What is Gloss?

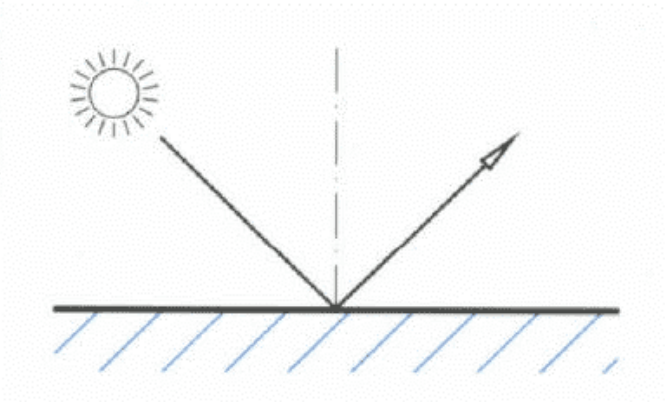
Gloss is an optical phenomenon caused when evaluating the appearance of a surface. The evaluation of gloss describes the capacity of a surface to reflect directed light.

Why is gloss measured?
Gloss is often used as a criterion to evaluate the quality of a product, especially in the case of products where the aesthetic appearance is of importance. This includes products such as automotive coatings, furniture coatings, plastics, metals and paper. A visual gloss evaluation includes many subjective sources of error and is not sufficient. Therefore, to be objective, it is necessary to put a measured value on the degree of gloss. A complete evaluation of gloss is dependent on several factors. Since the 1930's, measuring instruments have been used to associate reflection behavior and a defined measurement value under defined conditions. How this is done and what has to be considered will be explained on the following pages.

How is Gloss Perceived?
Gloss when perceived by the human eye is a subjective evaluation. However, visually observed differences can not always be measured physically by using, for example, glossmeters.

The appearance of gloss is influenced by several factors.

Surface properties



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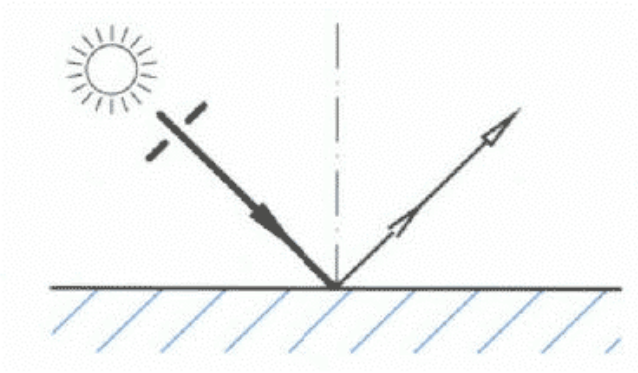
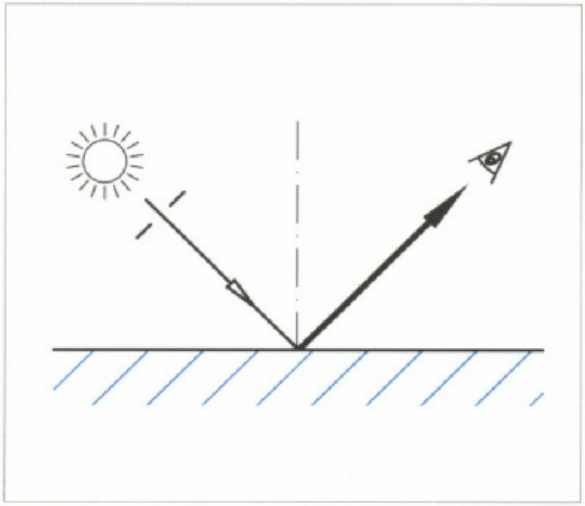
- Material (e.g. glass, coatings, metals)
- Surface profile (e.g. flat, structured)
- Transparency and substrate

Type of illumination



For gloss evaluation it is required to have direct illumination. A diffuse illumination causes diffuse reflection resulting in decreased gloss impression.

Observer



Visual evaluation is dependent on the eyesight , physiology and the mood
As the perception of gloss is a sensation which is not a mere physical measurement, it is difficult to describe with physical parameters.

Reflection Behavior of Surfaces
Different types of surfaces and their reflection behavior under direct illumination are evaluated in the following chapter.

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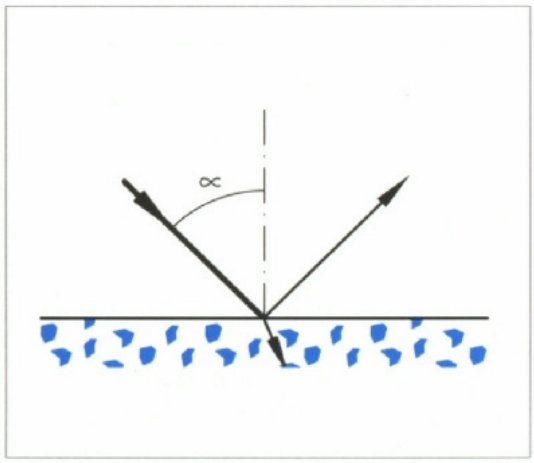
Glossy surface

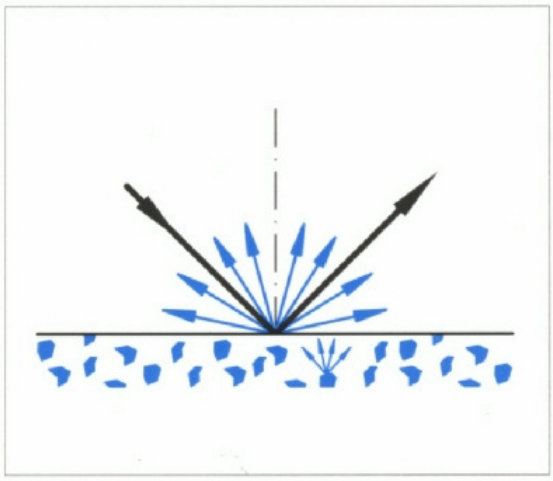


Gloss => direct reflection on the 1st surface.

In case of high gloss surfaces, light reflected from the surface follows the reflection law (angle of illumination = angle of reflection). The intensity of the reflected light is dependent on the angle of illumination and material properties.

Metals: very high intensity, hardly angle dependent

Coatings: low intensity, angle dependent



Color => diffuse reflection from within the sample.

Part of the illumination penetrates the surface and is selectively absorbed and scattered internally by pigment particles and other bodies. It then is diffused from within the first surface. This is how the impression color is caused. This diffuse reflection can be measured with BYK-Gardner color measuring instruments.

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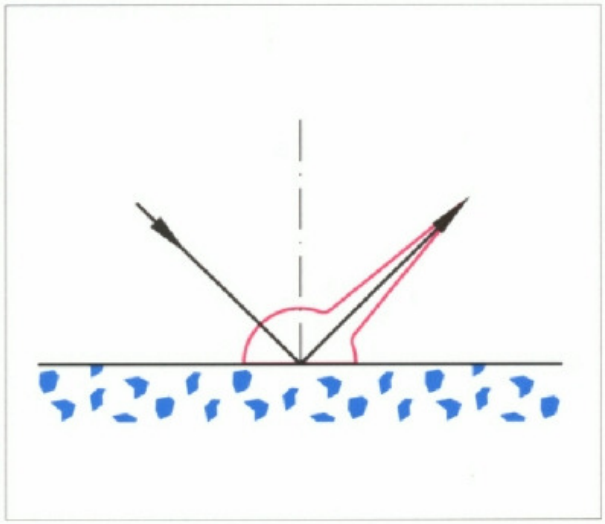
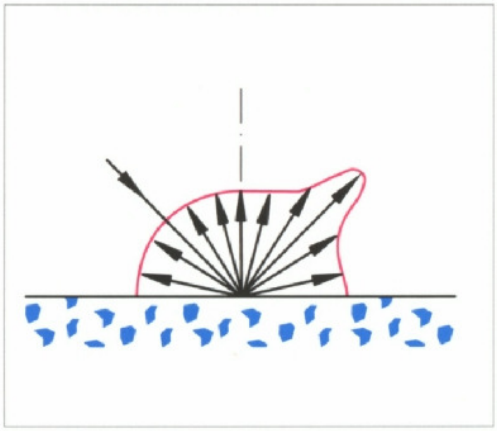
Glossy surface with haze



The dominant part of light is reflected in the main direction of reflection (specular). A small amount of light is scattered in directions adjacent to the direction of specular reflection. This scattered light of low intensity causes haze. The surface seems to be glossy, yet has a milky appearance.



Medium to mat surfaces

In this case light is not only reflected in the direction of specular reflection but also in other directions. The capacity of a surface to reflect a light source or other images is strongly reduced. The more

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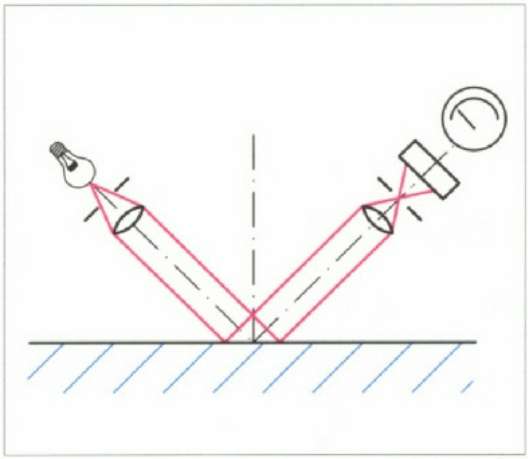
evenly the intensity is distributed in all directions, the less glossy a surface will appear.

The differences between high, semi and low-gloss surfaces can be determined with a regular glossmeter (e.g. micro-gloss, micro-TRI-gloss). The visually perceived phenomenon "haze" can hardly be detected with a regular glossmeter, and to date, only very complicated instruments have been available to measure this effect. Due to these facts, measurement of reflection haze is performed only on rare occasions. Consequently, supplier and vendor were often faced with disputes concerning the appearance quality as they were not able to measure haze.

By developing the haze-gloss, BYK-Gardner allowed the practical measurement of gloss and reflection haze with one laboratory instrument. Now it is possible to measure reflection haze as easily and as fast as you can measure gloss.

How is Gloss Measured?
By using reflectometers reflected light of a surface is measured in an angle range which is limited by aperture dimensions.



Light beam in a reflectometer

The light source is projected over the sample surface onto the opening of aperture 2. A photoelectronic detector measures the light passing

through the aperture.

The measurement results are influenced by various factors:

- Type of measuring instrument
- Angle of illumination
- Calibration of the instrument
- Surface characteristics

In order to obtain comparable measurement results apparatus and measurement procedure were internationally specified.

What are the conventions of an international specification?

- Measuring instrument (optics)
- Calibration of the instrument
- Surface of the sample
- Measurement procedure

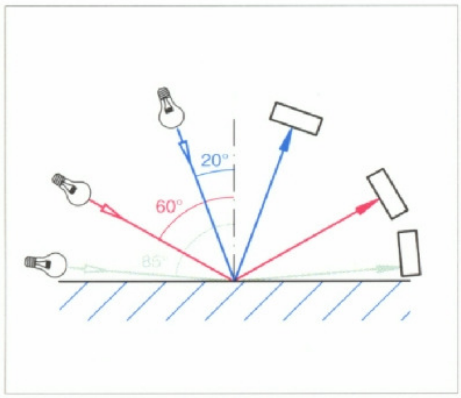
The most important specifications
ISO 2813
ASTM D 523
DIN 67530

These different specifications agree in the essential points.

Standardization of the instrument

- Angle of illumination I reflection 20º/60º/85º
- Dimensions of the source and receptor aperture
- Light source
- Receptor response (sensitivity).

The angle of illumination highly influences the measurement results. In order to evaluate the whole range from high-gloss to mat surfaces, three different angles Of illumination (which means three different measuring ranges) are defined for the paint and coatings industry:



20º high gloss surfaces
60º medium gloss surfaces
85º mat surfaces other industry specifications:
45º ceramic industry
75º paper industry (TAPPI specification)

Instrument calibration

The measurement of the reflectometer value R' is a relative measurement. Results are related to a highly polished black glass with a refractive index of 1.567. The glass has an assigned specular gloss value of 100 for each geometry. As instrument and standard tolerances are tightly controlled, the measurement error should not be more than ± 1 unit.

Surface properties

In order to achieve highly accurate and repeatable results, the test specimen should be

- flat
- free of structures
- similar in color and lightness
- non-luminescent material

Measurement procedures and measurement results

In order to differentiate gloss of samples, it is necessary to select the appropriate measuring geometry.

- First the test specimen is measured with the 60º geometry. The 60º geometry should be used if the gloss reading is between 10 and 70 units.
- If the 60º gloss is higher than 70 units the 20º geometry will be advantageous for comparison.
- If the 60º gloss is lower than 10 (30*) units, the 85º geometry should be used.

*recommendations according to DIN.

In some cases the 60º geometry will be advantageous for very mat test specimens.

At least three readings should be taken on a test specimen. If the range is greater than five gloss units, additional readings have to be taken. For correct measurement results, the mean gloss reading is to be calculated and the geometry used is to be reported. e.g. 20º reflectometer value R'20 = 55 units.

Why do specific gloss levels require different measuring geometries? The reflection on paint and plastic surfaces basically follows the Fresnel equation.

The amount of light that is reflected on the 1st surface or penetrating the material is dependent on the illumination angle. Since, in the case of a mat surface, the amount of reflected light is distributed over a wide-angle range only a small part is detected by the aperture of the reflectometer.

Therefore it is necessary to choose the correct measurement geometry to guarantee high measurement accuracy.

Which measurement geometry is required for which gloss level? In order to illustrate the proper selection for a measuring geometry, the following test was performed:

Thirteen black glass tiles (sample number 1-13) were visually ranked from mat (1) to high-gloss (13) and were measured with 20º, 60º and 85º geometries. By graphing the measurement results (0-100 gloss units) against sample number 1-13 each geometry has a different curve. It is remarkable that the measured gloss difference between two successive tiles is different on each curve. For example, sample number 10 and 11 show the largest difference in the 20º geometry and confirm the use of the 20º geometry for high gloss samples. While in the low gloss area, for example sample number 2 and 3, the largest differences can be achieved with an 85º

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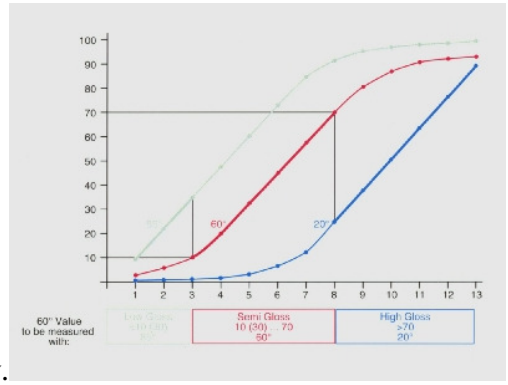


geometry.

Peculiarities when measuring gloss Different phenomena can cause problems when measuring gloss.

Calibration Mistakes during calibration will result in wrong measurement results.

- Calibration standard is not clean (fingerprints, dust)
- Calibration standard is damaged (scratches)
- Calibration standard has changed because of other influences (aging)
- Usage of semi-gloss standards as calibration standards.

In order to avoid the above mentioned sources of errors international specifications recommend a yearly re-calibration of the calibration standard.

These types of errors are to a large extent excluded with BYK-Gardner micro-gloss, micro-TRI-gloss and haze-gloss. In the case of the micro-gloss and micro-TRI-gloss the calibration standard is securely housed in a holder. The calibration is performed automatically.

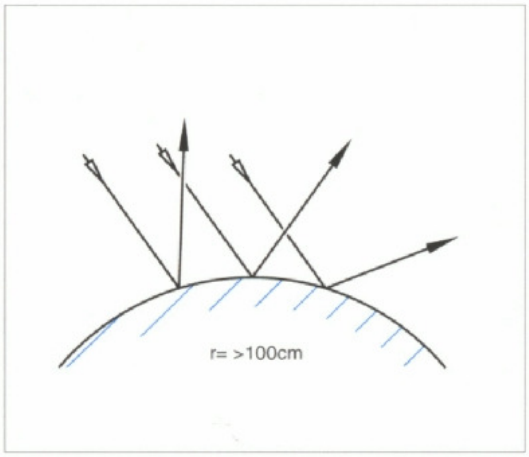
Due to the long-term stability of the haze-gloss, re-calibration is only necessary every two months, which protects the standard from routine use.

Surface properties

Curved surfaces

Gloss measurement is based on the detection of the spatial reflection behavior of a surface, which is strongly influenced by a curvature (distorted image). Depending on the geometry and the degree of gloss, a curvature < 100 cm (dia.) can contribute an influence on the

measured value. In addition, the risk of tilting the sample and the influence of ambient light has to be considered.



Regular structures on surfaces
will result in different gloss values dependent on the measuring direction. If gloss measurement is used as a quality control criterion for those types of surfaces, it is recommended to indicate the measuring direction.

Irregular structures
(artificial leather) show relatively high variations.

Peculiarities for high-gloss surfaces
When visually observed, high-gloss surfaces can differ in their appearance, while readings taken with a 200 glossmeter are equal or are very close. The reason for this phenomenon is scattered light being observed by the human eye. A regular glossmeter is not capable of measuring this scattered light.

Scattered light can be caused by:

- Long term surface structures--> Flow/leveling defects, orange peel leading to a distortion of the reflected image on the surface
- Short term surface structures--> Reflection haze: Microscopic defects on or just beneath the surface cause scattered light of low intensity adjacent to the direction of specular reflection (see "scattered light with gloss measurement").

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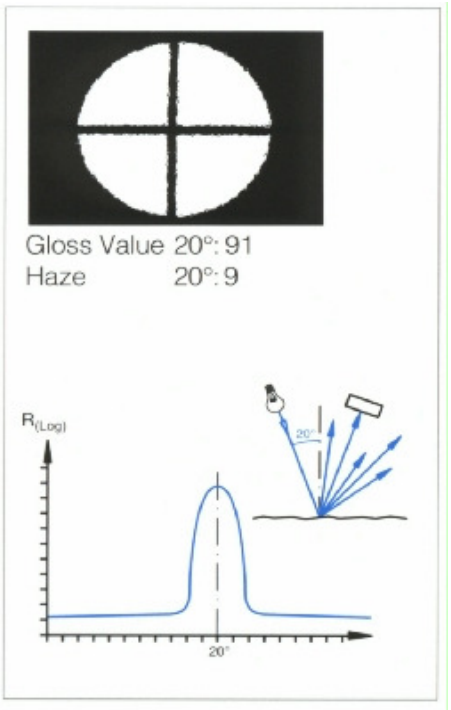
Scattered light with gloss measurement
When describing the appearance of a surface with a reflectometer, the limits of this test method are often reached.

How is visual appearance evaluation performed?
The image of a light source or another illuminated object (e.g. an overhead fluorescent light) reflected by the sample surface is visually evaluated. By using three different types of surfaces the following phenomena will be described:

- quality of a reflected image
- theoretical reflection behavior
- measured reflection distribution

On surfaces that exhibit flow/leveling defects or orange peel, the reflected image will be distorted.



This type of image distortion, caused by long term waviness, results in an enlargement of reflection peak.

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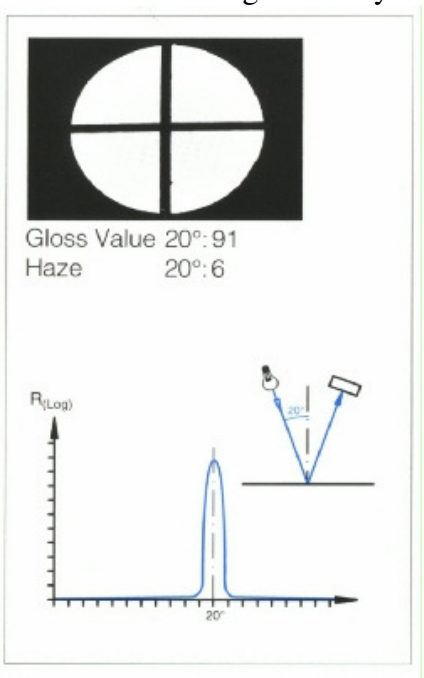
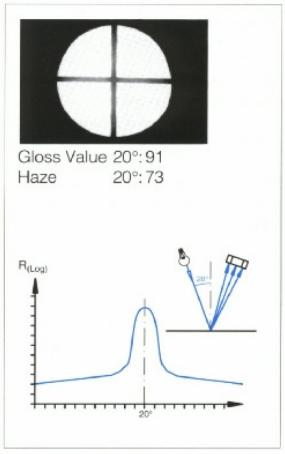
In the case of an undisturbed high-gloss surface, the reflected image appears as clean and distinct as observing it directly.



How is reflection haze measured?

Reflection haze is caused by microscopic defects, which result in scattered light adjacent to the direction of specular reflection, and is visually observed. With the haze-gloss, it is now possible to measure and differentiate both the directly reflected (gloss) and diffusely scattered (haze) light. With the haze-gloss, the measurement of reflection has become as easy and as fast as the measurement of gloss.

On surfaces with reflection haze the reflected image is surrounded by a halo.



Reflection haze caused by scattered light of low intensity, adjacent to the direction of specular reflection, can be measured with the haze-gloss.

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