Designation: ~~D6290 – 18~~ D6290 – 19

Standard Test Method for Color Determination of Plastic Pellets[1]

This standard is issued under the fixed designation D6290; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This test method is used for the instrumental measurement of the degree of yellowness (or change of degree of yellowness) under daylight illumination of homogeneous, nonfluorescent, nearly-colorless transparent or nearly-white translucent or opaque plastics. The measurement is made on pellets and based on tristimulus values obtained with a spectrophotometer or colorimeter.

1.2 This test method is applicable to the color analysis of plastic pellets. It is possible that each material will have unique characteristics that determine the color values.

1.3 This procedure outlines a method to determine color measurements, such as Yellowness Index (YI), CIE X, Y, Z, and Hunter L, a, b, or CIE L*, a*, b*.

1.4 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—This standard and ISO 17223 address the same subject matter but differ in technical content.

1.6 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D883 Terminology Relating to Plastics
D2244 Practice for Calculation of Color Tolerances and Color Differences from Instrumentally Measured Color Coordinates
E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials
E284 Terminology of Appearance
E308 Practice for Computing the Colors of Objects by Using the CIE System
E313 Practice for Calculating Yellowness and Whiteness Indices from Instrumentally Measured Color Coordinates
E456 Terminology Relating to Quality and Statistics
E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
E1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry
E1347 Test Method for Color and Color-Difference Measurement by Tristimulus Colorimetry
E1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional (45°:0° or 0°:45°) Geometry
E2935 Practice for Conducting Equivalence Testing in Laboratory Applications

2.2 *ISO/IEC Standards:*

ISO 17223 Plastics Determination of Yellowness Index and Change in Yellowness Index.
CIE Standard D 001 Colorimetric Illuminants and Observers (Disk) (www.cie.co.at)

3. Terminology

3.1 *Definitions*—Refer to Terminologies D883 and E284 for definitions of terms used in this test method.

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.40 on Optical Properties.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

4. Significance and Use

4.1 Before proceeding with this test method, refer to the specification of the material being tested. Any test specimen preparation, conditioning, dimensions, or testing parameters, or a combination thereof, covered in the materials specification shall take precedence over those mentioned in this test method. If there are no material specifications, then default conditions apply.

NOTE 2—Some materials, such as polyamide (nylon), can be cooled very differently during the production of the pellets. This variation in the cooling of the pellets can result in different levels of crystallinity in the pellets only. More crystalline nylons will be more opaque than amorphous nylons. This will result in differences in pellet opacity. The pellet shape is independent of the crystallinity of the material. This variation in pellet appearance, due to varying levels of crystallinity, does not affect final properties.

NOTE 3—This test method should not be used for general material specifications.

4.2 This test method describes a technique useful for making color comparisons of resins in pellet form that is fast and convenient as it does not require preparation, such as molding or extruding specimens. The test method shall be used only to compare specimens of similar pellet shape, size, texture, and degree of translucency. For example, compare translucent disc-shaped pellets to translucent disc-shaped pellets, not with opaque, rectangular shaped pellets.

4.3 Exact measurements of resin pellet color are not necessarily directly related to the color of the final cast, molded or extruded product due to the multitude of variables, such as producing variables, methods, and pellet shape and size. Color measurements can be useful for comparing resins in pellet form when all samples are similar in shape and size.

4.4 A three-number tristimulus system is necessary to quantify color completely and precisely. The general method used in this procedure measures color using the CIE Systems described in Practice E308, Test Method D2244, the CIE 1976 (X, Y, Z) system, and, the CIELAB 1976 color space.[3]

4.5 Individual components of the tristimulus measurement such as CIE Y (Luminance), Hunter L, a, b, or CIE L*, a*, b* values or other useful metrics like yellowness index in accordance with Practice E313 can be used to describe color attributes of materials.

5. Interferences

5.1 Comparisons of color measurements can only be made if the material is the same, the pellet cut, size and shape are essentially the same and the test instrument is the same type and within the same group. (See 6.2 and Section 10 and Tables A and B for instrument differences.)

6. Apparatus

6.1 Choices of apparatus include spectrophotometers, or tristimulus colorimeters, conforming to Guide E179.

NOTE 4—Most common white light sources used in colorimetric instruments are Tungsten Halogen, Pulsed Xenon, and LEDs.

6.2 There are several different optical geometries currently being used for measuring color. It is important that similar optical geometries be used if results are to be compared. These are designated as Groups defined as follows:

6.2.1 *Group I*—Spectrophotometer with 45 to 52-mm minimum port diameter with 0/45 directional geometry. See Test Methods E1347 and E1349.

6.2.2 *Group II*—Colorimeter with 31 to 52-mm minimum port diameter with 45/0 directional geometry. See Test Methods E1347 and E1349.

6.2.3 *Group III*—Sphere with minimum of 25-mm minimum port diameter with a nominal 0/diffuse geometry, measuring in the specular excluded mode. See Test Methods E1331 and E1347.

6.2.4 *Group IV*—Sphere with minimum of 25-mm minimum port diameter with a nominal diffuse/0 geometry, measuring in the specular excluded mode. See Test Methods E1331 and E1347.

6.3 If other optical geometries are used for this test method, they need to be added to the standard.

6.4 *Calibrated tiles,* for instrument standardization.

6.5 *Sample Cup—Clear Glass,* a minimum of 50-mm depth.

NOTE 5—The clear glass sample cup may be any shape that is larger than the port.

6.6 ~~*Black Sample*~~ *Cover* ~~of sufficient size to prevent external light from affecting the pellet measurement.~~an opaque, light exclusion device or cover.

7. Procedure

7.1 Standardize the instrument in accordance with the manufacturer's recommendations.

7.2 Fill the sample cup to the top with pellets.

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[3] CIE Publication 015:2004 (Third Edition): Colorimetry. Currently available through the U.S. National Committee of the CIE (cie-usnc.org) or the CIE website (http://www.techstreet.com/cie). Also, ANSI, New York, NY, USA, www.ansi.org.

7.3 Center the pellet filled sample cup at the sensor port for measurement. Use a centering device if one is provided by the manufacturer.

7.4 Cover the sample cup with an opaque, light exclusion device or cover.

7.5 For Yellowness Index measurement of plastic pellets, make the necessary readings in CIE X, Y, Z tristimulus values and calculate Yellowness Index in accordance with Practice E313 using one of the following illuminant/observer combinations:

7.5.1 CIE "Illuminant C" and 1931 2° Standard Observer.

7.5.2 CIE "Illuminant D_{65}" and 1964 10° Standard Observer

NOTE 6—Care must be taken not to allow the pellet sample to remain at the measurement port for a long period of time prior to measurement. Light exposure of high intensity may cause yellowness to change, thus altering the test value.

NOTE 7—Many instruments will report the Yellowness Index in accordance with Practice E313 directly thus no calculations are required for individual Yellowness Index, YI, value.

NOTE 8—For other measurements, such as CIE X, Y, Z, Hunter L, a, b, or CIE L*, a*, b*, make the necessary instrument settings and take the readings.

7.6 Repeat steps 7.2 through 7.5.2 two more times for a total of three results. Use 'dump-and-fill' with fresh pellets for each measurement.

NOTE 9—If there are not enough fresh pellets for three measurements, then it is recommended dumping the pellets and refilling the cup with the same pellets for each measurement.

8. Calculation

8.1 Determine the average yellowness index, YI, if requested, using the following formula:

$$YI = 100\left(C_x X - C_z Z\right)/Y \tag{1}$$

where:

YI = Yellowness Index,
X, Y, Z = The measured tristimulus values of the specimen calculated for either Illuminant C or D_{65}, and either the CIE 1931 standard colorimetric observer (2°) or the CIE 1964 standard colorimetric observer (10°) and coefficients C_x and C_z as selected below.

For C, CIE 1931 stnadard colorimetric observer (2°):

C_x = 1.2769 and
C_z = 1.0592.

Or

For D_{65}, CIE 1964 standard colorimetric observer (10°):

C_x = 1.3013 and
C_z = 1.1498.

9. Report

9.1 Report the following information:

9.1.1 Average of the Yellowness Index or other measurements if noted,

9.1.2 Sample identification, such as lot number, source, etc.,

9.1.3 Date test was conducted,

9.1.4 The instrument group port diameter, illuminant/observer combination, and

9.1.5 The instrument used including name of manufacturer, model, and serial number.

10. Precision and Bias[4]

10.1 *Precision:*

10.1.1 Table 1 reflects data tested with ten instruments in Group I, and Table 2with six instruments in Group II. All data are based on a round robin conducted in 1994-1995 in accordance with Practice E691, involving eight materials tested with six test results measured on three days by each laboratory. For each material, pellets were gathered and packaged by one source and the individual packages were sent to each of the laboratories which tested them. Each test result is the value of an individual determination. Each laboratory obtained six test results for each materials. Table 1A and Table 2B reflect the values as if each test value consisted of an average of three readings. (**Warning—**The following explanations of *r* and *R* (10.1.2 through 10.1.4) only are intended to present a meaningful way of considering approximate precision of this test method. It is not appropriate to rigorously apply the data in Table 1, Table 2, Table 1A, and Table 2A to acceptance or rejection of material, as those data are specific to the round robin and are not necessarily representative of other lots, conditions, materials, or laboratories. Users of this

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D20-1235.

TABLE 1 Yellowness Index of Pellets

Material	Apparatus Group I				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–3.99	0.206	0.495	0.576	1.385
Material B	–0.33	0.130	0.424	0.363	1.188
Material F	–0.133	0.113	0.524	0.317	1.467
Material H	0.538	0.076	0.443	0.214	1.241
Material C	1.539	0.095	0.398	0.267	1.116
Material E	8.82	0.376	1.840	1.052	5.153
Material A	15.8	0.365	0.877	1.023	2.455
Material D	24.6	0.139	0.860	0.390	2.409

TABLE 1A Yellowness Index of Pellets

Material	Estimate for Three Specimens (Apparatus Group I)				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–3.99	0.092	0.459	0.258	1.286
Material B	–0.33	0.058	0.408	0.162	1.143
Material F	–0.133	0.051	0.514	0.142	1.439
Material H	0.538	0.034	0.438	0.096	1.226
Material C	1.539	0.043	0.389	0.119	1.090
Material E	8.82	0.168	1.809	0.470	5.067
Material A	15.8	0.163	0.813	0.458	2.278
Material D	24.6	0.062	0.851	0.174	2.383

[A] S_r is the within-laboratory standard deviation or the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories:

$$S_r = [[(s_1)^2 + (s_2)^2 - - - + (s_n)^2]/n]^{1/2}$$

[B] S_R is the between-laboratories reproducibility, expressed as standard deviation:

$$S_R = [S_r^2 + S_L^2]^{1/2}$$

where: S_L is the standard deviation of laboratory means.

[C] r is the within-laboratory critical interval between two test results = 2.8 × S_r.

[D] R is the between-laboratories critical interval between two test results = 2.8 × S_R.

TABLE 2 Yellowness Index of Pellets

Material	Apparatus Group II				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–5.32	0.361	1.01	1.01	2.82
Material F	–1.85	0.177	0.838	0.495	2.35
Material H	–1.64	0.138	0.512	0.387	1.43
Material B	–1.61	0.152	0.646	0.425	1.81
Material C	–0.126	0.220	0.507	0.617	1.42
Material E	7.21	0.289	2.20	0.810	6.15
Material A	13.3	0.352	2.01	0.986	5.63
Material D	20.6	0.167	1.45	0.468	4.07

TABLE 2A Yellowness Index of Pellets

Material	Estimate for Three Specimens (Apparatus Group II)				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–5.32	0.161	0.908	0.452	2.54
Material F	–1.85	0.079	0.823	0.173	2.31
Material H	–1.64	0.062	0.497	0.173	1.39
Material B	–1.61	0.068	0.632	0.190	1.77
Material C	–0.126	0.098	0.467	0.276	1.31
Material E	7.21	0.129	2.18	0.362	6.11
Material A	13.3	0.158	1.98	0.441	5.56
Material D	20.6	0.075	1.44	0.209	4.05

[A] S_r is the within-laboratory standard deviation or the indicated material. It is obtained by pooling the within-laboratory standard deviations of the test results from all of the participating laboratories:

$$S_r = [[(s_1)^2 + (s_2)^2 - - - + (s_n)^2]/n]^{1/2}$$

[B] S_R is the between-laboratories reproducibility, expressed as standard deviation:

$$S_R = [S_r^2 + S_L^2]^{1/2}$$

where: S_L is the standard deviation of laboratory means.

[C] r is the within-laboratory critical interval between two test results = 2.8 × S_r.

[D] R is the between-laboratories critical interval between two test results = 2.8 × S_R.

test method need to apply the principles outlined in Practice E691 to generate data specific to their laboratory and materials or between specific laboratories. The principles of 10.1.2 through 10.1.4 then would be valid for such data.)