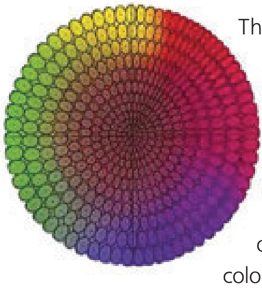
Industrial Coatings – A fascinating decoration

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.

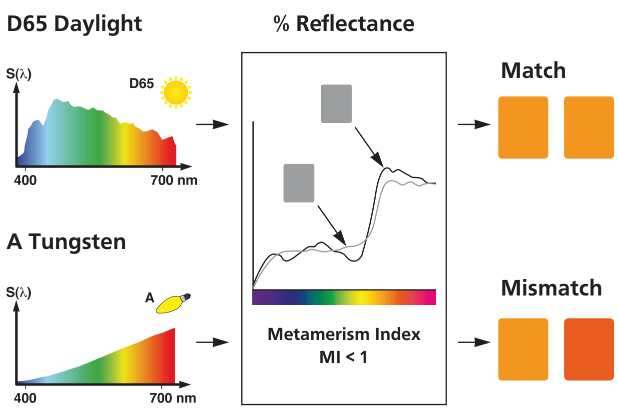
Visual test of metamerism

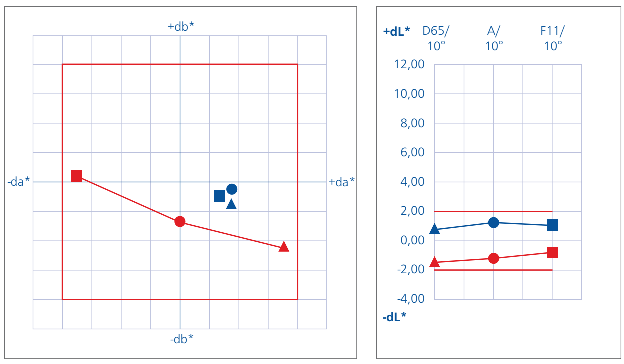
In a light booth standard and sample are viewed at the reference light source – most of the time D65. Then the light source is changed to at least one test light source which is significantly different from the reference light source. A common practice is to visually evaluate the sample pair under illuminant 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.

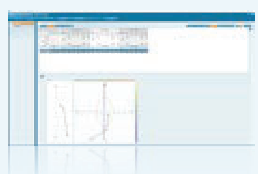
However L*a*b* values calculated for one illuminant are the same for both specimen, but are different for a second and third illuminant. The graph below shows measurements taken with the spectro2guide. The red line represents a metameric sample: the Δa* and Δb* values are significantly different for 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



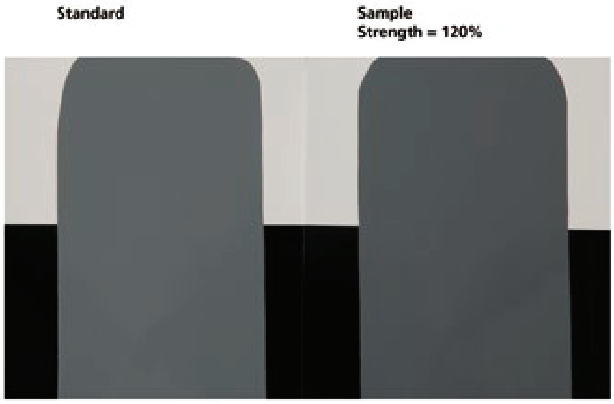

Determination of tinting strength

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

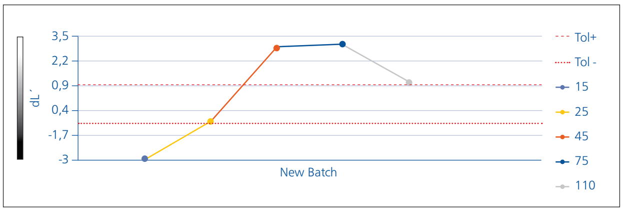
Drawdown Test Charts
byko-charts

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.

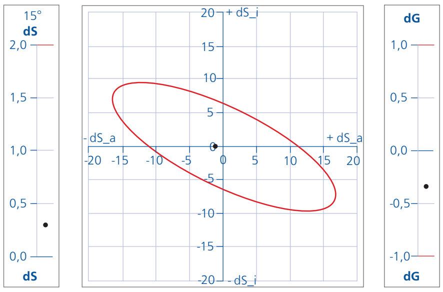
Metallic finishes show a lightness change with changing viewing angle. This effect is also referred to as "light-dark flop" and is e.g. an important quality criterion for architectural panels. The panels are either powder coated or coil coated. A reliable incoming QC procedure has to be defined so that 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.

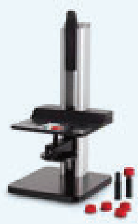
The BYK-mac i measures these two attributes as sparkle and graininess. The graph below displays the measurement data of the new batch. Both values are well within tolerance.



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

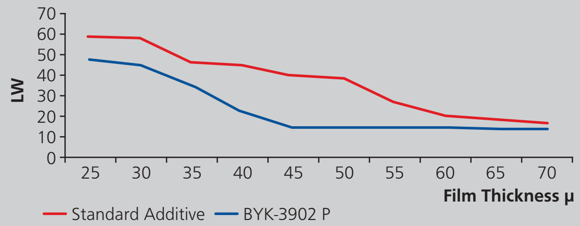


Sample Holder
BYK-mac i 12 mm

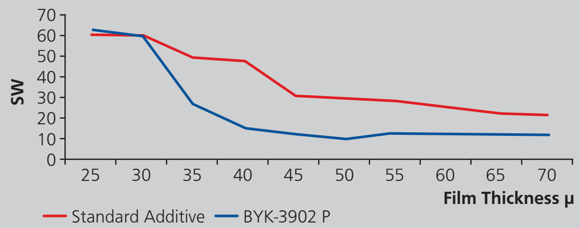
Optimization of flow & levelling properties
The appearance of a coated surface is not only influenced by color, but also by gloss and flow & levelling attributes. Eye catching finishes should look like a mirror – "high gloss and perfectly smooth". Powder coatings are highly durable and resistant finishes. 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



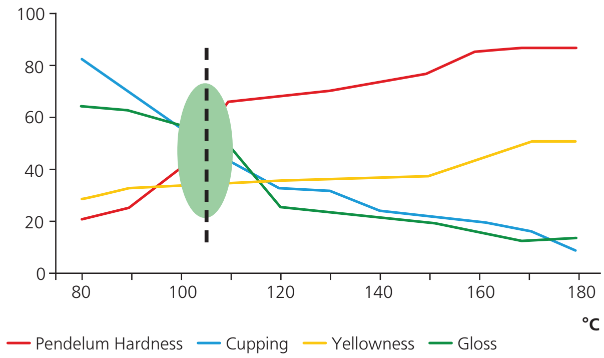
Measurements were taken with the wave-scan instrument which is rolled across the surface to scan the wavy light/dark pattern. The data of the optical profile is divided into different wavelength ranges (0.1 mm to 30 mm) by using mathematical filter functions. Commonly used are SW-data (0.3 – 1.2 mm) 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

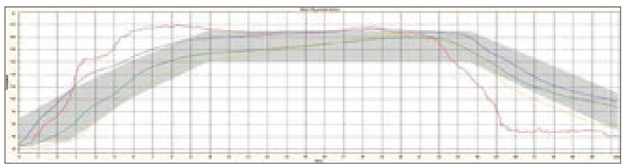
Measurement of Small Parts
micro-wave-scan

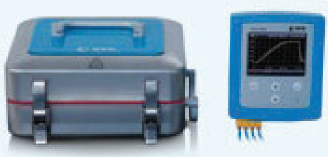
Temperature control of the production oven
The prerequisite for proper physical and optical properties is a controlled and stable baking process. Temperature as well as baking time determines the cross-linking quality of the paint. The picture on the right shows how on the one hand hardness and flexibility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



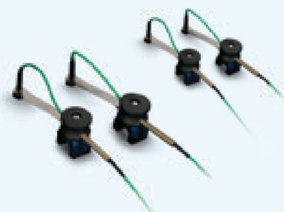
The oven recorder temp-gard is a valuable tool to routinely monitor the temperature distribution of the ovens as well as the object temperature. As the object temperature is highly influenced by the material, material thickness, and shape of the product, it is recommended to select the most critical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