Designation: D5386 – 16

Standard Test Method for Color of Liquids Using Tristimulus Colorimetry[1]

This standard is issued under the fixed designation D5386; 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 covers an instrumental method for the CIE (Commission International de l'Eclairage) tristimulus measurement of the color of near-clear liquid samples. The transmission measurement values are converted to the color scale in the platinum-cobalt (Pt-Co) system.

1.2 This test method has been found applicable to the color measurement of clear, liquid samples, free of haze, with nominal Pt-Co color values in the 0 to 100 range. It is applicable to non-fluorescent liquids with light absorption characteristics similar to those of the Pt-Co color standard solutions.

1.3 The tristimulus colorimetry may be calculated from spectral measurements or be obtained directly from a colorimeter. Practice E1455 provides some guidance on colorimeters, while Test Methods D1686 and D2108 deal with the visual and instrumental measurement of near-clear liquids.

1.4 In determining the conformance of the test results using this method to applicable specifications, results shall be rounded in accordance with the rounding off methods of Practice E29.

1.5 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.6 *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. For specific hazard statements, see Section 8.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1193 Specification for Reagent Water

D1686 Test Method for Color of Solid Aromatic Hydrocarbons and Related Materials in the Molten State (Platinum-Cobalt Scale)

D2108 Test Method for Color of Halogenated Organic Solvents and Their Admixtures (Platinum-Cobalt Scale)

D3437 Practice for Sampling and Handling Liquid Cyclic Products

D6809 Guide for Quality Control and Quality Assurance Procedures for Aromatic Hydrocarbons and Related Materials

D8005 Test Method for Color of Clear Liquids (Platinum-Cobalt Scale)

E29 Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

E179 Guide for Selection of Geometric Conditions for Measurement of Reflection and Transmission Properties of Materials

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

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

E1455 Practice for Obtaining Colorimetric Data from a Visual Display Unit Using Tristimulus Colorimeters

2.2 *Other Document:*

OSHA Regulations, 29 CFR paragraphs 1910.1000 and 1910.1200[3]

3. Summary of Test Method

3.1 The color of a liquid sample is measured as the difference between the tristimulus values for the light transmitted through the sample minus the tristimulus values for the

[1] This test method is under the jurisdiction of ASTM Committee D16 on Aromatic Hydrocarbons and Related Chemicals and is the direct responsibility of Subcommittee D16.04 on Instrumental Analysis.

Current edition approved Dec. 1, 2016. Published January 2017. Originally approved in 1993. Last previous edition approved in 2010 as D5386 – 10. DOI: 10.1520/D5386-16.

[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.

[3] Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, http://www.access.gpo.gov.

light transmitted through the same path length of water (Specification D1193, Type IV). The difference between the tristimulus values are used to calculate the color on the Pt-Co scale using the appropriate equations.

4. Significance and Use

4.1 The primary objective of the visual method of Pt-Co color measurement, as defined in Test Method D8005, is to rate specific materials for yellowness. This yellowness is frequently the result of the undesirable tendency of liquid hydrocarbons to absorb blue light due to contamination in processing, storage or shipping.

4.2 Clear liquids can be rated for light absorbing yellowish or brownish contaminants using scales that simulate the long-established visual-comparison method.

5. Apparatus

5.1 *Instrument*, with the following provisions:

5.1.1 *Instrument Sensor,* shall measure the light transmitted through a liquid sample in a cell as described in Guide E179. The instrument shall be capable of converting the measurement to CIE X Y Z tristimulus values for CIE illuminant C and the CIE 1931 2-degree standard observer as described in Practice E308.

5.1.2 The difference between the tristimulus color values for the sample and water shall be converted to the instrumental yellowness index (YI) defined by Practice E313. A correlation between measured YI values and the Pt-Co color standard solutions shall be used to yield an equivalent instrumental Pt-Co rating for liquid hydrocarbon samples.

5.2 *Sample Cells,* shall have clear, colorless, parallel entrance and exit windows. The internal distance between the faces shall be user selectable. Path lengths from 20 to 150 mm have been used for near-clear liquid hydrocarbon samples. When measuring samples using cells of the same path length, a path length tolerance of ±3 % or less would be appropriate. Matched cells are preferred but not required.

6. Reagents

6.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[4] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—References to water shall be understood to mean clear, colorless water, conforming to Type IV of Specification D1193.

6.3 *Cobalt Chloride,* ($CoCl_2 \cdot 6H_2O$).

6.4 *Hydrochloric Acid (sp gr 1.19)*—Concentrated hydrochloric acid (HCl).

6.5 *Potassium Chloroplatinate,* (K_2PtCl_6).

6.6 *Platinum-Cobalt Stock Solution*—Dissolve 1.245 g of potassium chloroplatinate (K_2PtCl_6) and 1.00 g of cobalt chloride ($CoCl_2 \cdot H_2O$) in water. Carefully add 100 mL of hydrochloric acid (HCl) and dilute to 1 L with water. The absorbance measured for the number 500 Pt-Co stock solution in a cell having a 10-mm path length, using a cell of the same path length containing water as the reference solution, must fall within the limits given in Table 1.

TABLE 1 Absorbance Tolerance Limits for Number 500 Platinum-Cobalt Stock Solution

Wavelength	Absorbance
430	0.110 to 0.120
455	0.130 to 0.145
480	0.105 to 0.120
510	0.055 to 0.065

7. Materials

7.1 *Platinum-Cobalt Standards*—From the Pt-Co stock solution, prepare color standards in accordance with Table 2 by diluting the required volumes to 100 mL with water in volumetric flasks. Pt-Co color standards with higher values can be prepared by using proportionally greater volumes of the stock solution. When properly sealed and stored these standards are stable for at least one year. Pt-Co color standards may also be purchased.

TABLE 2 Platinum-Cobalt Color Standards

Color Standard Number	Stock Solution, mL	Color Standard Number	Stock Solution mL
1	0.20	10	2.00
2	0.40	11	2.20
3	0.60	12	2.40
4	0.80	13	2.60
5	1.00	14	2.80
6	1.20	15	3.00
7	1.40	20	4.00
8	1.60	25	5.00
9	1.80	30	6.00

8. Hazards

8.1 Consult current OSHA regulations, suppliers' Safety Data Sheets, and local regulations for all materials used in this test method.

9. Sampling and Handling

9.1 Refer to Practice D3437 for proper sampling and handling of liquid hydrocarbon samples analyzed by this test method.

10. Calibration

10.1 Setup the instrument for operation by following the manufacturer's instructions. This should include setting operating parameters such as the path length of the sample cells to be used.

[4] *Reagent Chemicals, American Chemical Society Specifications*, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals,* BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary,* U.S. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

10.2 Standardize the instrument using a cell of the selected path length containing water as the sample.

10.3 Measure another sample of water in a cell of the selected path length to verify that the instrument produces a Pt-Co reading of 0.

10.4 Measure several Pt-Co color standards from Table 2 that span the expected color range of the liquid samples in a cell of the selected path length to verify the instrument produces the correct Pt-Co readings.

NOTE 1—Some instrument manufacturers may provide instructions on adjusting the instrument calibration to produce the correct Pt-Co readings.

11. Procedure

11.1 Verify that the instrument has been setup, standardized and is operating in accordance with the manufacturer's instructions.

11.2 Measure the liquid samples in a cell of the selected path length. Perform three (3) measurements without replacing the sample.

11.3 Calculate the average taken from the three measurements to be the Pt-Co reading for the sample.

11.4 Exercise care to avoid sample contamination.

12. Report

12.1 Report the following information:

12.1.1 Sample identification, and

12.1.2 Pt-Co reading for the sample rounded to the nearest whole number.

13. Precision and Bias[5]

13.1 *Precision*—Instrument correlations to the Pt-Co color scale are based on measuring the corresponding YI of Pt-Co color standards as defined in Test Method D8005. However, liquid samples often exhibit a slight green or red hue, scattering haze, or both, relative to the Pt-Co color standards. This can result in instruments of different models and manufactures reading nearly identical values for Pt-Co color standards but not for liquid samples. This precision statement accommodates all of the expected variables in instrumental Pt-Co color measurements of liquid samples and Pt-Co color standards in the 0 to 100 range.

13.1.1 A higher precision than is listed below may be achieved by using the same measurement method and instrument model, or both. A higher precision may also be achieved by measuring samples that are optically clear and are near identical in YI to the Pt-Co color standards.

13.1.2 The data for determining the precision of this test method are from an interlaboratory study using *o*-xylene, styrene, and toluene samples at approximate values of 2, 12, 17, 63, and 127 respectively. Pt-Co color standards at levels of approximately 0, 10, 254 and 498 were also used. Nineteen (19) laboratories participated in this study using instruments with all of the major transmission geometries (0:t, 8:t and 0:0) and using sample cells of different path lengths (10, 20, 33, 50 and 100 mm). Each of the samples was run on three different days in each laboratory.

13.2 Under the guidelines of Practice E691, the following criteria should be used to judge the acceptability (95 % probability) of results obtained by this test method.

13.2.1 *Intermediate Precision to Pt-Co 100 Level*—Based on an intermediate precision standard deviation of 0.44 + (0.0057 * Pt-Co reading), two test results obtained from two samples of the same material in the same laboratory by the same operator and on the same instruments in a short period of time should not differ by more than 1.23 + (0.0161 * Pt-Co reading).

Y = m X + b Y = Intermediate precision X = Platinum Cobalt Reading
b = y-intercept m = slope

Y = 0.0057 X +0.44 ← Intermediate precision SD
r = 0.0161 X +1.23 ← Intermediate precision at 95 % confidence level

13.2.2 *Reproducibility to Pt-Co 100 Level*—Based on a reproducibility standard deviation of 1.64 + (0.0552 * Pt-Co reading), two test results from samples of the same material from different laboratories should not differ by more than 4.60 + (0.1546 * Pt-Co reading).

Y = m X + b Y = Reproducibility X = Platinum Cobalt Reading
b = y-intercept m = slope

Y = 0.0552 X +1.64 ← Reproducibility SD
R = 0.1546 X +4.60 ← Reproducibility at 95 % confidence level

13.3 *Bias*—The bias of this test method cannot be determined because no referee method is available to determine the true value.

14. Quality Guidelines

14.1 Laboratories shall have a quality control system in place.

14.1.1 Confirm the performance of the test instrument or test method by analyzing a quality control sample following the guidelines of standard statistical quality control practices.

14.1.2 A quality control sample is a stable material isolated from the production process and representative of the sample being analyzed.

14.1.3 When QA/QC protocols are already established in the testing facility, these protocols are acceptable when they confirm the validity of test results.

14.1.4 When there are no QA/QC protocols established in the testing facility, use the guidelines described in Guide D6809 or similar statistical quality control practices.

15. Keywords

15.1 APHA; Hazen; hydrocarbons; instrumental color measurement; Pt-Co; platinum-cobalt; tristimulus

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR: RR:D16-1012. Contact ASTM Customer Service at service@astm.org.