Designation: D 6290 – 98[ε1]

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

This standard is issued under the fixed designation D 6290; 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.

ε[1] NOTE—Appendix X2 was corrected editorially in November 2000.

1. Scope

1.1 This test method is intended primarily 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. Each material may have unique characteristics that determine the color values.

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

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There is no equivalent ISO Standard.

2. Referenced Documents

2.1 *ASTM Standards:*

D 883 Terminology Relating to Plastics[2]

D 2244 Test Method for Calculation of Color Differences from Instrumentally Measured Color Coordinates[3]

E 179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials[3]

E 284 Terminology of Appearance[3]

E 308 Practice for Computing the Colors of Objects by Using the CIE System[3]

E 313 Test Method for Indexes of Whiteness and Yellowness of Near-White Opaque Materials[3]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E 805 Practice for Identification of Instrumental Methods of Color or Color-Difference Measurements of Materials[3]

E 1164 Practice of Obtaining Spectrophotometric Data for Object-Color Evaluation[3]

E 1331 Test Method for Reflectance Factor and Color by Spectrophotometry Using Hemispherical Geometry[3]

E 1347 Test Method for Color and Color-Difference Measurement by Tristimulus (Filter) Colorimetry[3]

E 1349 Test Method for Reflectance Factor and Color by Spectrophotometry Using Bidirectional Geometry[3,4]

3. Terminology

3.1 *Definitions*— Refer to Terminologies D 883 and E 284 for definitions of terms used in this test method.

4. Significance and Use

4.1 Before proceeding with this test method, reference should be made 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, translucent disc-shaped pellets should be compared to translucent disc-shaped pellets, not with opaque, rectangular shaped pellets.

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[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.

Current edition approved July 10, 1998. Published February 1999.

[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 06.01.

[4] *Annual Book of ASTM Standards*, Vol 14.02.

4.3 Exact measurements of resin pellet color may not be 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 E 308, Test Method D 2244, the CIE 1976 (X, Y, Z) system, and, the CIELAB 1976 color space.[5]

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 can be used to describe color attributes of materials. This test method describes a standard procedure on how these measurements are made.

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 Sections 6.2 and 10 and Tables A and B for instrument differences.)

6. Apparatus

6.1 Apparatus may be spectrophotometer, or tristimulus colorimeter, conforming to Guide E 179.

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 port with 0/45 directional geometry. See Test Methods E 1347 and E 1349.

6.2.2 *Group II*—Colorimeter with 52-mm port with 45/0 directional geometry. See Test Methods E 1347 and E 1349.

6.2.3 *Group III*—Sphere with minimum of 25-mm port with a nominal 0/diffuse geometry. See Test Methods E 1331 and E 1347.

6.2.4 *Group IV*—Sphere with minimum of 25-mm port with a nominal diffuse/0 geometry. See Test Methods E 1331 and E 1347.

6.3 There may be other optical geometries being used for this test method, which should be added if being used and brought to our attention as this procedure is being evaluated.

6.4 *Calibrated tiles*, for instrument standardization.

6.5 *Glass (clear)*, specimen cell at least 60-mm (2 ½-in.) diameter and a minimum of 50-mm depth and black sample cover of sufficient size to prevent external light from affecting the pellet measurement.

NOTE 4—The clear sample holder may be any shape that is larger than the port with at least 6-mm between the edge of the port and the edge of the sample holder.

7. Procedure

7.1 Standardize the instrument in accordance with the manufacturer's written instructions (usually once per shift).

7.2 Fill the sample cup to the top with pellets.

7.3 Center the pellet filled 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 make, the necessary readings of Tristimulus X, Y, Z to determine Yellowness Index as described in Test Method E 313 as soon as possible using illuminant" C", specular excluded, and CIE 1931 2° observer.

NOTE 5—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 6—Many instruments will report the Yellowness Index in accordance with Test Method E 313 directly thus no calculations are required for individual Yellowness Index value.

7.5.1 For other measurements, such as 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 7.6 two more times for a total of three results.

8. Calculation

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

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

where:
C_x = 1.2769, and
C_z = 1.0592.

8.2 Determine the average yellowness index by summing the test values and divide by the number of samples tested.

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 and etc.,

9.1.3 Date test was conducted,

9.1.4 The instrument group or geometry, and

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

10. Precision and Bias

10.1 *Precision*:

10.1.1 Table 1 reflects data tested with ten instruments in Group 1, and Table 2 with six instruments in Group 2. All data are based on a round robin conducted in 1994–1995 in accordance with Practice E 691, 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

[5] Based upon the *Colorimetry, 2nd ed.*, Publication CIE No. 15.2, Central Bureau of the CIE, Vienna, 1986. Currently available through the U.S. National Committee of the CIE, % Mr. Thomas Lemmons, TLA Lighting Consultants, Inc., 7 Pond St., Salem, MA 01970–4819.

TABLE 1 Yellowness Index of Pellets

Material	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 (Group 1)				
	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	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 (Group 2)				
	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.

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.

NOTE 7—**Caution:** The following explanations of *r* and *R* (10.2 through 10.2.3) only are intended to present a meaningful way of considering approximate precision of this test method. The data in Table 1, Table 2, Table 1A, and Table 2A should not be applied rigorously to acceptance or rejection of material, as those data are specific to the round robin and may not be representative of other lots, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their laboratory and materials or between specific laboratories. The principles of 10.2 through 10.2.3 then would be valid for such data.

10.1.2 *Concept of r and R*—If S_r and S_R have been calculated from a large enough body of data and for test results that are the result of testing one specimen:

10.1.3 *Repeatability Limit, r (Comparing two test results for the same material, obtained by the same operator using the same equipment on the same day)*—The two test results should be judged not equivalent if they differ by more than the *r* value for that material.

10.1.4 *Reproducibility Limit, R (Comparing two test results for the same material, obtained by different operators using different equipment in different laboratories)*—The two test results should be judged not equivalent if they differ by more than the *R* value for that material.

10.1.5 Any judgment in accordance with 10.1.1 or 10.1.2 would have an approximate 95 % (0.95) probability of being correct.

10.2 *Bias*—There are no recognized standards by which to estimate bias of this test method.

11. Keywords

11.1 color; pellets; plastics; yellowness; yellowness index

TABLE 3 Yellowness Index of Pellets

Material	All Groups				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–4.69	1.04	1.45	2.92	4.05
Material F	–1.61	1.06	1.91	2.96	5.36
Material B	–0.979	0.504	1.03	1.41	2.88
Material H	0.014	4.13	4.13	11.6	11.6
Material C	2.08	5.77	5.77	16.2	16.2
Material E	6.51	2.45	3.77	6.87	10.6
Material A	12.7	3.78	4.87	10.6	13.6
Material D	20.7	3.94	5.50	11.0	15.4

TABLE 3A Yellowness Index of Pellets

Material	Estimate for Three Specimens—All Instruments				
	Average	S_r[A]	S_R[B]	r[C]	R[D]
Material G	–4.69	0.466	1.11	1.30	3.10
Material F	–1.61	0.473	1.66	1.33	4.66
Material B	–0.979	0.226	0.925	0.632	2.59
Material H	0.014	1.85	1.85	5.17	5.17
Material C	2.08	2.58	2.58	7.23	7.23
Material E	6.51	1.10	3.07	3.07	8.60
Material A	12.7	1.69	3.50	4.73	9.81
Material D	20.7	1.76	4.23	4.93	4.23

[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.

ANNEX

(Mandatory Information)

A1. RR PRODUCTS IDENTIFICATION

A1.1 Identify RR Products as follows:

A1.1.1 *A*—PP Random
A1.1.2 *B*—PP Random
A1.1.3 *C*—PP Impact
A1.1.4 *D*—PP Impact
A1.1.5 *E*—PP Homopolymer
A1.1.6 *F*—LDPE
A1.1.7 *G*—EVA Copolymer
A1.1.8 *H*—HDPE

APPENDIXES

(Nonmandatory Information)

X1. Additional Instrument Information

X1.1 As discussed in this test method, there as many instruments with different geometries being used to make the measurements described herein. Different instruments give different values so comparison of data only can be done when similar instruments are used. For example, compare the average values in Table 1 to those in Table 2. Further Table 3 is what the precision and bias statement would be if all the data obtained in the round robin is used regardless of which group the instrument is in. Its pretty evident that the spread is very large.

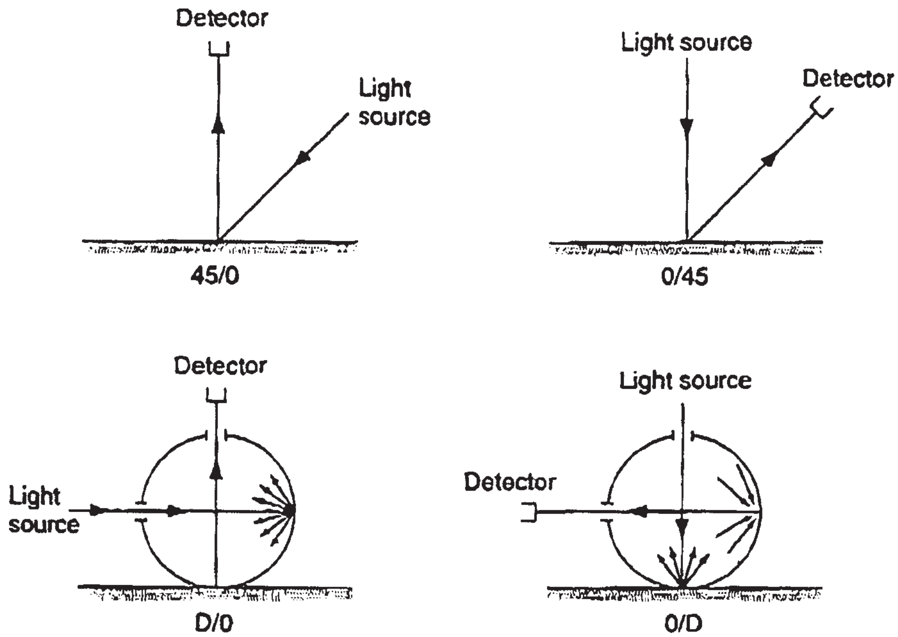

FIG. X1.1 CIE Recommended Illuminating and Viewing Geometries

X2. Group Identification

X2.1 *Group I*—Spectrophotometers with 45 to 52-mm port and 0/45 circumferential geometry.

X2.2 *Group II*—Colorimeter with 52-mm port and 45/0 bidirectional.

X2.3 *Group III*—Sphere with 25-mm port with 0/diffuse geometry.

X2.4 *Group IV*—Sphere with 25-mm port with diffuse/0 geometry.