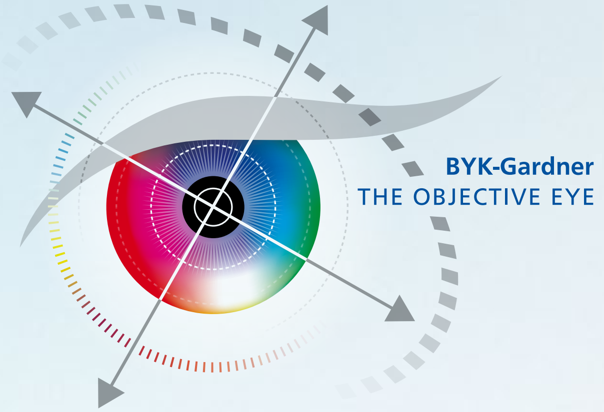
QC SOLUTIONS FOR COATINGS

Contents

The Objective Eye for Consistent Color and Appearance

A world without color and shine, wouldn’t this be boring? Decorative coatings can be encountered every day and everywhere: on furniture, building facades, bridges and refrigerators. Even “White Goods” are no longer necessarily white, but exhibit fascinating color looks – from very elegant stainless steel to metallic effects on to colorful, glossy or textured surfaces.

Coatings are fascinating. Not much thicker than a human hair, they combine a variety of functions. Besides the requirement to look perfect under different lighting conditions, they are also expected to retain their good look over a long time and even when being exposed to harsh environments. A multitude of color shades are available to offer the right nuance for every taste. The challenge is to find a precise measurement procedure to replace individual perception and personal experience with objective numbers.

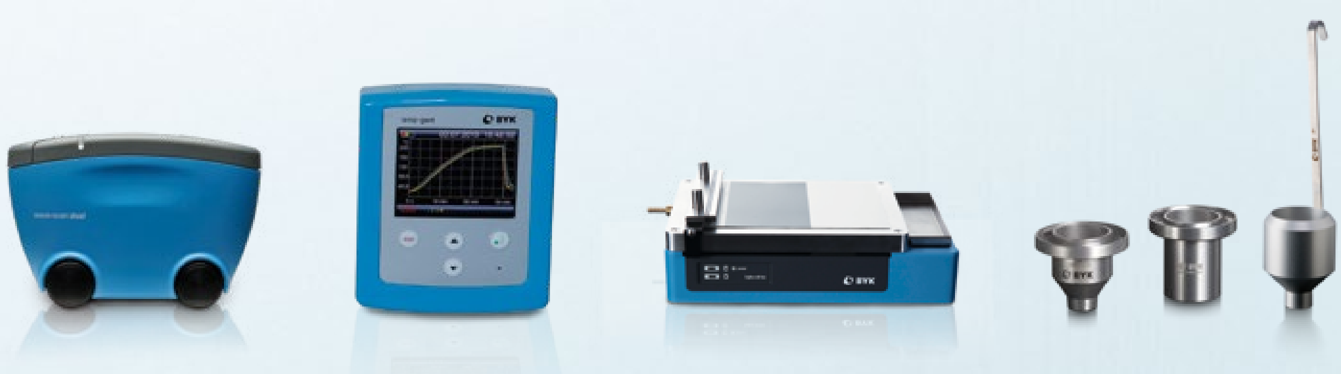


Consistent color and appearance are crucial before as well as after sale. The visual impression during the first ten seconds will establish our perceptual quality opinion and be the driving factor in our purchasing decision. Uniformity, which is also called harmony for products consisting of several components, is also important. This is of particular importance when parts are manufactured in different production sites or are made by different suppliers.

Visual color perception is influenced by our individual color preferences, which are dependent on personal factors (mood, age, gender etc.), environment (lighting, surrounding etc.) as well as our deficiency to communicate color and color differences. A color looks different in the department store (cool white fluorescent lighting) than at home (warm, incandescent lighting). Effect colors will even change their appearance depending on the type of daylight conditions being sunny or cloudy. In order to guarantee consistent color and appearance under all possible situations, it is essential to define numerical parameters with customer relevant tolerances, which can be controlled in daily production and communicated among the entire supply chain of raw material and final product suppliers. A high quality production process should only be based on figures and facts and not emotions.

Consistent color and appearance needs an OBJECTIVE EYE!

BYK-Gardner offers complete quality control solutions for your application in coatings.



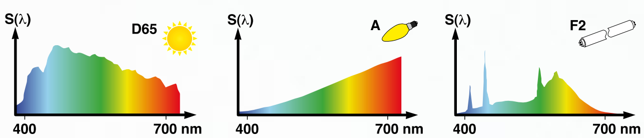
Color Measurement of Solid Colors

Honey Yellow, Raspberry Red, Sapphire Blue or Moss Green are very appealing and descriptive color names. But are you sure that every person means the same color by it? Usually not. How do you clearly describe a color and guarantee that same color over time?

Our color perception is dependent on our individual "taste", which is influenced by our mood, gender, age, but also the light source used, the viewing environment being light or dark, neutral or colorful as well as our deficiency to exactly remember and communicate one specific color.

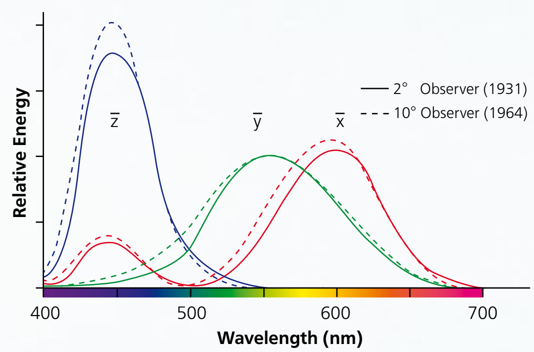
Standardized viewing conditions

For controlled visual and instrumental evaluation the light source, the surrounding and the observer are to be defined. Colors may match under one light source (daylight), but not under another (fluorescent light). This effect is known as **metamerism** and is a crucial quality requirement for multi-component products. Therefore, the match needs to be verified with the kind of light likely to be found where the product is sold or used. The CIE (Commission International de l'Éclairage) standardized commonly used **light sources**.



ISO and ASTM standards define the **surroundings** as portion of the visual field immediately surrounding the specimens as well as the ambient visual field, when the observes glances away from the specimen, such as the interior surfaces of the light booth. It shall have the color with Munsell notation N5-N7 and a 60° gloss not greater than 15 GU.

The **observer for visual appraisal** should have normal color vision and be trained in observing and classifying colors. Visual tests are recommended to check an observer's color vision periodically as it can change over time (see Guide ASTM E1499). The **observer for instrumental color control** was standardized with two different viewing fields: 2° standard observer and 10° standard observer. Today mainly the 10° observer functions are used as the eye integrates over a larger area.



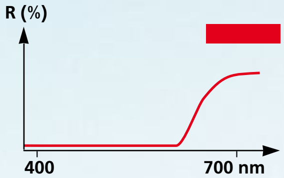
byko-spectra *pro*

Light booth for standardized visual color appraisal

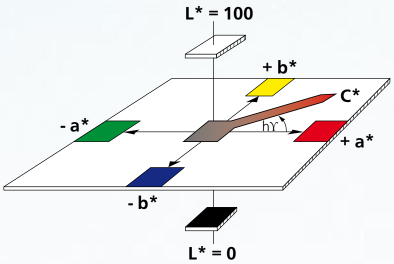
- Metamerism control – sample pairs can be evaluated under up to eight CIE illuminants D65/D75-A/HZ-CWF/TL84/U30-UV
- Excellent simulation of daylight D65 using halogen lamps combined with LEDs: CIE class A category
- Daylight lifetime lasts 600 hrs and change is automatically indicated
- Adjustable light intensity for optimum viewing of dark and light colors
- Automatic sequence mode for efficient metamerism evaluation

Standardized measurement parameters

For instrumental color measurement the optical properties of the product need to be measured. A spectrophotometer measures the amount of light that is reflected by the object at different wavelengths in the visible range (400–700 nm). The reflectance curve shows the spectral data and acts as a "finger print" for the object color.



Internationally standardized **color systems**, like the widely used CIELab system, combine data of standardized illuminant, standardized observer and spectral reflection data in three color components describing the lightness, hue and chromaticity of a color.



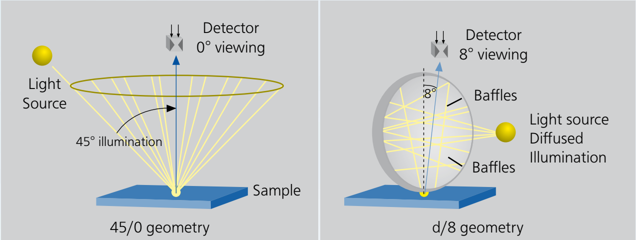
Tolerances are established either on each color component or on the total color difference ΔE*.

$$\Delta E^* = \sqrt{(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2}$$

Over the years new color systems and equations (ΔECMC – ΔE94 – ΔE99 – ΔE2000) were developed based on visual comparison studies for solid colors to improve the visual correlation, which shows elliptical tolerance behavior.

Standardized instrument geometries

International standards define the geometric conditions of spectrophotometers:

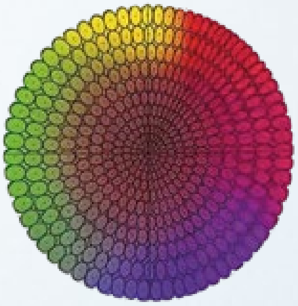


45/0 – Control color as you see it
For final QC of solid colors a 45° circumferential illumination is defined to achieve repeatable results on unstructured and structured surfaces.

d/8 – Control the hue of a color
If the color without influence of surface gloss or texture is to be controlled, diffused illumination is required.

References

CIE 15	Colorimetry
ISO 3668	Visual Comparison of the Color of Paints
ASTM D1729	Visual Appraisal of Color Differences



CMC Tolerance Ellipsoids in CIELab Color Space

spectro2guide
The revolution in portable color control

- Color, gloss and new fluorescence measurement in one instrument
- Balanced and upfront design with large 3.5" color touchscreen
- Docking station with built-in standard for automatic calibration
- Live preview of measurement spot with zoom function
- Smart high tech LEDs with peak performance for Digital Standards
- Data analysis out-of-the-box with WiFi or USB connection

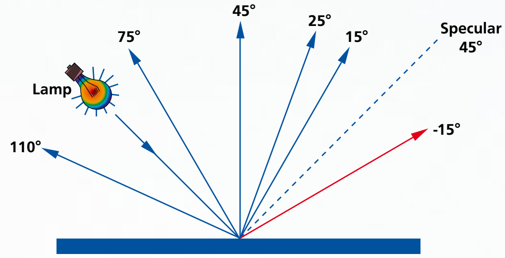
Color Measurement of Effect Colors

Innovative effects with color flip-flop and sparkle have also found their way into other industries besides automotive. Brilliant, high quality finishes emphasize the excellent quality of appliances, furniture, architectural elements and many other industrially coated products.

Multi-angle color evaluation

In contrast to solid colors, effect finishes change their color and appearance with viewing angle and lighting conditions. Metallic finishes will show a lightness travel depending on the viewing angle. Pearl colors with special interference pigments can not only show a lightness change with different viewing angle, but also a change in chroma and hue (color travel).

International standards define measurement geometries for multi-angle color measurement to objectively describe the color of metallic finishes. Research studies show that a minimum of three, and depending on the effect finish up to six viewing angles are needed.

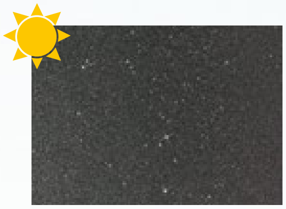


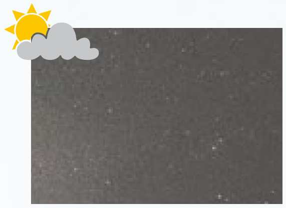
As the color perception of effect finishes is changing by viewing angle it is necessary to define different tolerances for each viewing angle. Therefore, new color equations based on visual correlation studies were developed:

- ΔE94 with lightness travel (Rodrigues, 2004)
- ΔE_{eff} (DIN 6175-2, 2001)
- ΔEAudi2000 (Dauser, 2012)

Visual effect evaluation

The latest developments are special effect pigments, which create high sparkling effects under direct illumination. Viewed under diffused lighting conditions the sparkling effect will disappear as the light intensity is equal from all directions. Therefore, metallic pigments will look more or less grainy depending on the flake size and a pearl will look more like a solid color. Under direct illumination, i.e. the light intensity comes from mainly one direction (sunny sky), the same metallic or effect finish will look completely different showing small light flashes with low to high intensity. In contrast to graininess, the sparkle effect is depending on the illumination angle resulting in a sparkle travel.





References

DIN 6175-2	Tolerances for Automotive Paints – Part 2: Goniochromatic Colors
ASTM E2194	Multiangle Color Measurement of Metal Flake Pigmented Materials

byko-spectra *effect* light booth
Standardized visual evaluation of effect finishes

Multi-angle color evaluation

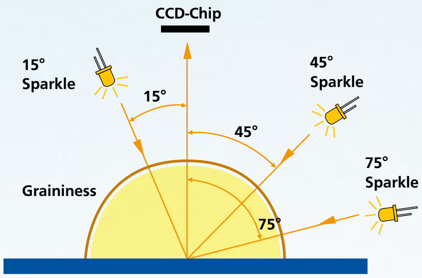
- Daylight illumination at 45°
- Tiltable sample table with six viewing angles (-15°, 15°, 25°, 45°, 75°, 110°)
- Timer to track daylight lamp usage

Sparkle evaluation

- Illumination at three angles (15°, 45°, 75°)
- Very bright LEDs to simulate direct sunlight
- 10 year warranty on LEDs

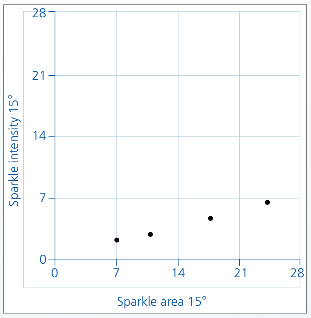
Instrumental effect measurement
In order to objectively measure effect characteristics, the new BYK-mac i combines a multi-angle spectrophotometer (6-angle color measurement) with a second measurement set-up for sparkle and graininess evaluation. A CCD camera takes pictures under various lighting conditions:

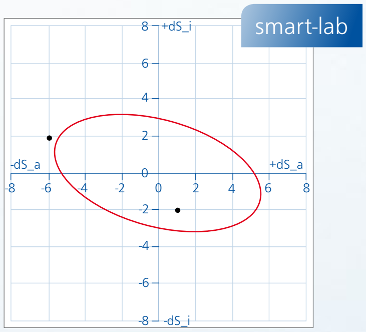
- Diffused illumination with two white LEDs built-into a white coated hemisphere
- Direct illumination at three angles with three white super bright LEDs



The pictures are analyzed using the histogram of lightness levels of the individual pixels as the base information. The uniformity of light and dark areas is summarized in one graininess value. A graininess value of zero would indicate a solid color. The higher the value, the grainier or coarser the sample will look under diffused light.

In case of sparkling, a threshold is set and only the very bright pixels above the threshold are evaluated. To allow a better differentiation, the impression of sparkle is described by a two dimensional system: sparkle area and sparkle intensity for each angle.





A sparkle tolerance model was developed, which allows setting a maximum limit value for "Delta Sparkle" similar to a weighted total color difference equation.

$$dS = \sqrt{\left(\frac{f_1(Sa_{Std}, dSa, Si_{Std}, dSi)}{Tol\_Gr}\right)^2 + \left(\frac{f_2(Sa_{Std}, dSa, Si_{Std}, dSi)}{Tol\_Gr \times Tol\_GF}\right)^2}$$

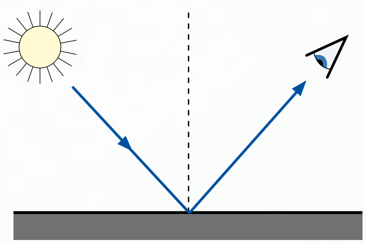
BYK-mac i
Portable multi-angle color & effect control

- 6-angle color measurement for light-dark and color flop
- Sparkling and graininess analysis
- Detection of fluorescent light excited in the visible range
- Unique LED technology
  → Excellent technical performance
  → No need for lamp exchange
  → The key to a global QC system using digital standards

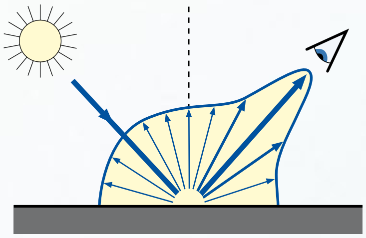
Gloss Measurement

Glossy, semi-glossy, satin-finished or matte – how would you like your refrigerator or living room wall to appear? This is of course a matter of personal taste and preference. However – once defined, the specified appearance needs to be supplied in a constant and controlled quality.

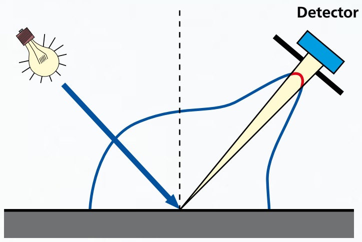
Gloss measurement
Gloss is a visual impression dependent on the surface condition. The more direct light is reflected, the more obvious the impression of gloss will be. A high gloss refrigerator has a smooth surface which reflects images distinctly, almost like a mirror. The incident light is directly reflected on the surface, i.e. only in the main direction of reflection. The angle of reflection is equal to the angle of incidence.



A matt emulsion paint for interior walls includes matting agents which produce a micro roughness scattering the light diffusely in all directions. The more uniform the light is scattered, the less intense the reflection will be in the main direction. The surface will appear more and more matte.



Gloss meter
International standards define the measurement of specular reflection with a gloss meter. The light intensity is measured over a small range of the reflection angle.



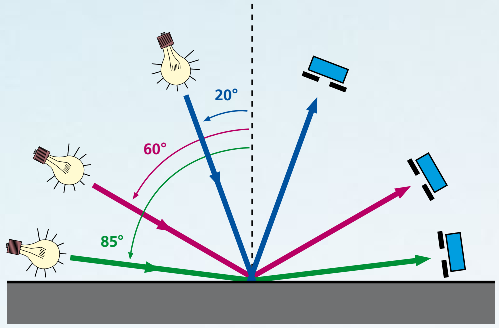
A light source, simulating CIE illuminant C, is placed at the focal point of a collimating lens. A receptor lens with an aperture in the focal plane followed by an illumination detector completes the basic optical design.

The intensity is dependent on the material and the angle of illumination. The measurement results are related to the amount of reflected light from a black gloss standard with a defined refractive index. The measurement value for this defined standard is equal to 100 gloss units. Materials with a higher refractive index can have a measurement value above 100 gloss units (GU).

References

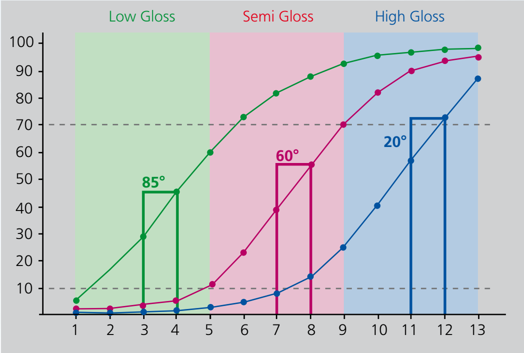
ISO 2813	Determination of Specular Gloss of Non-Metallic Paint Films at 20°, 60°, 85°
ASTM D523	Standard Test Method for Specular Gloss

The angle of illumination is of high influence. In order to obtain a clear differentiation over the complete measurement range from high gloss to matte, three geometries, i.e. three different ranges, are standardized:



Gloss level	60° value	Recommended geometry
Semi gloss	10 to 70 units	60° geometry
High gloss	> 70 units	20° geometry
Low gloss	< 10 units	85° geometry

In a case study 13 samples were visually ranked from matte to high gloss and measured with the three specified geometries. In the steep slope of the curves, the differences between the samples can be clearly measured, while in the flat part the measurement geometry no longer correlates with the visual perception.

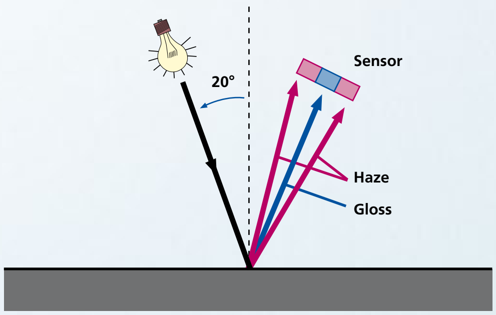


Why three different gloss ranges?

A single measurement geometry, such as 60°, may not provide instrument readings of gloss that correlate well with visual observations when comparing different gloss levels. This is why international standards provide for measurement at three different angles of incidence, namely 20°, 60°, and 85°. Each of the three geometries uses the same source aperture, but a different receptor aperture. The choice of geometry depends on whether one is making a general evaluation of gloss, comparing high gloss finishes or evaluating low gloss specimens for sheen. The 60° geometry is used for comparing most specimens and for determining when the 20° or 85° geometry may be more applicable. The 20° geometry is advantageous for comparing specimens having 60° gloss values higher than 70. The 85° geometry is used for comparing specimens for sheen or near grazing shininess. It is most frequently applied when specimens have 60° gloss values lower than 10.

Haze measurement

Micro structures caused by e.g. poor dispersion, can create a milky appearance. The majority of the incident light is reflected in the specular direction which makes the surface appear highly glossy. Due to the microscopic texture some light is diffused with low intensity adjacent to the specular reflection which will result in a high gloss surface with haze on top of it. Therefore, the haze-gloss has two additional haze sensors next to the 20° gloss detector measuring the intensity of the diffused light.



micro-gloss

The new intelligence in gloss measurement

- Unsurpassed industry standard in gloss measurement
- 1- angle and 3-angle gloss meters for high gloss to matte finishes
- Automatic calibration check in holder
- Measurement modes for any task: Statistics – Difference – Pass/Fail
- Continuous mode for uniformity check of large surface areass
- Wireless data transfer

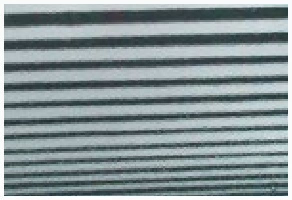
Orange Peel and DOI Measurement

Eye catching finishes should just be "beautiful" – what does this mean in regards to appearance? Some like it a bit wavy and brilliant, twinkling as a water surface, whereas others prefer the perfectly smooth appearance like a mirror. The expression "Orange Peel" is widely used to describe structures typically found on coatings. Amount and size of such structures depend on the paint type and the application conditions, but also on the end use.

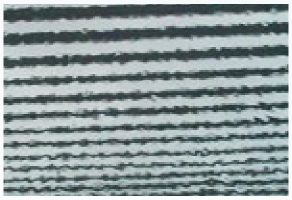
The visibility and appearance of structures depend on their size, the observing distance, and the image forming quality.

Structure size

Surfaces with different structures will appear visually different.

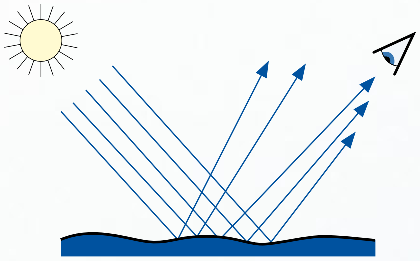


Small structure



Large structure

Orange peel can be seen on high gloss surfaces as a wavy pattern of light and dark areas. Depending on the slope of the structure element the light is reflected in various directions. Only the elements reflecting the light in the direction of our eyes are perceived as light areas.

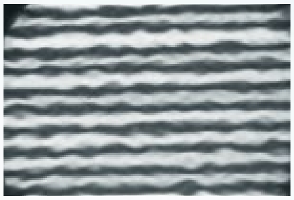


Observation distance

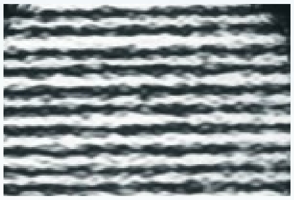
The visibility of an object decreases with increasing observing distance. Structures with a size of 10 to 30 mm can best be seen at a distance of approximately 3 m. Fine structures with a wavelength of 0.1 to 1 mm can only be recognized at a close distance. Very fine structures that are below the resolution of the human eye (approximately 0.1 mm) can no longer be recognized as a light and dark pattern, but as a reduction of the image forming quality (IFQ), i.e. brilliance.

Image Forming Quality

The higher contrast and sharpness of a reflected object, e.g. the edges of black and white lines, the better the image forming quality will be. Fine structures disturb the reflected image. Consequently edges become blurry and are no longer sharp.



Low contrast

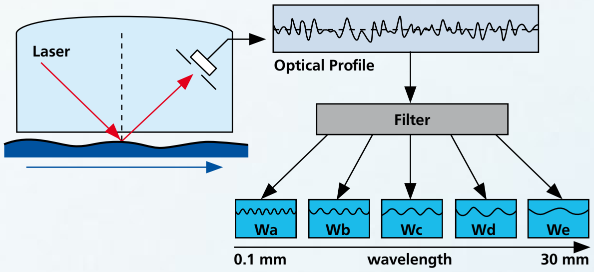


High contrast

At a close distance, the image forming quality is diminished by very fine structures close to the resolution of the human eye. This is often described with terms like brilliance, sharpness, or distinctness of image (DOI). At a larger distance (approximately 3 m), the image forming quality is mainly influenced by structures between 1 - 3 mm. This effect is referred to as Wet Look.

Simulation of the visual perception waviness

Like our eyes, the wave-scan optically scans the wavy light/dark pattern. A laser point source illuminates the specimen at a 60° angle and a detector measures the reflected light intensity at the equal but opposite angle. The orange peel meter is rolled across the surface and measures point by point the optical profile of the surface over a defined distance.

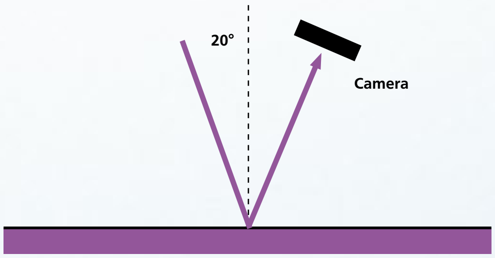


The wave-scan analyzes the structures according to their size. In order to simulate the resolution of the human eye at various distances, the measurement signal is divided into several ranges using mathematical filter functions:

Wa 0.1 – 0.3 mm wavelength
Wb 0.3 – 1.0 mm wavelength
Wc 1.0 – 3.0 mm wavelength
Wd 3.0 – 10.0 mm wavelength
We 10.0 – 30.0 mm wavelength
SW 0.3 – 1.2 mm wavelength
LW 1.2 – 12.0 mm wavelength

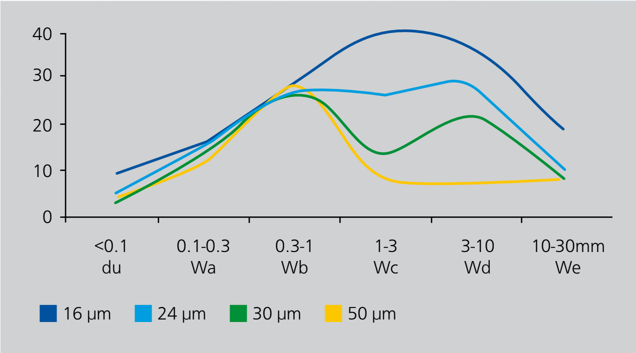
Dullness

Structures that are smaller than 0.1 mm influence the visual perception. Therefore, the wave-scan uses a CCD camera to measure the diffused light caused by these fine structures. This parameter is referred to as "dullness".



Structure spectrum

The values of dullness and Wa to We form a "structure spectrum" which allows a detailed analysis of orange peel and its influencing factors. The example below shows the influence of clear coat film thickness on the appearance. Increasing film build improves flow and levelling. In the graph, this can be seen in decreasing Wc and Wd values.



wave-scan *dual*

The industry standard for reliable appearance control

- Good correlation to visual perception
- Orange Peel & DOI on high and medium gloss surfaces
- Easy-to-use on flat and curved samples
- Scroll wheel operation with intuitive operation
- Professional data analysis and documentation with smart-chart software

Temperature Measurement

"Caution Hot!" Not only hot beverages should be handled with care, but this is also true for baked coating systems used in today's mass production. Optimum curing is the prerequisite to achieve the high mechanical and appearance QC requirements specified for finished products. In order to avoid rejects and ensure consistent quality, the exact temperature profile of the baking oven must be controlled on a routine schedule.

The traditional range of baked coating systems has changed considerably with the introduction of environmental friendly systems e.g. high solids, water-borne paint systems and powder coatings. Drying times vary from a few minutes to half an hour dependent on the paint material and production process. The right catalysts and amount of heat initiate the cross-linking process among the various components in the paint system. Paint properties largely depend on the cross-linking quality.

Poor curing can lead to failures:

- Insufficient adhesion to the substrate
- Insufficient elasticity to resist mechanical stress
- Insufficient surface hardness
- Premature aging, brittleness, and chipping which can lead to rust and corrosion
- Discoloration and loss of gloss

In order to determine the optimal cross-linking parameters of a system, a series of tests must be carried out at different baking temperatures. As a result, the paint supplier specifies the minimum and maximum temperature which determines the limits of an optimal curing process. The following table shows specifications of a powder coating system.

Temperature		Time
Min Temp	140 °C	
Low Temp	180 °C	20 min
Ref Temp	190 °C	15 min
High Temp	200 °C	15 min
Max Temp	220 °C	

In a second step, it is essential to check on a regular basis whether the production oven works properly. The method of heating the oven (gas, oil, electricity), the air distribution, as well as the assembly line speed must be taken into consideration. The oven temperature is influenced by power variations and oven construction. The object temperature depends on parameters such as material, material thickness, geometrical shape, size and the place of suspension (top, middle, bottom). In order to guarantee a consistent temperature at a set baking time, it is necessary to directly measure the object temperature.

The necessary components of an effective temperature measuring system include:

- Temperature probes to gather temperature information
- Temperature recorder to collect the data
- Thermal barrier to protect the temperature recorder
- Software to generate a temperature profile and analyze curing data

Temperature Recorder

The recorder accompanies the object on its way through the oven. Often a dummy product is used instead of the coated product. The measurement system stores the analog signals of the temperature probes in digital form. The recording module is protected by a thermal barrier made of stainless steel with temperature safe insulation.

temp-gard

Innovative oven temperature recorder

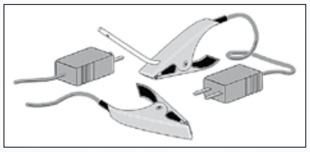
- Large color display with temperature graph
- Data transfer via USB stick – no probe changes between runs
- Highly accurate – long-term stable results are guaranteed
- Robust, but light weight and easy to carry thermal barrier

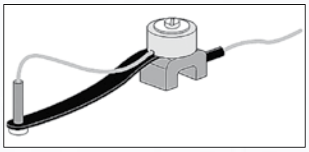
Temperature Probes for any Application

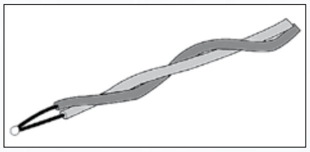
Temperature probes are an essential part of a temperature measurement system. They are placed at critical points on the object to record an accurate temperature profile throughout the process. All BYK-Gardner probes are high quality thermocouple type “K” probes and conform to ANSI MC 96.1 (special limits of error: 1.1 °C or 0.4 %). A variety of designs are available to meet the specific requirements of different measurement locations and material types.

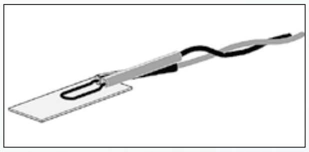
Temperature Probes

- Magnet and clamp probes for air and object temperature
- Probes with exposed junction for hard to access areas
- Self-adhesive foil probes – ideal for small items
- Eyelet probes for very high temperatures of up-to 500 °C
- IR probes for IR oven controls
- Choice of connection cable length: 1.5 m, 3 m and 8 m
- Quick response time: 5 seconds to 2.5 minutes depending on probe style
- Can be used as replacement probes for other dataloggers



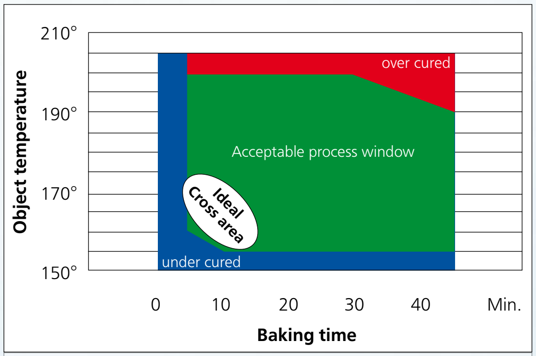






Temperature Data Analysis Software

In order to efficiently analyze the temperature data a professional software is needed. Thus, the curing process can be optimized. The software will merge the temperature data with oven parameters and analysis criteria to generate a temperature profile. Data will be stored in a database for documentation and easy future access. The oven process can be optimized with means of the BYK-Gardner cure index (Porsche value). The cure index is calculated based on the energy that was applied to the paint system during the complete baking process. A value of 100 % is ideal. Values below 100 % mean the system is not completely cured; values above are a hint for over curing. Additionally, the cure chart offers a visual aide to quickly determine the minimum temperature at the shortest baking time. The cure chart also provides information on over or under cure conditions of the oven.



temp-chart

Software developed in close cooperation with the industry

- Definition of measurement setup, sensor names and location
- Standard QC reports: critical values, cure index, peak/slope
- Pass/Fail display – limits based on critical values or cure index
- Trend analysis – comparison of check zones over time

Raw Materials – what goes in is important

“The first step is always the hardest”. This also applies when formulating a coating. The application of the final finish determines the selection of the raw materials. Not only are mechanical properties like abrasion resistance and adhesion important, but also optical attributes like color, gloss and opacity; and one cannot forget the overall costs of the formulation. In order to guarantee consistent quality a routine quality control system needs to be established at the very first production step.

Paint is a liquid or powdery coating that is applied on objects as a very thin layer. By means of chemical or physical processes, it converts to an adherent film. Paint normally consists of the following components:

- Pigments
- Binder
- Fillers
- Additives
- Solvents / Water (not in powder coatings)

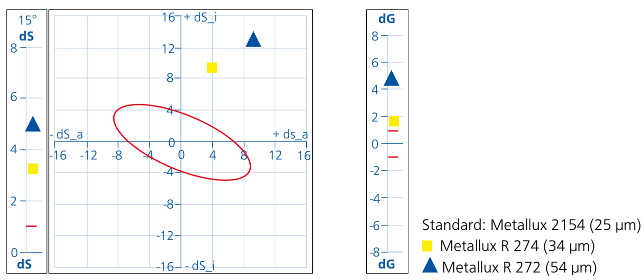
Pigments

Pigments are fine solid particles, which are substantially insoluble in the vehicle. They ensure hiding of the background and generate the color impression. In modern industrial coatings, solid absorption pigments, as well as metallic and pearlescent pigments are used.

Metallic pigments

Metallic pigments are very thin platelet-shaped particles made out of aluminum or bronze. They act like small mirrors and directly reflect the light causing a light-dark flop when changing viewing angle. Depending on the aluminum granulates and the process used, either irregular Cornflakes or round Silver Dollar particles are formed. Their properties, such as brilliance (sparkle and metallic gloss), flop, distinctness of image etc., are influenced by particle size / shape, particle-size distribution and smoothness of the surface. The coarser the pigments and the rounder their shape, the higher the proportion of reflected light and, thus, the more the metallic look is pronounced.

In the graph below a comparison of three silver dollar pigments with different flake size (25 µm – 34 µm – 54 µm) is shown. Visually, the silver finish with the coarser aluminum pigment appears more sparkling under direct illumination and grainier under diffused lighting.

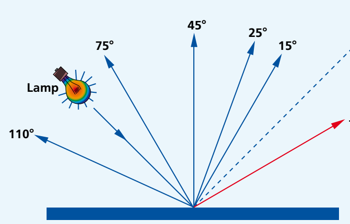


The BYK-mac i data correlate with the visual judgment: sparkle area, sparkle intensity and graininess increase with flake site.

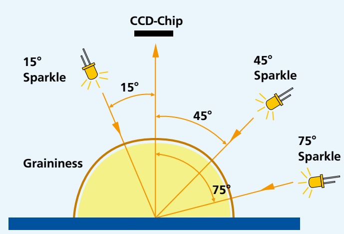
BYK-Gardner Solution

Multi-angle Color & Effect

BYK-mac i



6-angle Color Measurement

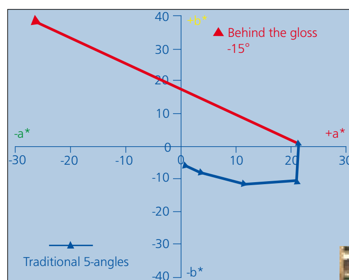


Sparkle and Graininess Measurement

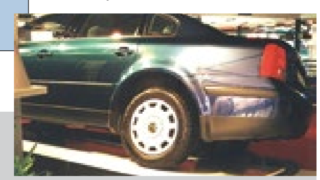
Pearlescent pigments

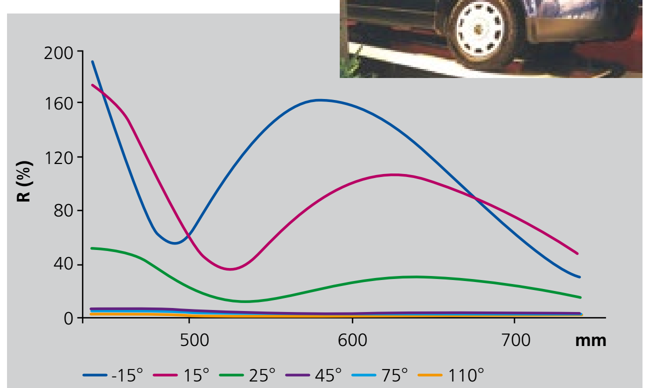
Pearlescent pigments usually consist of a transparent core material that is covered with different layers of metal oxide. A trick copied from nature is used: White light is refracted at the boundary layers and dispersed into its component – the colors of the rainbow. This causes an extraordinary color travel effect that depends on the differences of refractive indices between core material and metal oxide layer, the thickness of the metal oxide layer and the viewing angle. Typically the interference color can be seen on the opposite side of the specular reflection. Therefore, the BYK-mac i uses an additional measurement angle at -15°. The a*b*-chart on the right shows measurement data of the pigment Colorstream® Viola Fantasy. The color changes from purple to green. With the traditional multi-angle spectrophotometers (blue line) the shift to green cannot be captured. Only by taking an additional reading at -15° "behind" the gloss, the numbers agree with visual perception.

The color change from purple to green can also be seen in the spectral curves. It is typical for a pearlescent pigment that when using the same illumination angle, but taking readings at -15°, the reflection maximum is shifted to shorter wavelengths compared to the 15° measurement angle. Therefore, in this case, the color appears green.

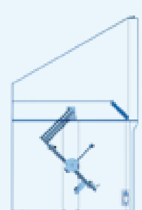


Courtesy of Merck

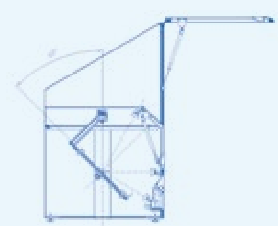




Objective Visual Evaluation
byko-spectra *effect*



Color Travel
Illumination and Sample pivot together



Sparkle Travel
Direct illumination under 15°/45°/75°

Color Measurement of Titanium dioxide (TiO_2)

Titanium dioxide is the brightest, whitest pigment available. Due to its high refractive index (even higher than diamond) it effectively scatters the light and provides maximum opacity for a coating. Rutile is the most common natural form of TiO_2 and preferred over anatase because of the lower photocatalytic activities and thus, better weather stability of the final coating.

The purity of TiO_2 is process related. The chloride process makes up purer and brighter grades than the sulfate process. Additionally, impurities introduced by treatment chemicals or extraneous metal ions within the crystallites can degrade brightness. They usually discolor the pigment towards grey or yellow.

One way to perform a color measurement is to incorporate the TiO_2 pigment into the coatings system of the final application. To ensure a smooth and homogeneous surface, the paint is applied to opacity drawdown charts with an automatic film applicator. The charts are made of black and white areas that are large enough to be measured with color instruments. An alternative is to take readings on dry pressed pucks. The pucks are made by applying high pressure to the dry TiO_2 which is contained by a ring. The pressure is essential as it is the driving force to compact the pigment and hold it together for measurement. The face of the puck is then measurement with a spectrophotometer.

The standardized CIE colorimetric values L* and b* are used to characterize brightness and undertone: the higher the L* value, the higher the brightness, the lower the b* value, the less yellow the appearance. In the table below, results for different grades of TiO_2 are displayed. The spectro2guide can be used to measure CIELab color numbers. The instrument stores and directly transfers measurement data to smart-chart data analysis Software.

	Grade 1	Grade 2	Grade 3	Grade 4
Brightness L*	96.6	97.4	97.3	97.2
Undertone b*	2.1	1.5	1.5	1.5

Besides brightness and undertone, optimum hiding power and tinting strength are properties that the TiO_2 pigment has to meet (see page 20 "Architectural Coatings" and page 28 "Industrial Coatings").

BYK-Gardner Solution

Solid Color & Gloss
spectro2guide

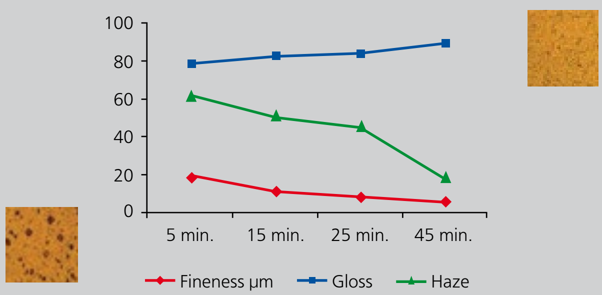
Gloss
micro-gloss

Gloss & Haze
haze-gloss

Gloss and Haze Measurement of Titanium dioxide (TiO_2)

Gloss and haze level of a TiO_2 pigment is mainly controlled by the primary particle size and the number of particles with a diameter larger than 0.5 µm. To achieve glossy finishes with improved distinctness of image, oversized particles have to be minimized. The haze-gloss is an objective tool to measure matte to high-gloss surfaces by offering three gloss geometries (20°, 60°, 85°) as well as reflectance haze measurement in one unit. However, to measure gloss and haze the TiO_2 has to be incorporated in the coatings system and a drawdown has to be made.

Gloss and Haze dependent on dispersing time



During the dispersion process, the pigments are dispersed into small particles: the smaller the particles, the smoother the surface. The graph above shows the influence of degree of dispersion on gloss and haze. Pigment particles that are smaller than 10 µm show a tremendous reduction in haze and a slight increase in gloss, resulting in a glossy finish with improved imaging forming qualities.

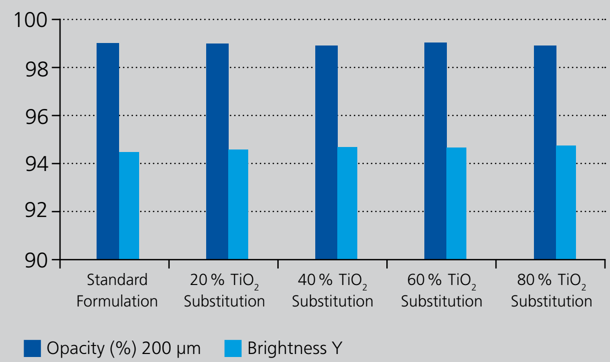
Absorption pigments

Organic and inorganic absorption pigments selectively absorb and scatter the incident light. Besides the color itself, tinting strength is one of the most important properties that need to be controlled. Tinting strength is directly influenced by the pigment type and concentration used in the coating system (see page 28 "Industrial Coatings").

Fillers

Fillers are solid particles, which are virtually insoluble in the vehicle. They serve to increase the volume of the paint and to improve mechanical and optical properties. They are usually less expensive than other pigments and reduce the overall costs of a paint formulation. Among all, calcium carbonate fillers are quantitatively the most important class. They exhibit a neutral tone and a high brightness ($L^* \geq 95$) and can therefore be used to substitute TiO_2. As their mean particle size is larger and their refractive index is lower, care has to be taken to achieve the required hiding power. New synthetically produced calcium carbonate types are available which consider the aforementioned. In a medium class interior paint formulation with 12.5 % TiO_2 and a PVC (pigment volume concentration) of 76 % the amount of TiO_2 was substituted 1:1 by the new calcium carbonate type. The graph below shows the results: Opacity as well as brightness compared to the standard formulation did not change up to a TiO_2 substitution of 60 %.[1)]

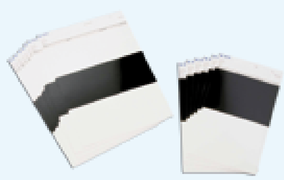
Substitution of TiO_2



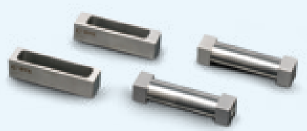
In this experiment only an increase in 85° gloss from 4 to 7 gloss units was monitored.

[1)] Dr. Petra Fritzen; Solvay Chemicals GmbH: Ein gut gefülltes Paket; Farbe und Lack (June 2015); page 58 – 62

Automatic Film Applicator
byko-drive



Drawdown Test Charts
byko-charts



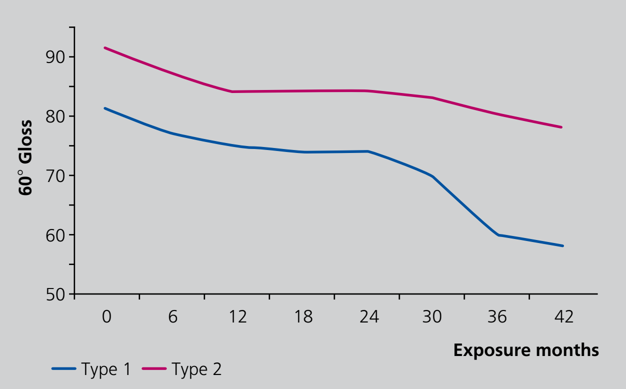
Applicators
Bar applicatos

Binder
The binder or resin combines all solid components of the coating and acts as the film former. It imparts mechanical properties such as hardness, flexibility and adhesion. The binder itself is clear and glossy.

Resin systems are subject to degradation by thermal and photo induced oxidation. Therefore, resistance against weathering and UV radiation needs to be ensured. This is highly important for corrosion coatings that protect objects like bridges, storage tanks or steel structures against environmental influences. Tests are either done by using accelerating weathering chambers or under real-world conditions. The most popular weathering areas are located in Arizona and South Florida.

In the example below, two different types of silicone-epoxy resins were exposed. As displayed in the graph, type 2 started at a higher initial 60° gloss and even after 42 months of Florida exposure continues to maintain a much higher gloss level than type 1.

Outdoor weathering



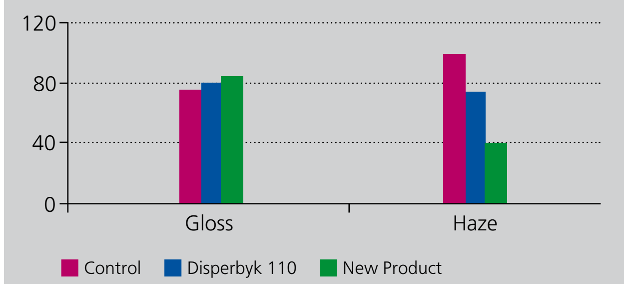
Color retention was excellent for both systems. After 42 months of outside exposure they exhibit a ΔE* of less than 1 compared to the control.

Additives
Additives are substances that are added to a coating in very small amounts to improve properties such as wetting and dispersing, flow and leveling, defoaming or can act as matting agent.

Wetting and Dispersing Additives

One of the most important steps in the production of pigmented coatings is the homogeneous distribution and stabilization of pigments and fillers within the liquid binder solution. If this step is not optimized, a variety of defects can occur: e.g. flocculation, gloss reduction, color shift and settling. Wetting and dispersing additives are surface-active substances that improve the wetting of solids and prevent the flocculation of the particles.

Influence of wetting/dispersing additive



The diagram above shows the influence of wetting/ dispersing additives on the dispersion quality. Two different additives used in a solvent-free coating system are compared with the same system without additive (= control). The new product perfectly stabilizes the pigments resulting in an increased 20° gloss value and a significant reduction in haze.

Flow and Leveling Additives

The chapter "Industrial coatings" discusses an application how the orange peel of powder coatings can be optimized by using the flow & levelling additive BYK-3902 P. Measurements were taken using the wave-scan instrument (see page 30).

BYK-Gardner Solution

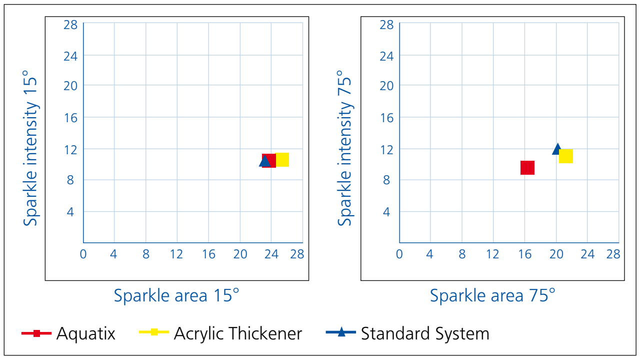
Solid Color & Gloss
spectro2guide

Gloss
micro-gloss

Gloss & Haze
haze-gloss

Rheology Additives

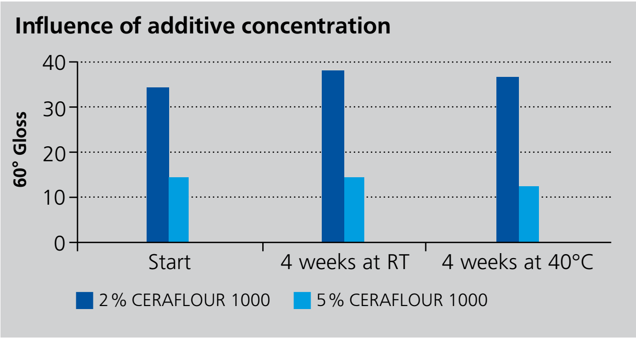
Rheology additives are used to adjust the flow behavior of the coating. For example waxes are utilized to improve the orientation of effect pigments. In the following example a waterborne system was evaluated using three different rheology additives: a standard system, an acrylic thickener and the wax additive AQUATIX®. Visually, the three panels look the same under direct illumination at a steep angle. When comparing at a lower grazing angle, the system using the wax additive shows less sparkling.



BYK-mac i measurement data correlate with a visual judgment. The sparkle area for the system with wax additive at 75° is smaller than for the two other systems. As Sparkle 75° evaluates flakes which are non-parallel oriented, this clearly shows that by using the wax additive AQUATIX® the orientation of the aluminum flakes is improved.

Matting Agents

Dependent on their particle size, wax additives can have an influence on the surface gloss. Usually, particle sizes larger than 1 µm produce a matting effect. CERAFLOUR 1000 is a micronized polymer with wax-like properties to improve surface protection and haptics (soft feel effect). It has a matting effect, especially in radiation curable systems. The graph below shows the influence of additive concentration on the gloss level of a 1-K AC-PU Copolymer Dispersion. Even after 4 week storage at 40°C the matting effect isn`t hardly reduced.



Orange Peel & DOI
wave-scan

Multi-angle Color & Effect
BYK-mac i

Architectural Coatings – Goodbye to dreary

White houses with blue roofs, that is the popular image of the Greek island Santorin. But nowadays architectural coatings are not only offered in "white", but in a wide range of colors and nuances to satisfy everybody's taste. Nevertheless, besides their decorative purpose, architectural coatings must provide certain durable and protective functions to interior and exterior surfaces. In order to comply with important quality criteria and guarantee consistency, a routine quality control system needs to be established.

As architectural coatings are used to paint buildings and homes, they are utilized by professionals as well as do-it-yourself painters. Professionals tend to be more sensitive to application characteristics, whereas homeowners simply paint the wall with the new color but still want the paint to resist color and gloss changes with aging or abrasion.

Determination of hiding properties
Opacity is an important property of architectural paint. One coat hiding reduces labor costs of a paint job and is a competitive advantage in promoting paints to professionals.

For quick visual assessments of opacity the paint is very often applied on black & white checkerboard charts by roller or brush. In order to achieve objective and reliable data reflectance measurements are done with a spectrophotometer.

BYK-Gardner Solution

Solid Color & Gloss
spectro2guide

Automatic Film Applicator
byko-drive

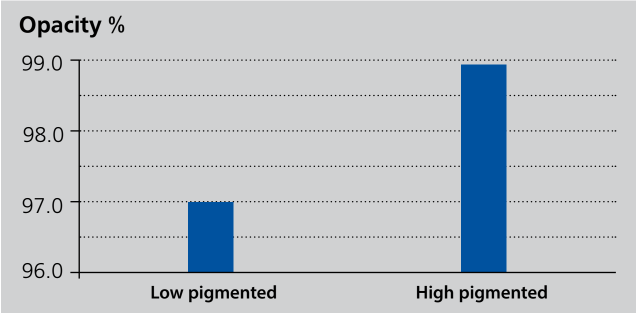
Opacity is the ability of a finish to hide the substrate below. It is also referred to as contrast ratio or hiding power. Contrast ratio is defined as the ratio of the reflectance of a film being applied on a black substrate to that of an identical film on a white substrate. Opacity (%) is simply the contrast ratio multiplied by 100 to get a percentage value.

$$\textbf{Opacity (\%)} = \frac{Y_{black}}{Y_{white}} \times 100\,\%$$

To ensure a smooth and homogeneous surface, the paint is applied to opacity drawdown charts with an automatic film applicator. The charts are made of black and white areas that are large enough to be measured with color instruments having a d/8 measuring geometry. After being dried for at least 24 hours the average of three readings are to be taken on the black as well as the white area.

When using the spectro2guide the opacity value is automatically calculated and displayed on the instrument. Dependent on the results, the coating systems are ranked in four different classes.

Classes	Opacity	Judgment
Class 1	≥ 99.5	Excellent hiding
Class 2	≥ 98.0 % and < 99.5 %	Good hiding
Class 3	≥ 95.0 % and < 98.0 %	
Class 5	< 95.0 %	

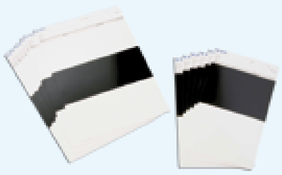


In the graph above two differently pigmented wall paints are evaluated. They are applied with 200 µm film thickness. The lower pigmented system shows a significant lower opacity than the higher pigmented paint.

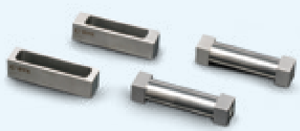
As opacity checks are frequently done it is very important to ensure that the drawdown charts below the paint film are highly consistent in color and gloss. The use of byko-charts drawdown charts guarantees tightest tolerances and prevent erroneous paint batch rejections.

References

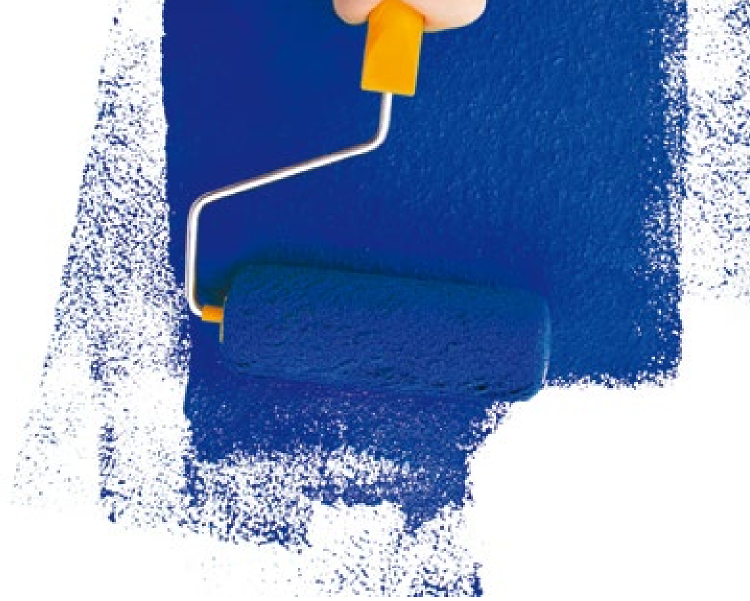
ISO/DIS 18314-2	Analytical Colorimetry: Saunderson correction, Tinting Strength, Hiding Power
ISO 6504	Determination of Hiding Power



Drawdown Test Charts
byko-charts



Applicators
Bar applicatos

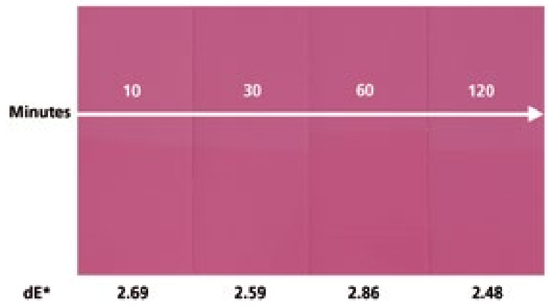


Colorant Compatibility

A colorant sometimes fails to disperse completely in a base paint due to poor compatibility, which can be the fault of the colorant, the paint, or both. This will result in poor color development and can be mainly noticed when high shear forces are applied e.g. application by paintbrush. If there is the tendency for a dark colorant to agglomerate (flocculate) in a paint system, the higher shear application forces the pigments to de-agglomerate resulting in a darker appearance of the color.

A quick test is the so called "rub-up" test. A drawdown with uniform thickness is made on a test-chart. After allowing the paint to dry for a certain time a gentle rubbing action with the finger applies stress to one area of the coating. This tends to disperse the colorants and produces a color difference between the un-sheared and sheared areas of the paint film.

The difference can be measured with the spectro2guide using the total color difference value dE*: The smaller the dE* value the better the color development and vice versa.



In the above picture a paint system was dispersed from 10 to 120 minutes. The dE* between before and after rub-up is pretty large which means that the pigments tend to flocculate. The use of an additive can improve the stability of the paint system. ASTM D5326 describes a more sophisticated procedure with better reproducibility than the finger rub-out.

Touch up properties

Touch up is the ability of paint to maintain its original appearance when a small area is re-painted with the same paint after the original coat has dried. Small imperfections are often found during inspection of a newly painted wall and it is much less costly if these areas can be touched up instead of having to repaint the entire surface. ASTM D3928 Standard Test Method describes a visual assessment rating for touch up properties. Excellent rating means that there is no noticeable variation in gloss between the touched up and non-touched up area on the panel. A rating of very poor represents a great variation.

Rating ASTM D3928	Score
Excellent	10
Very good	8
Good	6
Fair	4
Poor	2
Very poor	0

The micro-gloss offers an objective way to measure matte to semi-gloss architectural coatings by using the 85° and 60° gloss geometry. The gloss meter can therefore give a clear differentiation between the touched up and non-touched up areas and helps the paint manufacturer to optimize paint properties.

BYK-Gardner Solution

Color & Gloss
spectro2guide

Objective Visual Evaluation
byko-spectra *pro*

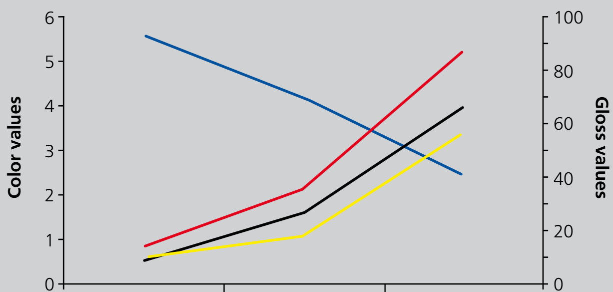
Weather Stability

Regardless of any environmental influences, color and gloss of interior and exterior walls should remain the same. Weathering studies are routine performance tests to determine durability of paint under extreme weather conditions. The tests are either carried out outside under natural conditions or in the laboratory using accelerated weathering tests. External influences (e.g. solar radiation, moisture, oxygen, and heat) can cause degradation of the colorant and resin. This might lead to changes in color, loss of gloss, embrittlement, flaking, chalking, etc...

Changes in color and gloss are determined by regularly comparing the weathered samples to the original standard. The total color difference dE* is usually recorded. Acceptable changes depend greatly on the hue. Brilliant colors tolerate greater deviations than dark and achromatic colors. In order to obtain additional information about the yellowing, often the db* is documented. The b* value represents the yellow/blue amount, i.e. the greater the deviation on the b* value, the more the paint yellowed. UV light absorption can also cause degradation of the bonds of certain polymers used in the paint resulting in a loss of gloss.

spectro2guide is able to measure both color and gloss on the same spot in accordance with international standards.

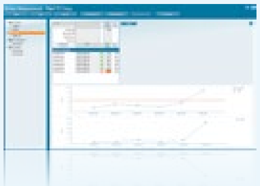
Accelerated weathering



	1 week	2 weeks	3 weeks
dL*	0.55	1.65	3.94
db*	0.58	1.08	3.34
dE*	0.85	2.13	5.23
60° Gloss	92	69	41

The above graph shows the results of an extreme accelerated weathering test of a blue architectural coating without UV stabilizer. It is obvious that the 60° gloss value rapidly decreases and the color deviations dE*, dL*, and db* increase extremely.

Gloss
micro-gloss



Professional documentation
smart-lab Gloss

Architectural Coatings – Color sells

"My home is my castle!" This statement makes it very clear that delivering the color the customer wants to decorate his room is critical. And this is why paint manufacturers spend so much money on color chips, color chip racks and brochures to suggest colors and color schemes. In today's marketplace just about anything can be personalized; having personalized color choices is certainly essential to be successful.

Color matching at the point of sale is challenging for retailers and paint manufacturers alike. It is necessary to be able to match a given color for the customer in a fast and efficient manner at no extra cost.

If it is done manually by eye, it is very difficult to get the same color the second time. If more paint is needed or the same color is required for a different project, chances are high that there will be a color mismatch generating additional costs.

In order to improve quality and reduce costs, color matching systems are available using a spectrophotometer which measures the required color and communicates with software that gives the best formula. A store associate then uses a dispenser to add the colorant to a base paint, shakes it thoroughly, and the paint is ready to go. The whole process takes just a few minutes and is highly repeatable. BYK offers a variaty of solutions from basic color selection tools to full color formulation.

Color selection tools
These are "electronic fan decks" that use a spectrophotometer which has a color palette programmed into the memory. The target color, whether that is a color chip or piece of fabric, is measured and the closest match is displayed. Since these tools are tied to a given palette or fan deck, existing of 1000 – 2000 colors, the hope is that the color is close enough to one of the colors in the selection. The spectro2guide can store up-to 5000 standard colors and quickly displays the closest match including total color difference value ΔE*. Additionally, all features of a complete color QC instrument are available e.g. commonly used color scales and illuminants, metamerism and Pass/Fail.

Look-up software
The fact remains that more than 2000 colors to choose from are needed to achieve a satisfying match. Therefore, more advanced lookup systems are available. These systems combine a spectrophotometer and a database that is typically populated with thousands of colors and known formulas. The instrument measures the target color. By comparing the spectral reflectance of the target and that of the stored colors, the software retrieves the closest match. A large amount of known formulas are needed and care has to be taken to constantly update the database. For architectural coatings, formulas for each base and sheen combination are needed creating an additional challenge.

Complete color matching system
The most complete solution is a color matching system that consists of a spectrophotometer to measure color and a formulation software that calculates the amount of each colorant needed to match that color. The colorants are then

BYK-Gardner Solution

Benchtop Color
auto-match Sensor

Portable Color
spectro2guide

dispensed into a can of white or un-tinted paint base. Multiple bases for each paint line are used because the deeper and darker colors require less TiO_2 in the base. Additionally, each paint line can have multiple sheen or gloss levels. All of these variables are characterized and programmed into the software by making letdowns of each base, of each product line, with various concentrations of each colorant for each gloss level. The preparation and maintenance of the colorant data is vital to the success of the complete system. It is recommended to apply the letdowns to opacity drawdown charts, like the byko-charts, using an automatic film applicator to ensure a smooth and homogeneous surface.

BYK-Gardner's in-store color matching software starts every color match by comparing the spectral curve of the target color to all the spectral curves of known formulas that are stored in the database. If it finds a good match, it uses the same set of colorants to make the target color. This is a useful way to reduce metamerism, because all similar colors will use the same colorant set.

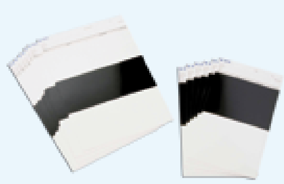
If there is no color in the database that is close enough to the target color, the software will perform correction steps or if needed will start a completely new match. The in-store color matching software does not randomly selects colorants, but has some optional rules that can be implemented for the various colorants and colorant combinations.

There is more than just getting a good color match:

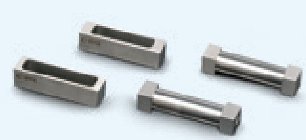
- Some colorants resist fade better than others
- Some colorants resist chemicals better than others
- Some colorants should not be used in combination with others
- Some colorants are less expensive than others

The software can be operated with the auto-match sensor, a small and rugged benchtop instrument for usage at the point of sale. Delivering the color the customer wants, is just a measurement away!

Automatic Film Applicator
byko-drive



Drawdown Test Charts
byko-charts



Applicators
Bar applicatos

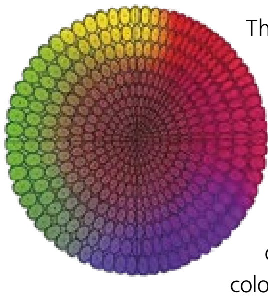
Industrial Coatings – A fascinating decoration

Patchwork might be good for quilts but certainly not for coated industrial goods. As many finished products consist of multiple components which are manufactured by different suppliers and at different locations, uniformity of color and appearance is crucial. Not only the paint batches need to be delivered with consistent quality, but also the production process of the finished product needs to be controlled.

According to Wikipedia the oldest transmitted paint formulation dates back to the 12th century. Since then a lot has changed. Industrial coatings with lower solvent content were introduced resulting in water based systems with almost no solvent. Increasing environmental demands during the last years and requirements for low VOC (volatile organic compounds) systems open the doors for powder coatings with 100 % solids content. Independent of the material, the optical properties of industrial coatings need to fulfill certain quality aspects before they can be applied on the final product.

Color and Gloss harmony

Color consistency from batch to batch is of course a "must" requirement for an industrial coating. The "correct" color has to be ensured across different material types and gloss levels. Color tolerances are dependent on the application and the hue. Studies have proven that CIELab color space is not uniform.



The diagram shows the CIELab color space divided into a multiple number of ellipsoidal micro-spaces. All colors within one ellipse are perceived as the same color. It can clearly be noticed that the size and shape of the ellipses are different dependent on the hue. Additional, chromatic colors have larger ellipses than achromatic colors and a difference in hue is more obvious than a difference in chroma.

Therefore, tolerances need to be defined by color families and differently for the individual color components (ΔL*a*b*C*H*). Over the years, new color systems and equations for solid colors were developed based on visual studies: e.g. ΔECMC– ΔE94 – ΔE99 – ΔE2000. They correct for the non-uniformity of CIELab color space and improve visual correlation. Additionally, the major advantage of these equations is that one tolerance can be used for all colors.

spectro2guide includes all new equations and even simultaneously measures 60° gloss to ensure complete appearance harmony.

BYK-Gardner Solution

Color & Gloss
spectro2guide

Objective Visual Evaluation
byko-spectra *pro*

Color consistency under different illuminants
As multi-component products are utilized under different lighting conditions, color consistency needs to be checked under multiple light sources as well. Otherwise parts painted with different batches have the potential risk to appear the same under daylight but show an apparent mismatch under indoor room lighting. This phenomenon is known as metamerism.

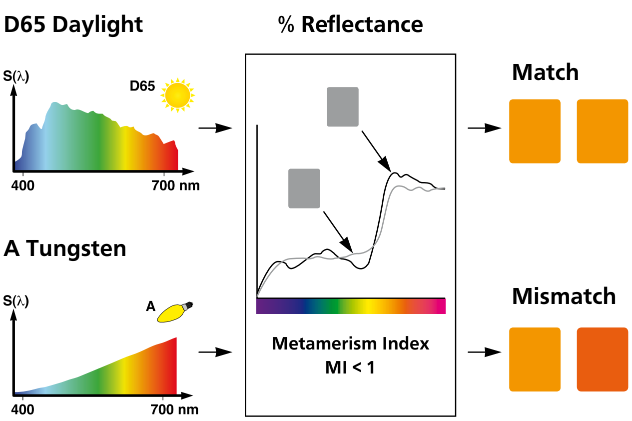
Visual test of metamerism

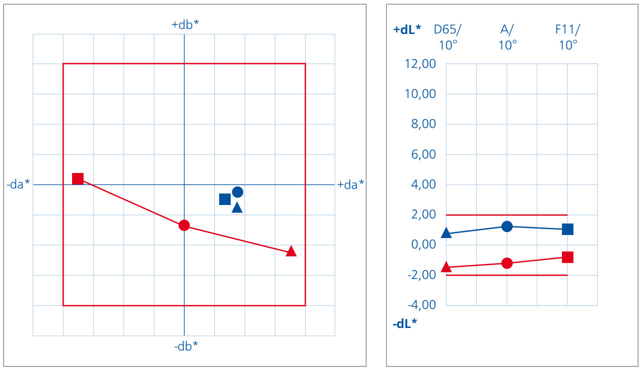
In a light booth standard and sample are viewed at the reference light source – most of the time D65. Then the light source is changed to at least one test light source which is significantly different from the reference light source. A common practice is to visually evaluate the sample pair under illuminant A and a fluorescent light source representing TL84 or CWF. This can be easily done using the byko-spectra lighting cabinet. The light booth supports commonly defined standard illuminants and an automatic sequencing of different light sources for standard testing procedures can be programmed.

Instrumental test of metamerism

The reason for metameric paint batches is that the pigments or colorants used in the formulation are different. This can occur when e.g. raw materials are no longer available because of environmental issues or more cost efficient solutions require raw material changes. In any case, the spectral curves of the metameric pair are different. Typically the curves cross each other at least three times.

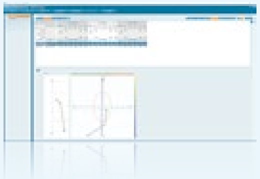
However L*a*b* values calculated for one illuminant are the same for both specimen, but are different for a second and third illuminant. The graph below shows measurements taken with the spectro2guide. The red line represents a metameric sample: the Δa* and Δb* values are significantly different for illuminant D65, A and F11 (TL84). In comparison the sample charted in blue matches very similar for all three illuminants. Therefore, it is not metameric.





Color differences are charted for three illuminants
D65/10°▲ A/10°● F11/10°■

Gloss
micro-gloss



Professional documentation
smart-lab Color



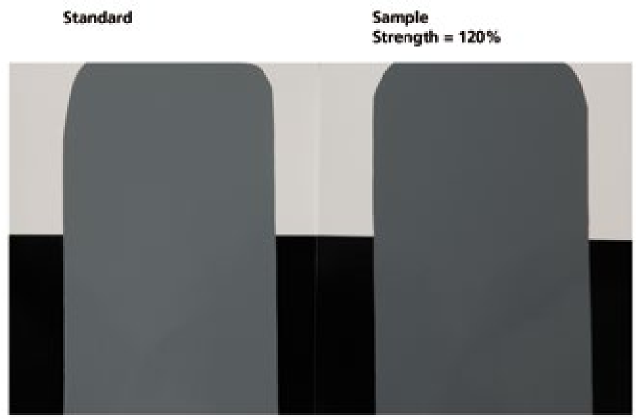

Determination of tinting strength

As tinting strength is directly influenced by the pigment type and concentration used in the coating system, it is an important economic factor when selecting one paint over the other. Differences in tinting strength result from batch-to-batch variations during colorant manufacturing and are therefore a crucial test for incoming QC at a paint maker. If the tinting strength of the colorant is not within the specified limits, the paint formula needs to be adjusted to achieve the required color shade. Tinting strength can be influenced by using an optimized wetting/dispersing additive at an optimized dispersing time.

Tinting Strength is the ability of a colorant or pigment to alter the color of a paint film. It is determined at the wavelength of maximum absorption using the absorption and scattering coefficients K/S of standard and batch. Tinting Strength is expressed in %.

$$\text{Strength (\%)} = \frac{\text{BatchK/S}(nm_{max})}{\text{StandardK/S}(nm_{max})} \times 100\ (\%)$$

Tinting strength of a colorant is always determined relative to a standard or reference paint of the same chemical type. The procedure is based on the dilution with a defined white paint. Drawdowns are then made on opacity charts at complete hiding i.e. minimum 98 % opacity. In order to create a uniform drawdown the use of an automatic film applicator is highly recommended. The drawdowns are measured with a spectrophotometer. Readings can be taken using an instrument with d/8 specular including or excluding or 45/0 measuring geometry. The standard is assigned with a tinting strength of 100 %. The tinting strength of the batch is determined relative to the standard and automatically displayed by the spectro2guide. If the batch has a tinting strength < 100 %, it means that it is weaker and more colorant is needed to achieve the required color shade. As differences in gloss can be mistaken for a weaker or stronger tinting strength, care has to be taken to keep surface properties of standard and batch alike.



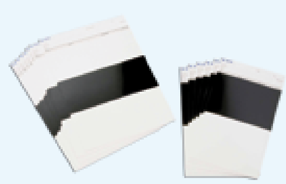
The picture above shows the test results for a carbon black concentrate. By increasing the dispersion time from 20 to 30 minutes, the tinting strength is increased by 20 %.

References

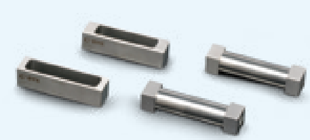
ISO/DIS 18314-2	Analytical Colorimetry: Saunderson correction, Tinting Strength, Hiding Power
DIN 6172	Special Metamerism Index: Change in Illuminant

BYK-Gardner Solution

Automatic Film Applicator
byko-drive



Drawdown Test Charts
byko-charts

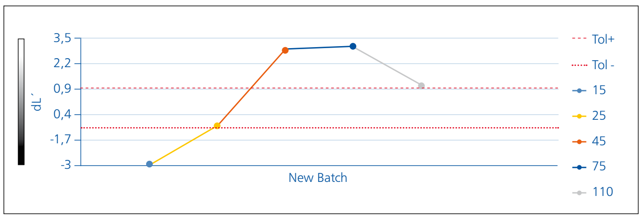


Applicators
Bar applicatos

Color control of effect finishes

Special effect coatings play a dominant role in many applications as they make an object distinctively appealing: washing machines are no longer necessarily white, building facades shine in all kinds of metallic colors, and even mechanical engineering adopts the "noble" look of effect finishes.

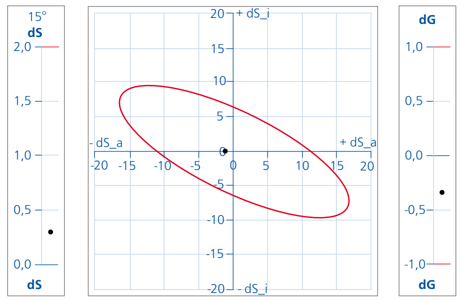
Metallic finishes show a lightness change with changing viewing angle. This effect is also referred to as "light-dark flop" and is e.g. an important quality criterion for architectural panels. The panels are either powder coated or coil coated. A reliable incoming QC procedure has to be defined so that panels with a different lightness flop are not assembled at the same building. Such a "mismatch" will become very obvious when viewed from a distance.



The above graph shows measurement data taken with the BYK-mac i multi-angle spectrophotometer. A new coil coating batch is compared to the defined standard. ΔL* changes from a negative value (= darker) at the near specular angle 15° to a positive value (= lighter) at the flop angle 75°. As both values are out of tolerance, the two panels will look differently when being assembled side by side.

Metallic finishes also change their appearance with lighting conditions. They start to "sparkle" when being viewed under direct sunlight, whereas under diffused lighting conditions a more or less distinct grainy pattern becomes visible.

The BYK-mac i measures these two attributes as sparkle and graininess. The graph below displays the measurement data of the new batch. Both values are well within tolerance.



For small parts, the BYK-mac i is also available with 12 mm aperture. To ensure repeatable sample placement and reliable measurement results, the use of a special sample holder is highly recommended. The holder is equipped with a mask to fit the aperture of the BYK-mac i 12 mm as well as, a tilting handle to fix the instrument. Application specific presentation tools are included.

Color & Gloss
spectro2guide

Multi-angle Color & Effect
BYK-mac i

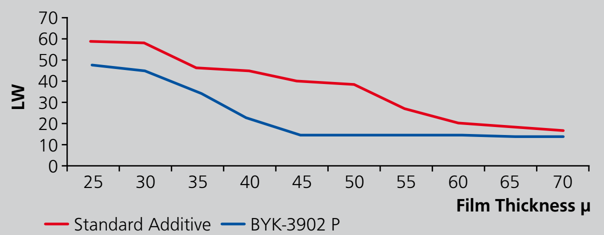
Sample Holder
BYK-mac i 12 mm

Optimization of flow & levelling properties

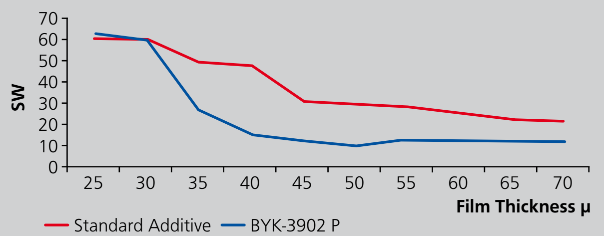
The appearance of a coated surface is not only influenced by color, but also by gloss and flow & levelling attributes. Eye catching finishes should look like a mirror – "high gloss and perfectly smooth". Powder coatings are highly durable and resistant finishes. As the name already implies they are in powder form and do not use a solvent. They are typically applied electrostatically before being cured under high temperatures.

Powder coatings typically have a wavy appearance. To achieve an attractive smooth look, levelling additives are used to reduce differences in surface tension, consequently, avoiding craters and improving orange peel. These additives are very often polyacrylate based and only needed in small amounts in the formulation. The graphs on the right show how the additive BYK-3902 P clearly decreases LW and SW values in a polyester/epoxy powder coating system. BYK-3902 P is particularly suitable for thin-layer powder coatings that are used to reduce costs or for applications like racing bikes were the final product is weight sensitive. Therefore, compared to a standard flow & levelling additive the improvement is especially noticeable at lower film thickness of 30 – 45 µm.

LW data dependent on film thickness



SW data dependent on film thickness



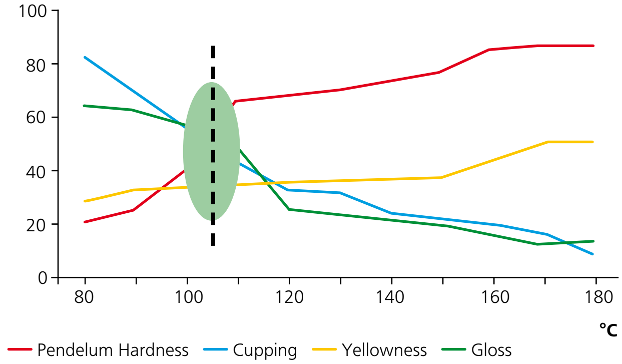
Measurements were taken with the wave-scan instrument which is rolled across the surface to scan the wavy light/dark pattern. The data of the optical profile is divided into different wavelength ranges (0.1 mm to 30 mm) by using mathematical filter functions. Commonly used are SW-data (0.3 – 1.2 mm) and LW-data (1.2 – 12mm) to describe flow levelling behavior. For small and curved parts the micro-wave-scan is beneficial.

BYK-Gardner Solution

Orange Peel & DOI
wave-scan

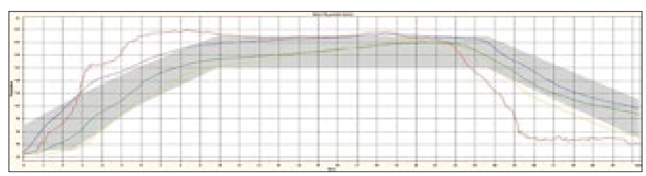
Measurement of Small Parts
micro-wave-scan

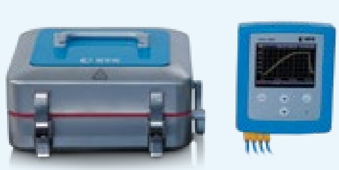
Temperature control of the production oven
The prerequisite for proper physical and optical properties is a controlled and stable baking process. Temperature as well as baking time determines the cross-linking quality of the paint. The picture on the right shows how on the one hand hardness and flexibility of the paint film are influenced by the baking temperature, but on the other hand also the optical properties color and gloss.



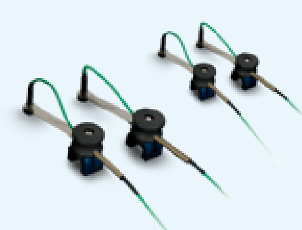
The oven recorder temp-gard is a valuable tool to routinely monitor the temperature distribution of the ovens as well as the object temperature. As the object temperature is highly influenced by the material, material thickness, and shape of the product, it is recommended to select the most critical measurement spots on the object. Additionally, one sensor is used to monitor air temperature.

The graph below shows temperature measurements of a multi-component product. Sensor 1 is placed on a part made out of thinner steel. The high curing index of 244 % clearly determines that the part is over-cured and most probably will not reach the product specifications.





Temperature Control
temp-gard



Temperature Control Accessories
Temperature Probes

Wood Coatings – Keep the natural look

Wood is one of the most versatile raw materials in the world. It creates a warm and comfortable atmosphere and is therefore, often used for furniture and parquet flooring. A living room table or a kitchen cabinet plays an important role in defining a home's personality. On the one hand, fresh and exciting looks are demanded by consumers; on the other hand, the natural look should still be noticeable. Due to its individual character, the measurement of color and gloss on wooden surfaces are of special challenge.

When being used for furniture, wood coatings have to fulfill two main requirements: they have to guarantee durability and resistance against a variety of household chemicals and solvents, but at the same time the product has to look nice and esthetically appealing.

Depending on the exclusivity of the furniture, different "types" of wood are used. High-end furniture is made out of natural solid wood or veneer, whereas inexpensive products are made of plywood. Solid wood is usually covered with a clear or tinted stain that is applied in different ways determined by the geometry of the part. Flat parts like boards and cabinet doors are coated by rolling or flowing when being processed by a flat conveyor line. More complicated shaped parts like chairs or complete furniture pieces are hung on carriers and sprayed. Plywood can either be coated with an opaque solid coating or laminated with a thin paper film of different design ranging from solids to wood grain imitations.

As design decisions are often made at different locations than manufacturing takes place and parts from different suppliers worldwide are assembled to the finished product, a reliable color and gloss control is crucial. A color instrument using a sphere (d/8), specular-included geometry is best suited to measure color variations on wooden surfaces. Depending on the gloss level of the sample, either a 60° or 20° gloss measurement is recommended additionally.

BYK-Gardner Solution

Color & Gloss
spectro2guide

Objective Visual Evaluation
byko-spectra *pro*

Color measurement

The first step for a reliable color control system is to ensure that the defined "look" can be sufficiently reproduced in any manufacturing environment. Therefore, standards with reasonable tolerances have to be established between customer and suppliers. A color spectrophotometer like the spectro2guide can be a valuable tool in the process, because it can save standards together with their tolerances. This eliminates the error that physical wood standards easily change over time and reduces storage capacity of reference samples. After this has been done, regular production control can be performed on the finished products. As long as the surface is homogeneous – like with solid colored plywood – color measurements can be performed easily. The challenge starts when wooden grain becomes visible.

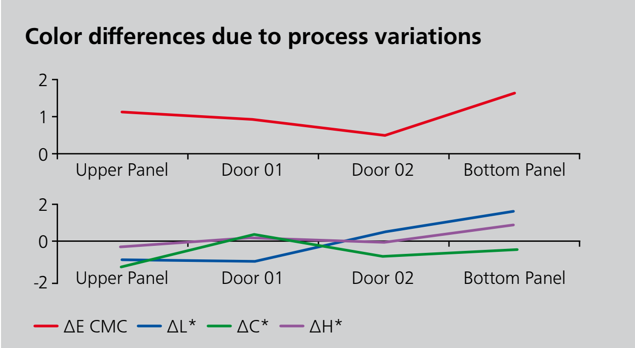
Laminated plywood

The imitation wood grain is printed on a thin paper film, which is then glued onto the plywood. The print follows a certain pattern and therefore, measurementlocations can be easily defined to make sure to always measure on the same spot. Dependent on the size of the product an average of 3 to 5 readings is recommended. To improve repeatability and reproducibility, a template with cut-outs can be created to clearly define the measurement spots.

Solid wood or veneer

As every tree is different, also the wood panels processed from it are "living materials" that will never look the same. The challenging factor is the irregular pattern of the grain which still can be seen through the transparent or semi-transparent stain. When doing an evaluation, either visual or instrumental, one has to focus on the "dominant color". This means that knotholes and the surrounding areas as well as extremely light or dark areas should be excluded. The remaining area is then measured by taking an average of 6 to 9 readings. Color differences of light colors that can still be accepted are in the range of +/- 1 ΔL*a*b* and for dark colors in the range of +/- 1.5 ΔL*a*b*.

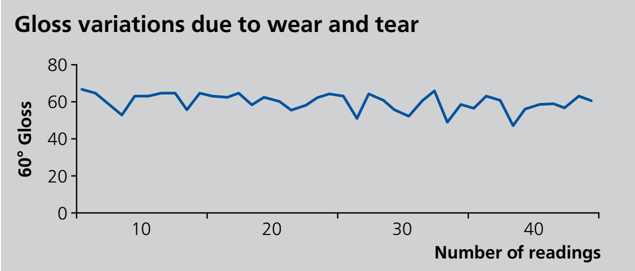
Process variations measured with the spectro2guide can be analyzed in trend graphs. The following graphs show data for a chromatic wood stain being applied on different furniture panels.



To obtain good correlation between visual assessment and instrumental readings, the samples shall be viewed parallel to the grain.

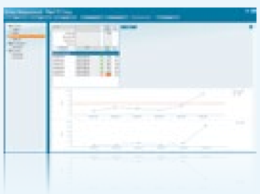
Gloss measurement

Dependent on the type of coatings (waxes, oils, varnishes, shellacs, lacquers, and water-based finishes), different looks can be created from very matte and dull up-to high gloss surfaces. Gloss variations are very obvious on large surfaces like furniture panels and parquet flooring. The micro-gloss offers a quick solution for objective quality control. In "continuous mode" the instrument conveniently scans large areas and checks gloss uniformity. Up-to 99 measurements can be taken at a defined interval and as a result the display shows the average value of all readings as well as the minimum and maximum value. In the graph below gloss variations of parquet flooring in a living room are charted. Scratches and wear mark spots result in lower 60° gloss values.



On smaller samples it is sufficient to calculate an average gloss value of 3 to 5 readings. As wooden surfaces have a certain preferred direction based on the grain and fiber orientation it is very important to define the measurement direction of the glossmeter. A common way is to take readings in the fiber direction where the wooden structure is visible.

Gloss
micro-gloss



Professional documentation
smart-lab Gloss

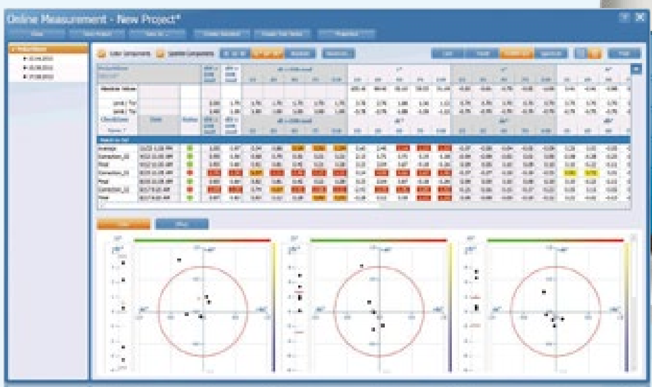
BYK-Gardner Solutions for Coatings

BYK-Gardner Objective Eyes

BYK-mac i

Multi-angle Color and Effect Control.

Cat. No. 7030 BYK-mac i 23 mm | Cat. No. 7034 BYK-mac i 12 mm



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Online Measurement. Instant Data Analysis.

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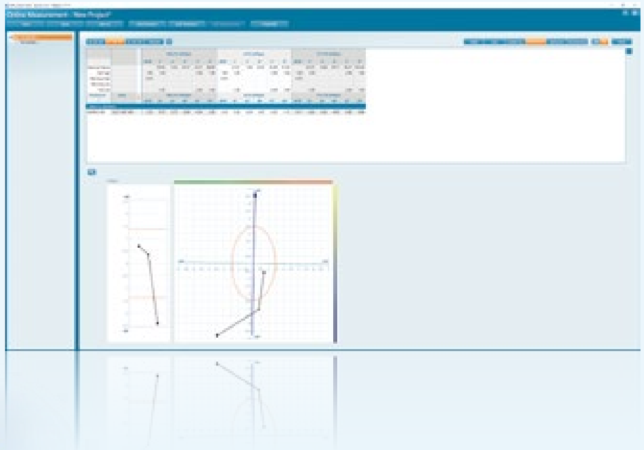

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byko-spectra *effect*

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haze-gloss

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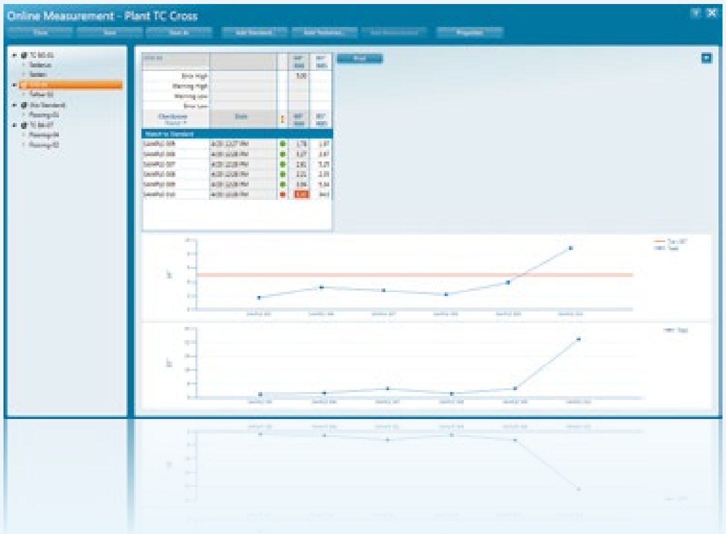

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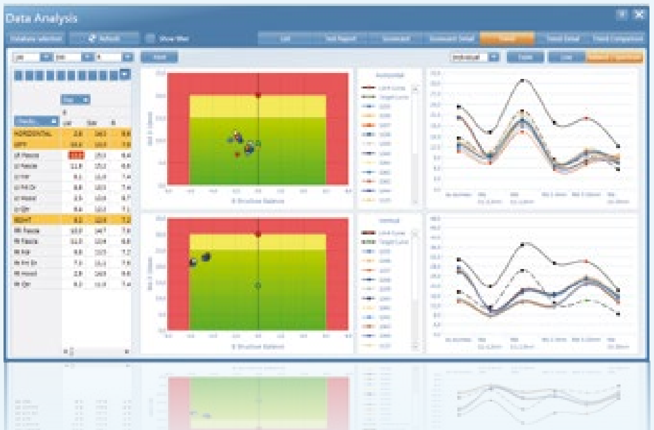
Professional Documentation

Kat. Nr. 4866



smart-process

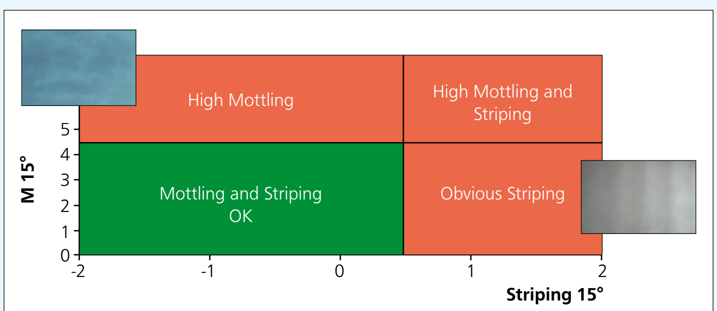
Structure Spectrum for Optimization.

Cat. No. 4831

wave-scan

Orange Peel and DOI Measurement.

Cat. No. 4840 wave-scan dual



cloud-runner

Objective Mottling Analysis with smart-process.

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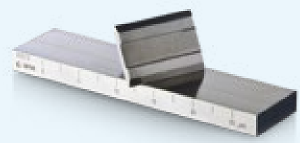
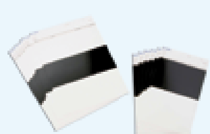


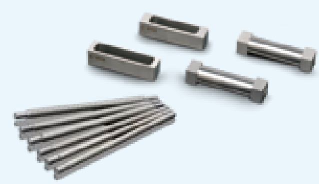
Fineness of Grind

Wet Film Thickness

Automatic Film Applicator



Drawdown Test Charts



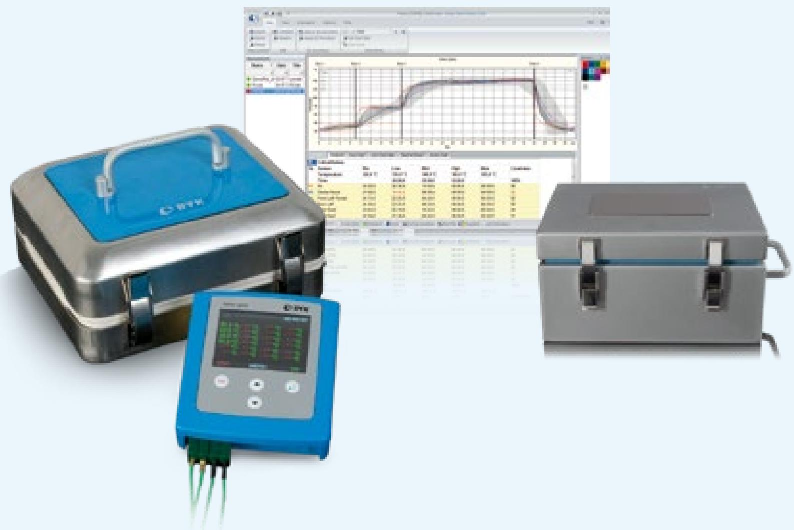
Applicators

BYK-Gardner Oven Temperature Recorder

temp-gard

Curing Process under Control.

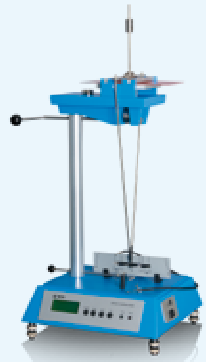
Cat. No. 3319 temp-gard *pro* I Cat. No. 3341 temp-gard *basic*



Dry Coating Testing

Abrasion Tester

Film Thickness



Pendulum Hardness

Buchholz Indentation

Cross-Cut Adhesion

Cupping Tester

Flexibility Tester

Impact Tester

For a live demo please view our videos on **www.byk.com**

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