	Barium sulfate	Calcium carbonate	Calcium metasilicate	Aluminum silicate
Particle shape	Granular	Granular	Acicular	Platy/lamellar
Specific gravity	4.45	2.65	2.90	2.58
Oil absorption (g/100 g)	12	16-30	20-33	40-115
Refraction index	1.64	1.57	1.63	1.62
Source	Natural/synthetic	Natural/synthetic	Natural	Natural

Common name	Talcs	Hydrated alumina	Silica	TiO <sub>2</sub> (comparison)
Chemical type	Magnesium aluminum silicate	Hydrated aluminum oxide	Silicon dioxide	Titanium dioxide
Particle shape	Platy/fibrous	Tabular	Granular	Granular
Specific Gravity	2.80	2.42	2.65	4.0
Oil absorption (g/100 g)	25-50	30-40	20-45	14-18
Refraction index	1.59	1.56	1.55	2.70
Source	Natural	Natural/synthetic	Natural	Synthetic

# INTELLIGENT SOLUTIONS

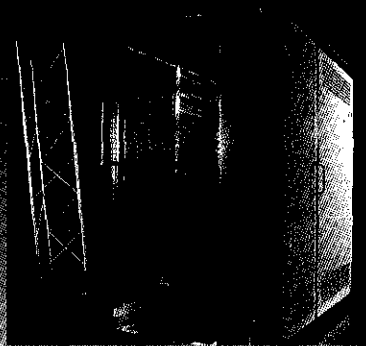
PED Technologies offers intelligent solutions for all your finishing needs:

## THE ULTIMATE CURE



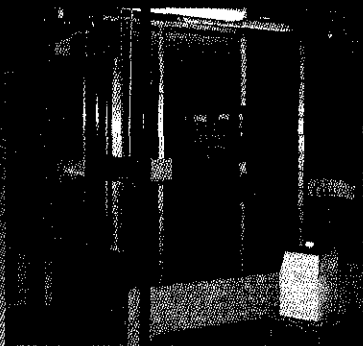
The PED Contraflow curing oven combines infrared with reverse convection air movement, resulting in fast cure times, minimal floor space requirements and energy efficiency. The Contraflow allows you to achieve the ultimate level of curing perfection.

## TURBOCHARGE YOUR FINISHING LINE



The PED Solar booster oven will turbocharge coated products to the desired temperature in a fraction of the existing time. This means shorter cure times, faster line speeds, improved quality, higher productivity and increased profits.

## POWDER & LIQUID FINISHING SYSTEMS



Take control of your coating requirements. PED designs and integrates compact, flexible systems offering user friendly operation, fast response times, minimal installation time and maximum investment value. Each system is custom designed to fit your specific needs.

**Make the INTELLIGENT choice. Call PED Technologies today to find solutions for all your finishing needs!**

**Phone (606) 282-2750**

**PED TECHNOLOGIES**

1369 Cox Avenue • Erlanger, KY 41018 • Fax (606) 525-0992

cium carbonate, barium sulfate, and silicates. The table lists data for  $TiO_2$  for comparison.

**Barium sulfate.** This probably comes as close to an ideal filler for high-gloss systems as any available. The filler has a low oil absorption, which means the coating has only a slight reduction in flow and smoothness even at higher levels, such as 50 PHR or 33 percent loading.

All pigments and fillers reduce to some extent the melt-flow and smoothness of a coating powder as well as its physical properties, such as flexibility and impact resistance. But barium sulfate, or barytes, reduces melt-flow and smoothness less than other fillers. The filler is very inert and doesn't react with the binder or with outside environmental factors, such as acid rain. Barium sulfate only slightly reduces coating-powder gloss and doesn't adversely affect the physical properties of the binder system as much as other fillers.

Both the ground mineral (barite) and the precipitated synthetic filler (blanc fixe) are widely available. The precipitated grades have a finer particle size and a purer chemical composition than the ground grades. The ground grades are usually coarser than the precipitated

grades and may contain other minerals, such as silica or silicates. The high specific gravity of barium sulfate, 4.4, means the specific gravity of the coating powder will also be high. This reduces the coverage on a cost-per-square-foot-per-mil basis.

The coverage of a powder in square feet per pound per mil is inversely proportioned to the specific gravity and can be easily calculated from the equation:

$$\frac{192.3}{\text{sp gr}} = \text{coverage in sq ft/lb/mil}$$

[Author's note: For a more detailed discussion of coverage and specific gravity, see "Misconceptions about the applied cost of wrinkle finishes and other textured powder coatings," by Thomas P. Frauman and Michael Correll, *Powder Coating*, vol. 8, no. 6 (September 1997): pp. 75-81, and the Powder coatings clinic, by Douglas S. Richart, in this issue.]

**Calcium carbonate.** This is another filler widely used in coating powders. Many grades are available based on



## The DualScope MP4 for measuring coating thickness.

The DualScope MP4, the latest unit in a complete line of hand-held instrumentation, has one very smart feature. Intelligent probes.

With the MP4 specific application information is stored directly in the probe. That means, when the probe is connected, the MP4 automatically loads application specific parameters.

No calibration is needed, so you work faster. And smarter. Just consider these other benefits:

Measures platings/coatings over steel and aluminum.

Variety of interchangeable probes.

One-point calibration for new applications.

RS232 interface for connecting to a printer, or downloading to a host computer or data logger.

Expanded application memories.

When speed and accuracy count, count on Fischer. It's the wise choice.

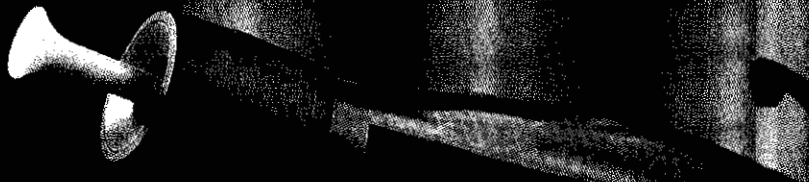
For more information, call us at 1-800-243-8417, in Connecticut, (203) 683-0781 Or fax us: (203) 688-8496.

Now accepting major credit cards



Fischer Technology, Inc., 750 Marshall Phelps Road, Windsor, CT 06095

# We're a Soft Touch for Great Savings



## ProTouch™ and SoftSpray™ Plus Powder Coating and Powder Recovery in One Package

Binks Sames SoftSpray Plus series of manual electrostatic powder coating outfits are designed for flexibility. Binks Sames ProTouch series of floor style powder booths – for systems where manual application equipment is used – are designed for savings.

**SoftSpray Plus** features the NEW Binks Sames JRN 406 Corona lightweight hand gun providing very high first pass transfer efficiency with a wide variety of powders. Its gun mounted adjustment for vortex air, as well as current and voltage adjustment with the new GNM 100, provides application flexibility and uniform film build.

**ProTouch** Floor Style Booths provide powder recovery in an economical booth configuration and feature the Binks Sames exclusive of a rollaway cartridge collector to collect more than one color. Several standard batch and conveyorized versions are available.

Call **1-888-99-BINKS Ext. 800** today for the Binks Sames distributor nearest you.

### *Great Savings*

*Limited time package offers:*

**Package 1 - SoftSpray Plus  
+ ProTouch Booth**

**Package 2 - SoftSpray Plus +  
ProTouch Booth + Batch Type  
Gas Fired Curing Oven**

*Call for package details and  
product demonstration.*



## **Binks Sames**

*...Leading the evolution of coating  
equipment and finishing systems*

the ground mineral (calcite), with precipitated grades also available. As with barium sulfate, the precipitated grades have a finer particle size and a purer chemical composition than the nonprecipitated grades.

Depending on the ore body that the calcium carbonate comes from and on the degree of beneficiation, or upgrade, most ground grades of calcium carbonate contain levels of magnesium carbonate, iron, and silica (quartz). Calcium carbonate, not as inert as barium sulfate, is attacked by acids. It's slightly alkaline and can adversely interact with binder systems that contain strong acid catalysts.

On the one hand, this filler has a somewhat higher oil absorption than barium sulfate, which usually means slightly more orange peel at the same loading. On the other hand, calcium carbonate has a lower specific grav-

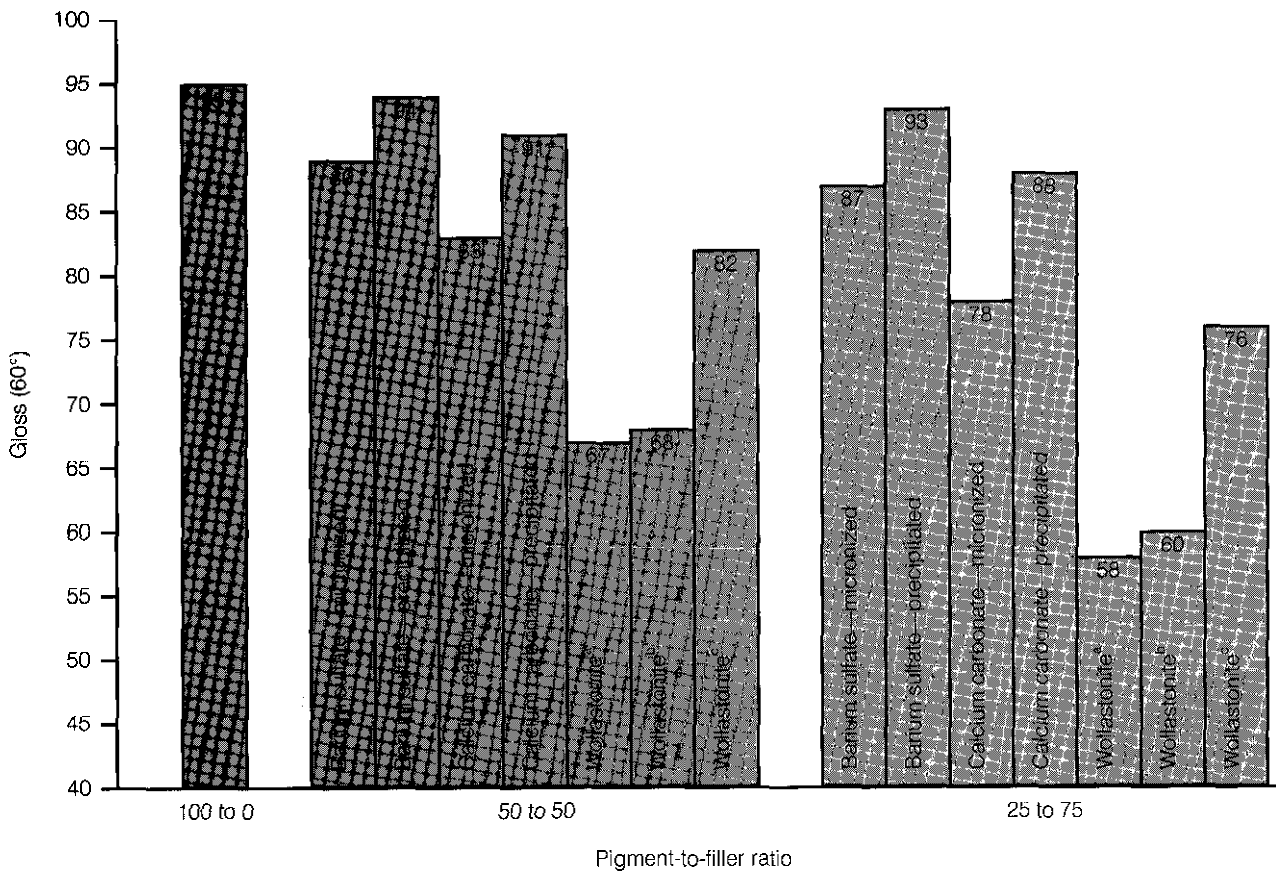
ity and better coverage at equal weights than barium sulfate. Calcium carbonate only slightly affects coating gloss (see Figure 1).

**Wollastonite.** Another filler used in coating powders is calcium metasilicate, or wollastonite. This ground mineral is mined from a large ore body in New York. Its uniqueness as a filler comes from its acicular, or needle-like, shape.

The various grades available vary in aspect ratio from about 2 to 1 through 7 to 1. Aspect ratio is the ratio of length to diameter of the individual particles. The longer aspect-ratio grades are mainly used as a reinforcing agent in plastics; the lower aspect-ratio grades are used in coatings and ceramics. Coating powders made with wollastonite have a naturally lower gloss than powders made with barium sulfate or with calcium carbonate.

**FIGURE 1**

**Affect of fillers on the gloss of an interior, white, epoxy-polyester hybrid coating powder**



Notes: <sup>a</sup> Largest particle-size wollastonite  
<sup>b</sup> Slightly finer than largest particle-size wollastonite  
<sup>c</sup> Finest particle-size wollastonite

**Other fillers.** Clays, talcs, silica, and alumina are also used in coating powders, but not as often as the other three fillers. These fillers are more often used in the manufacture of liquid paint. Clays and talcs have high oil absorption values, which result in a lower coating flow. They're used in textured and special-effects coatings. In liquid paints, the high oil absorption doesn't detract from smoothness and provides desirable rheological characteristics.

Silica is used in functional coatings, especially electrical grades, but its use is diminishing because of its classification as a possible human carcinogen. Hydrated alumina is used primarily in functional coatings, where it imparts flame retardancy and arc and tracking resistance in high-voltage electrical insulation.

### Fillers and coating gloss

To characterize the effects of several fillers widely used in coating powders, a series of powders were prepared<sup>1</sup>. The powders were based on a 50-to-50 epoxy-polyester hybrid binder pigmented white at a constant pigment-to-binder (P-to-B) ratio of 0.6 to 1.0. The ratio of the TiO<sub>2</sub>

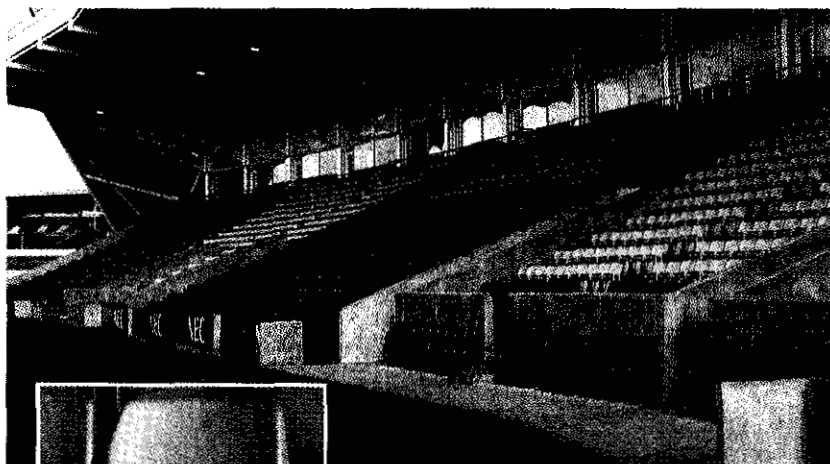
pigment to filler was varied from 100 to 0, 50 to 50, and 25 to 75 by using barium sulfate, ground and precipitated grades; calcium carbonate, ground and precipitated grades; and wollastonite ground to three different particle-size ranges.

Coating powders were prepared using standard melt extrusion methods and were sprayed on panels, cured, and then evaluated for gloss. Figure 1 shows results.

The powder with 100 percent TiO<sub>2</sub> showed the highest gloss level. The powders that contained barium sulfate and calcium carbonate, both of ground and precipitated grades, were somewhat lower in gloss, ranging from 78 to 94 on a 60° glossmeter, compared with 95 for the powder made with 100 percent TiO<sub>2</sub>.

The coatings prepared from the ground grades and those prepared with the higher filler-to-pigment levels had slightly lower gloss than those prepared with the precipitated grades. This result was expected because finer-particle-sized pigments or fillers produce a somewhat higher gloss than the ground—or micronized—grades that have a larger average particle size. Larger-particle-size pigments and fillers tend to protrude

## IF YOU'RE GOING TO THE BALL GAME, MAKE SURE YOU'VE GOT YOUR BEST COAT ON.



- Very low VOCs
- Tough but highly flexible
- Long term adhesion and color stability
- No primer (or phosphating) required
- Electrostatic or fluidized bed application
- Seven year track record worldwide
- No reported failures in service

Coated in Plascoat PPA571, this stadium seating not only looks good but is extremely tough and flexible as well.

It's resistant to blistering sun, downpours, even ketchup - not to mention the wear and tear from Mexican Waves!

And it still looks this good.

# PPA 571

Call 800-489-7236

Plascoat Corp., Crown Centre, Suite 600  
5005 Rockside Road, Cleveland, Ohio 44131  
Tel: 216-520-1272 Fax: 216-520-1273

Distribution Office, Punda Mercantile Inc.  
The Elmwood Building, 4115 Sherbrooke St. W., 6th Floor  
Montreal H3Z 1K9, Canada E-Mail: punda@cam.org  
Tel: 514-931-7278 Fax: 514-931-7000

**PLASCOAT**

The *Art* of Protection

ISO9002 Certification

through the surface of the coating, resulting in microscopic roughness. This causes a scattering of light, resulting in lower gloss. Higher concentration of fillers also increases surface roughness.

Although the micronized grade of calcium carbonate produced a coating with a somewhat lower gloss than the coating made with barium sulfate in this study, the results could easily have been reversed if different particle-size grades had been used.

The gloss of coatings with wollastonite, however, is consistently lower than the gloss of coatings made with barium sulfate or with calcium carbonate. Gloss is lower at higher filler-to-pigment ratios, as Figure 1 shows.

### Particle size and coating gloss

In coating powders, as in paints, gloss is a function of specular reflection. Smooth, planar surfaces reflect a large portion of incident light rays. In lower-gloss coatings, some of the light rays are scattered because of a macroscopically or microscopically rough surface, resulting in lower gloss. Chemists think that the microscopi-

cally rough surface seen with wollastonite is a result of its acicular particle shape, which disrupts the surface smoothness.

This is confirmed by the different degrees of gloss shown by the three wollastonite particle-size grades. The finest particle-size grade gives the highest gloss. The largest particle-size grade gives the lowest gloss. The middle grade is of slightly finer particle size than the largest grade and gives a slightly higher gloss<sup>2</sup>.

The finest particle-size grade, which also has the lowest aspect ratio, yields a coating with a microscopically smoother surface with higher gloss than other grades. Wollastonite has an oil absorption similar to calcium carbonate and produces coatings equally as smooth as those made with calcium carbonate but with lower gloss (see Table 3).

If manufacturers want a high-gloss coating, they should use a fine-particle-size grade of calcium carbonate or barium sulfate as their filler. If they want a low-gloss coating, they should use wollastonite as their filler choice, based on the results of this study.

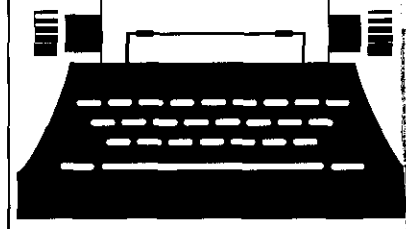
## Write an article for Powder Coating

Our articles are written by technical professionals for technical professionals.

Send for our booklet describing the types of articles we're looking for as well as tips on preparing an article for consideration.

Write PC #398 or write to:

Editor  
Powder Coating  
1300 E. 66th Street  
Minneapolis, MN  
55423



Some of the other fillers shown in Table 3 produced reduced-gloss coatings, but that's because their high oil absorption resulted in rough, unattractive coatings with heavy orange peel. At low levels—such as P-to-B ratios from 0.05-0.15 to 1.0—these fillers usually yield coatings of higher gloss but with a textured surface.

This is also true for mica, which produces rough, unattractive coatings. In a few cases, manufacturers use mica in heat-resistant coatings because it helps prevent blistering at high temperatures.

### Conclusion

Fillers are an important part of the raw materials available to the formulator to control many functional characteristics of a coating powder. The addition of fillers to a powder coating formulation results in some loss of the coating's physical properties, especially at levels of 50 PHR and higher. The difference between the coating with fillers and the coating without fillers depends a great deal on the base coating powder formulation as well as on the filler characteristics. **PC**

### Endnotes

1. The study was done for NYCO Minerals, 124 Mountain View Drive, Willsboro, NY 12996-0368; 518/963-4262. Detailed copies of the study are available from the company.
2. The finest particle-size grade of wollastonite is NYAD® 1250. The largest particle-size grade of wollastonite is NYAD® 325, and the grade of wollastonite that is slightly finer than the largest particle-size grade is NYAD® 400.

*Douglas S. Richart is president of D.S. Richart Associates, an independent consulting company, P.O. Box 4308, Reading, PA 19606; 610/370-9870. Since 1969, he has been involved in the technical aspects of coating powders, including formulating, developing, processing, testing, and evaluating. Author of a number of papers and other publications, he wrote the powder coating section of the Kirk-Othmer Encyclopedia of Chemical Technology. A member of the Powder Coating Institute and holder of many patents, he earned a BS degree in chemistry from Franklin and Marshall College, Lancaster, Pa.*

## WANT A CONVEYOR SYSTEM DESIGNED FOR POWDER COAT OPERATIONS?



Enclosed track protects conveyor chain from dirt and abrasives.

Inverted conveyor design automatically shields products from contaminants.



See what the clean conveyor can do for your finishing operation. Send for a brochure.

## INSTALL THE CLEAN CONVEYOR



**RICHARDS-WILCOX, INC.**

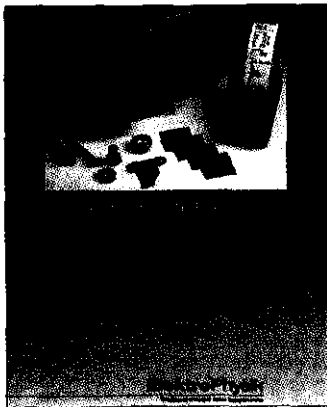
A CONSTRUCTOR GROUP COMPANY

600 South Lake Street, Aurora, Illinois 60506  
800/877-8456

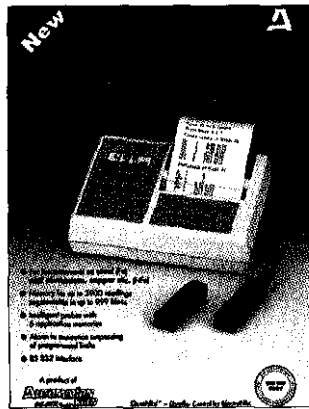
# INFOFILE: FILM THICKNESS GAUGES

The editors have selected these brochures and technical bulletins to help you find useful information on film thickness gauges. To get any of these items, simply write in the appropriate number on the reader service cards in the back of the magazine.

### Gauge series



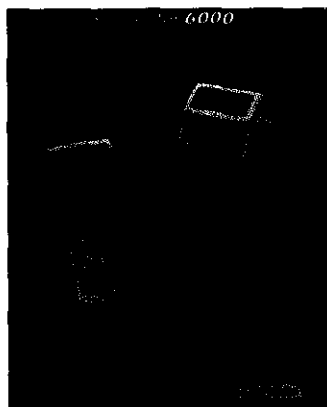
Company's Minitest 4100, 2100, and 1100 coating thickness gauges can be used to test film thickness of nonmagnetic coatings on steel, insulating coatings on nonferrous metals, and nonferrous metal coatings on insulating substrates. Statistics can be downloaded to a computer or a printer. 4 pages. **ElektroPhysik, Arlington Heights, IL. 847/437-6616. #600**



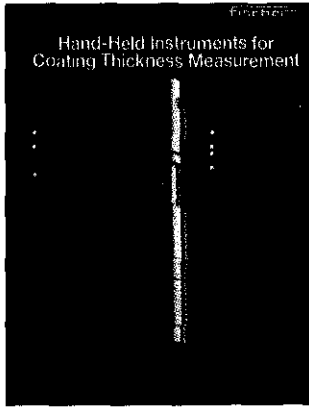
### Hand-held gauge

QuaNix® 5500 can be used to measure film thicknesses on ferrous and nonferrous parts. The hand-held gauge is combined with a printer that allows you to print values as you take them or to print them later with a statistical report. Scanning the surface of the substrate with the probe gives continuous readings. 2 page. **Automation USA, Westminster, MD. 410/857-3811. #601**

### Combination gauge



The PosiTector® 6000-FN Series measures the coating thickness of powder on ferrous and nonferrous metals with one probe. The gauge automatically powers up, calibrates, and takes measurements. A model option stores 5,000 readings in up to 100 groups, and average and standard deviation calculations appear on the display. 4 pages. **DeFelsko, Ogdensburg, NY. 315/393-4450. #602**



### Thickness gauges

MP1C, MP2C, and MP3C hand-held film thickness gauges allow you to interchange probes for a variety of applications. Each probe includes a measuring element, a memory chip, and a connector. Models are available for measuring film thicknesses on ferrous and nonferrous surfaces. Company offers three other gauges and a variety of probes. 14 pages. **Fisco Technology, Windsor, 203/683-0781. #1**