

Applications Note

$$\Delta = 2t + \frac{\lambda}{2} \quad (\text{must equal a whole number of } \lambda \text{ for a bright fringe or } 2m\lambda)$$

$$n\lambda = 2t + \frac{\lambda}{2}$$

$$t = \frac{n\lambda - \frac{\lambda}{2}}{2} = \frac{\lambda}{2} \left(n - \frac{1}{2} \right)$$

substituting

$$D^2 = 2r \left[\frac{\lambda}{2} \left(n - \frac{1}{2} \right) \right]$$

AN 1073



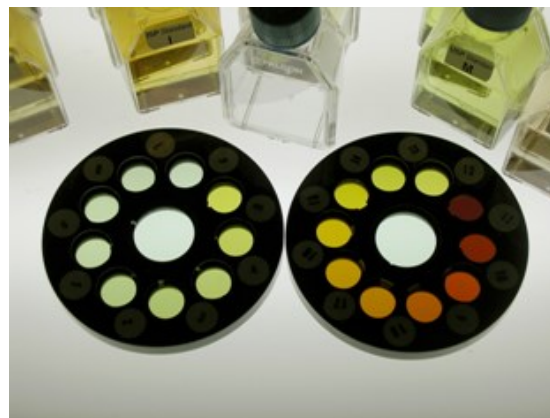
Measuring with Gardner Index

(Used to measure) the color of drying oils, varnishes, fatty acids, polymerized fatty acids and resin solutions.

Abstract

The Gardner Index is a yellowness index. It was originally developed for color specification of resins. Initially, liquid standards of potassium dichromate, ferric chloride and cobaltous chloride, or potassium chloroplatinate were used. These solutions varied in stability and tended to fade with time. Colorimetric values are now used to create glass standards as defined in ASTM Designation D1544, "Standard Test Method for Color of Transparent Liquids (Gardner Color Scale)."

The Gardner Scale is a visual scale [described in ASTM D1544, "Standard Test Method for Color of Transparent Liquids (Gardner Color Scale)"] originally developed in the 1920s to describe the color of drying oils, varnishes, fatty acids, polymerized fatty acids and resin solutions. These liquids are generally a moderately-saturated greenish or reddish-yellow color in the raw form, and get progressively clearer at higher levels of processing. These liquids were replaced with glass standards as defined in ASTM Designation D1544 "Standard Test Method for Color of Transparent Liquids. The eighteen visual Gardner standards are defined by Yxy (C/2°) values (given below). As the standards range from 1 to 18, the color goes from light to dark, increases in dominant yellow saturation, and shifts from a greenish tint to a red tint.



Gardner Color	Y	x	y
1	80	0.3177	0.3303
2	79	0.3233	0.3352
3	76	0.3329	0.3452
4	75	0.3437	0.3644
5	74	0.3558	0.3840
6	71	0.3767	0.4061
7	67	0.4044	0.4352
8	64	0.4207	0.4498
9	61	0.4343	0.4640
10	57	0.4503	0.4760
11	45	0.4842	0.4818
12	36	0.5077	0.4638
13	30	0.5392	0.4458
14	22	0.5646	0.4270
15	16	0.5857	0.4089
16	11	0.6047	0.3921
17	6	0.6290	0.3701
18	4	0.6477	0.3521

With the advent of instrumentation, the visual scales were correlated with colorimetric scales. The first of these colorimetric scales provides a relationship between Gardner Index and CIE Yxy (ASTM D1544). Measurements are taken in transmittance in a 20mm cell.

Gardner Index vs. ASTM D6166

In June 1997, the ASTM D01.34 (Naval Stores) subcommittee approved another instrumental correlation to the visual Gardner Color Scale. This new instrumental Gardner scale is based on a 10-mm path length transmittance measurement and is described in ASTM D6166, Standard Test Method for Color of Naval Stores and Related Products (Instrumental Determination of Gardner Color). This color scale triangulates the chromaticity coordinates and expands the values to include a decimal. This scale is thought to be more robust for off-hue samples.

Both of these scales are widely used today and are implemented in the EasyMatch QC software packages.

Gardner D6166 is calculated as follows:

$$G_{TM} = G_I + G_F$$

Where, G_{TM} = the Gardner color of the test material

G_I = the integer portion of the test material's Gardner color value

G_F = the fractional portion of the Gardner color value.

$$G_F = \frac{(x_{n+1} - x_n)(x_{TM} - x_n) + (y_{n+1} - y_n)(y_{TM} - y_n)}{(x_{n+1} - x_n)^2 + (y_{n+1} - y_n)^2}$$

By comparing the x chromaticity coordinate of the test material with the x chromaticity coordinates for the D1544 visual Gardner Color standards, the integer portion of the Gardner color can be determined using this equation:

$$G_I = G_n, \text{ where } X_n < X_{TM} < X_{n+1}$$

Where G_n = the Gardner color value which is lighter than the test material

X_n = the x chromaticity coordinate of the Gardner color standard which is lighter than the test material

X_{TM} = the x chromaticity coordinate of the test material

X_{n+1} = the x chromaticity coordinate of the Gardner color standard which is darker than the test material.

The fractional portion of the Gardner color is calculated as follows:

Y = the y chromaticity coordinate of the Gardner color standard which is lighter than the test material

Y_{TM} = the y chromaticity coordinate of the test material

Y_{n+1} = the y chromaticity of the Gardner color standard which is darker than the test material

X_n , X_{n+1} , and X_{TM} are as defined above.

The "Gardner-20mm" and "Gardner D6166" indices are both effective for instrumentally measuring the Gardner Color of chromatic yellow liquids, however:

- "Gardner D6166," based on a chromaticity coordinate correlation, is thought to be a more robust correlation method for off-hue samples than the "Gardner-20mm" Yellowness Index correlation.
- The "Gardner D6166" index is defined in an ASTM test method which has wider acceptance than a manufacturer-specific metric like "Gardner-20mm."

Summary

The Gardner D1544 using Chromaticity Coordinates, and D6166 indices are all effective for instrumentally measuring the Gardner Color of chromatic yellow liquids. These methods remove the subjectivity of visual measurements and the problem with reproducibility of making visual standards but still strongly relate to the original visual color scale.

References

Measurement of Color in Resins and Adhesive Systems" by Fred E. Huebner and Harry N. Monck in the September 1992 issue of the *TAPPI Journal*.

About HunterLab

HunterLab is the technology leader in color measurement solutions, providing instruments, software, knowledge and service to a wide variety of industries. With over 5 decades of experience in more than 65 countries, HunterLab applies our leading edge technology to your products helping you measure and communicate color simply and effectively.

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