Insight on Color **Vol. 9, No. 6**

Haze

Haze is cloudiness of a product that is caused by scattering of light. Light may be scattered by particles suspended in the substance, such as pigment particles or contaminants, or by an imperfect surface caused by dirt, oil, or a fine texture. Haze is an important appearance attribute which can be quantified and then used to assess the quality of objects such as liquids, glass, plastics, painted panels, and even metals.

Types of Haze

The type of haze you see when you look at an object is determined primarily by the way in which you view the object. You view a transparent or slightly translucent material by looking at the light which is transmitted through it (transmission haze). You view an opaque material by looking at the light reflected from it (reflection haze). Hazy appearance is described as either transmission haze or reflection haze. Both of these terms are described in greater detail below.

Transmission Haze

Transmission haze is defined as the forward scattering of light from the surface of a nearly clear specimen viewed in transmission. Normally, light scattered back through the sample is not included. Also, only light scattered more than 2.5° from the incident light is considered to contribute to haze. When measuring haze, the percentage of light diffusely scattered compared to the total light transmitted is reported.

$$\%\ \text{Haze} = \frac{T_{\text{diffuse}}}{T_{\text{total}}} \times 100$$

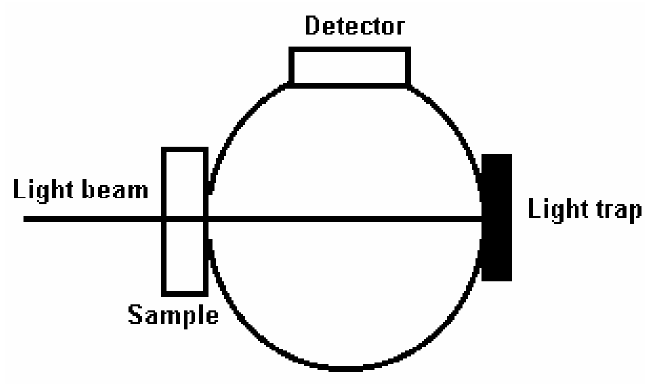
where T = % transmission.

ASTM D1003-95, "Standard Test Method for Haze and Luminous Transmittance of Transparent Plastics"

ASTM Method D1003-95 describes the type of instrument to be used for measuring transmission haze. This haze meter uses a pivoting sphere and a single collimated beam of light. The light enters one side of the sphere at an entrance port and is directed to an exit port on the opposite side of the sphere. When the sphere is in the first position, the light leaves the exit port and is absorbed by a light trap placed at that port as shown in Figure 1. When the sphere is pivoted, the beam of light is directed toward the sphere wall and diffused. The detector is filtered to Illuminant C and the $\bar{y}$ function of the 2° standard observer and the % haze is reported to the nearest 0.1%.

The HunterLab D25P sensor, which is no longer manufactured, was a colorimeter that met the optical configuration described above. Later, the D25P was modified so that instead of the sphere pivoting, the light source moved so that the light beam was directed toward the sphere wall. This was an equivalent configuration to the one specified by ASTM D1003-95. The Y value when the light was directed at the light trap was used as an indicator of the diffuse transmission and the Y value when the light was directed at the sphere wall was used as an indicator of the total transmission.

Figure 1



Measurements Using Current HunterLab Instruments

Currently there is no HunterLab sphere instrument that meets the ASTM D1003-95 specification. The two sphere instrument families, ColorQuest and UltraScan, both have diffuse light sources that originate from the inside of the sphere rather than a collimated beam light source. Furthermore, the spheres of both of these instrument types are in a fixed position and cannot be pivoted.

The method used to get similar haze results is to use a white tile at the reflectance port to simulate the pivoted position when light is directed at the sphere wall. There are drawbacks to using this method. The first is that the white standard that is placed at the port to complete the sphere may have a slightly different reflectance than the actual sphere wall and the second is that the reflectivity may vary slightly with each new placement of the standard. To increase accuracy, use a standard with reflectivity similar to the material which coats the sphere and use the same standard for standardization of the instrument as for haze measurements.

In order to compare results obtained for these various geometries, four samples were measured for haze on a D25P sensor and then measured on both the ColorQuest II Sphere and the UltraScan XE. The values obtained are shown in the table below.

Sample	D25P (SN 0034)	ColorQuest II Sphere (SN 6103)	UltraScan XE (SN 2138)
1	0.64	2.48	0.68
2	3.92	5.80	3.75
3	10.37	11.90	9.66
4	19.49	20.43	18.28
5	33.33	32.91	31.13

Reflection Haze, ASTM E430-91, "Standard Test Methods for Measurement of Gloss of High-Gloss Surfaces by Goniophotometry"

Reflection haze is defined as the spread of the specular component of the reflected light from a glossy surface. The specular component is the light that is reflected from an object at an angle equal to but opposite the incident light. Most glossmeters measure at the specular angle plus or minus several degrees and therefore cannot report the amount which the specular component spreads. The light that is spread 0.3° from the specular is responsible for distinctness-of-image gloss. The light that is spread 2° is responsible for a quality known as bloom or narrow-angle reflection haze. The light spread 5° is referred to as wide-angle reflection haze.

Measurements Using DORIGON II

A Distinctness of Reflected Image Abridged Goniophotometer, DORIGON, can be used to measure the different types of reflection haze. This instrument is no longer manufactured by HunterLab, but many units are still in operation.

First, the specular reflectance of the sample is determined relative to some standard. A black glass standard is used when measuring nonmetals and a mirror standard is used when measuring metals. The Rs value is calculated as follows:

$$\mathrm{Rs} = 100 \text{ x } \frac{\mathrm{Rs}_{\text{sample}}}{\mathrm{Rs}_{\text{standard}}}$$

where Rs is specular (mirror-like) reflection.

The Rs value is then used for calculating the distinctness-of-image (DOI), 2° haze, 5° haze, and 15° diffuseness.

$$\mathrm{DOI} = 100 \text{ x } \frac{\mathrm{Rs} - \mathrm{R}0.3^\circ}{\mathrm{Rs}}$$

$$2^\circ \text{ haze} = 100 \text{ x } \frac{\mathrm{R}2^\circ}{\mathrm{Rs}}$$

$$5^\circ \text{ haze} = 100 \text{ x } \frac{\mathrm{R}5^\circ}{\mathrm{Rs}}$$

$$15° \text{ diffuseness} = 100 \text{ x } \frac{R15°}{Rs}$$

where Rx° is the reflectance at x degrees from the specular.

The DORIGON II can also be used to show a goniophotometric curve, which is a graphical representation of the log of the spread of reflectance. The more mirror-like the surface, the more steep and definite the curve. The hazier the surface the flatter the peak. An example of a goniophotometric curve is shown in Figure 2.

Figure 2

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