



Designation: D1218-99

An American National Standard Designation: ~~D1218-99~~ (Reapproved 2007)

# Standard Test Method for Refractive Index and Refractive Dispersion of Hydrocarbon Liquids<sup>1</sup>

This standard is issued under the fixed designation D 1218; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope <sup>\*</sup>

~~1.1 This test method covers the measurement of refractive indexes, accurate to six units in the fifth decimal place, and refractive dispersions, accurate to twelve units in the fifth decimal place, of transparent and light-colored hydrocarbon liquids that have refractive indexes in the range from 1.33 to 1.50, and at temperatures from 20 to 30°C. The test method is not applicable within the accuracy stated to liquids having colors darker than No. 4 ASTM Color as determined by Test Method D1500, to liquids having bubble points so near the test temperature that a reading cannot be obtained before substantial weathering takes place, to liquids having a refractive index above 1.50, or to measurements made at temperatures above 30°C.~~

1.1 This test method covers the measurement of refractive index, accurate to four decimal places or better, of transparent and light-colored hydrocarbons in the range of 1.3300 to 1.5000 at temperatures from 20 to 30°C by manual (optical-mechanical) or automatic (digital) procedure.

1.2 The manual (optical-mechanical) procedure also covers the measurement of refractive dispersion accurate to the fourth decimal place or better.

~~NOTE 1—The instrument can be successfully used for refractive indexes above 1.50 and at temperatures both below 20°C and above 30°C. As yet, certified liquid standards for the ranges above a refractive index of 1.50 are not available, so the precision and accuracy of the instrument under these conditions have not been evaluated. Similarly, certified refractive indexes of liquids at temperatures other than the 20 to 30°C range are not available, although the instrument can be used up to 50°C.~~

1.2.1—The test method may be suitable for measuring the refractive indices of liquids above 1.5000 and at temperatures both below 20°C and above 30°C; however, the test method precision may not apply. Verification of the accuracy of such measurements will depend upon the availability of reliable, certified reference standards that demonstrate the performance of the instrument used under the particular measuring conditions.

1.3 The test method may not be applicable to liquids that are strongly colored, or that have bubble points so near the test temperature that a reading cannot be obtained before substantial weathering takes place. Liquid color should be limited to No. 4 ASTM Color or lighter, as determined by Test Method D 1500.

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.

## 2. Referenced Documents

### 2.1 ASTM Standards: <sup>2</sup>

~~D 841 Specification for Nitration Grade Toluene~~ 1193 Specification for Reagent Water

~~D 1500 Test Method for ASTM Color of Petroleum Products (ASTM Color Scale)~~

~~D 6299 Practice for Applying Statistical Quality Assurance Techniques to Evaluate Analytical Measurement System Performance~~

~~D 6300 Practice for Determination of Precision and Bias Data for Use in Test Methods for Petroleum Products and Lubricants~~

~~E 1 Specification for ASTM Thermometers~~ Specification for ASTM Liquid-in-Glass Thermometers

### 2.2 ASTM Adjuncts:

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D-2 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.04 on Hydrocarbon Analysis.

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<sup>2</sup> This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.04.0D on Physical and Chemical Methods.

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<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto: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.

### 3. Terminology

#### 3.1 Definitions:

3.1.1 *refractive index*—the ratio of the velocity of light (of specified wavelength) in air, to its velocity in the substance under examination. It may also be defined as the sine of the angle of incidence divided by the sine of the angle of refraction, as light passes from air into the substance. This is the relative index of refraction. If absolute refractive index (that is, referred to vacuum) is desired, this value should be multiplied by the factor 1.00027, the absolute refractive index of air. The numerical value of refractive index of liquids varies inversely with both wavelength and temperature.

3.1.2 *refractive dispersion*—the difference between the refractive indexes of a substance for light of two different wavelengths, both indexes being measured at the same temperature. For convenience in calculations, the value of the difference thus obtained is usually multiplied by 10 000.

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### 4. Summary of Test Method

4.1 The refractive index is measured by the critical angle method with a Bausch & Lomb Precision Refractometer (or other instruments of equivalent or superior performance), using monochromatic light. The instrument is previously adjusted by means of a solid reference standard and the observed values are corrected, when necessary, by a calibration obtained with certified liquid standards.

4.1 The refractive index is measured using a high-resolution refractometer of an optical-mechanical or automatic digital type with the prism temperature accurately controlled. The instrument principle is based on the critical angle concept.

### 5. Significance and Use

5.1 Refractive index and refractive dispersion are fundamental physical properties that properties, which can be used in conjunction with other properties to characterize pure hydrocarbons and their mixtures.

## PROCEDURE A—MANUAL (OPTICAL-MECHANICAL) PROCEDURE

### 6. Apparatus

6.1 *Refractometer*, Bausch & Lomb, “Precision” type, range 1.33 to 1.64 for the sodium *D* line. Other instruments of equivalent or superior performance, such as automatic refractometers, shall meet the precision section requirements as minimum criteria. <sup>2</sup> high-resolution optical-mechanical refractometer of the “Abbe” type with suitable measuring range (1.3300 to 1.5000 or higher) and an accuracy/resolution of 0.0001 or better refractive index.

NOTE2—When other instruments are used, follow the manufacturer’s instruction for operation and maintenance. Section 12 shall strictly be adhered to on any instrument used, except that Sections 11 and 13 may be substituted with the appropriate manufacturer’s instructions.

6.2 *Thermostat and Circulating Pump*, capable of maintaining the indicated prism temperature constant within 0.02°C of the desired test temperature. The thermostating liquid should pass the thermometer on leaving, not on entering, the prism assembly.

NOTE3—In the Bausch & Lomb refractometer, the thermostating liquid shall pass the thermometer on leaving, not on entering the prism assembly.

6.3 *Thermometer*—ASTM Saybolt Viscosity Thermometer 17C having a range from 19 to 27°C, and conforming to the requirements of Specification E1. The thermometer shall be used in an approved holder, as shown in Fig. 1, such that almost total immersion (not more than emergent stem) is obtained, and reading to 0.01°C is possible.

NOTE4—Other temperature sensing devices, such as thermocouples, that can provide equivalent or better temperature control may be used in place of the thermometer specified in 6.3.

6.4 <sup>2</sup> Prior to 2001, Test Method D 1218 was based on a Bausch & Lomb Refractometer. However, this instrument is no longer manufactured. Currently available manual refractometers are of the “Abbe” type (critical angle refractometers, see X1.2.3). There is a variety of refractometers that have been found to be suitable for this measurement. Some instruments offer a wider measuring range but it is important to verify the uniformity of accuracy across the entire measuring range and to ensure suitable calibration materials are available for this verification.

<sup>2</sup> Annual Book of ASTM Standards, Vol 05.01.

<sup>3</sup> Available from ASTM International Headquarters. Order No. ADJD6300. (Originally published as Lawrey, D. M. G., ed., *Calculation of Precision Data: Petroleum Test Methods*, ASTM International, 1996.)

6.2 Temperature Control Unit, either an external liquid bath with both heating and cooling capability and pump for maintaining the indicated prism temperature within 0.1°C, or an internal electronic temperature control system (such as Peltier system). If an external bath is used, the thermostating liquid shall pass the temperature measuring device on leaving, not on entering the prism. The temperature control unit (external or internal) shall have the following control specification:

Stability	± 0.1°C
Uniformity	± 0.1°C
Display Resolution	0.1°C or better

6.3 Temperature Measuring Device, for those apparatus employing mercury in glass thermometer, ASTM Thermometer 17C having a range from 19 to 27°C, and conforming to the requirements of Specification E 1. For apparatus using non-mercury in glass thermometer, a platinum resistance probe, thermocouple, or equivalent temperature sensors are acceptable.

6.4 Light Sources—The following light sources have been found satisfactory:—The following type of light source can be used in conjunction with an optical-mechanical (Abbe type) refractometer:

6.4.1 Sodium Arc Lamp—The Unitized “Sodium Lab Arc” is furnished with the instrument., Na<sub>D</sub> line at 589 nm.

6.4.2 Mercury Arc Lamp—The H-4 type capillary mercury arc is furnished as an accessory to the refractometer.

6.4.3 Hydrogen Discharge Lamp—Any type of lamp capable of producing light having an intensity of at least 32 lx (3 footcandles) on an area of 1 cm<sup>2</sup> on the entrance face of the illuminating prism. The luminous intensity may be conveniently measured by means of a photographic light meter held 254 mm (10 in.) from the lamp and perpendicular to the light beam. For convenience, the lamp should be mounted on an extension of the sodium lamp support., Hg<sub>c</sub> line at 546 nm or Hg<sub>g</sub> line at 436 nm.

6.4.3 Cadmium Arc Lamp, Cd<sub>c</sub> line at 644 nm.

6.4.4 Other Sources—Helium may be used in place of hydrogen in the lamp discussed in 6.4.3 Mercury-Cadmium Arc Lamp.

6.4.5 Light Filters—For isolating the various spectral lines from the above sources, special light filters are required. The following are tentatively recommended:

Wave length, Å	Spectral Line	Filter
6678	—Helium	Goring No. 2404
6563	—H <sub>c</sub>	None required. May use Goring No. 2404.
5893	—Na <sub>D</sub>	None required
5464	—Hg <sub>c</sub>	Wratten No. 62, or No. 77A, Goring Nos. 3486+4303+5120
5016	—Helium	Wratten No. 45
4864	—H <sub>F</sub>	Goring Nos. 5030+3387, 4303, or Wratten No. 45
4358	—Hg <sub>g</sub>	Goring Nos. 5113, 3389+5850.

Helium Discharge Lamp.

NOTE 5—In determinations of refractive indexes above approximately 1.53 (wherever the short wavelengths show a higher scale reading than the long), this system of filters is rendered worthless, and filters must be chosen that remove all spectral lines of shorter wavelength than the one being read. Below this refractive index, the specific filters listed above, which remove spectral lines of longer wavelengths than the one being read, should be used.  
3—Measurement of refractive dispersion requires more than one type of light source.

6.5 Light Filters—Arc lamps can emit a number of spectral lines that result in multiple-borderlines observed in the refractometer. Filters can be used to eliminate unwanted lines (borderlines). Depending upon instrument design, the manufacturer will recommend and supply a suitable filter or adapt a commercially-available filter (for example, interference filter) to suit the application.

## 7. Solvents Reagents and Materials

7.1 n-Pentane, 95 mol% minimum purity. (**Warning**—Extremely flammable. Harmful if inhaled. Vapors may cause flash fire.)  
n-Pentane, 95 mol % Minimum Purity, for cleaning the prism faces. (**Warning**—Flammable. Harmful if inhaled. Vapors may cause flash fire.)

NOTE 4—Low boiling hydrocarbon fractions with boiling range 50 to 100°C have also been found to be acceptable.

7.2 Toluene, conforming to Specification D841. (**Warning**—Toluene, HPLC Grade, for cleaning the prism faces. (**Warning**—Flammable. Vapor harmful.)

## 8. Reference Standards

8.1

7.3 1-Bromonaphthalene, 98 mol % Minimum Purity, contact liquid when calibrating with solid reference standard. (**Warning**—Toxic when ingested.)

7.4 Primary Reference Materials, for calibrating the instrument.

7.4.1 Solid Reference Standard, accurate to ±0.00002 with the value of the refractive index engraved upon its upper face.

8.2 Primary Liquid Standards—The organic liquids listed below, with the values of their refractive indexes for the D, F, and C lines certified at 20, 25, and 30°C, obtained from the API Standard Reference Office: (**Warning**—Flammable.)

2,2,4-Trimethylpentane  
Methylcyclohexane  
Toluene

$n_D=1.39$   
 $n_D=1.42$   
 $n_D=1.49$

## 9. Sample

9.1A sample of at least 0.5 mL is required. The sample shall be free of suspended solids, water, or other materials that tend to scatter light. Water can be removed from hydrocarbons by treatment with calcium chloride, followed by filtering or centrifuging to remove the desiccant. The possibility of changing the composition of a sample by action of the drying agent, by selective adsorption on the filter, or by fractional evaporation shall be considered. (**Warning**—, with the value of refractive index engraved on its upper face.)

7.4.2 *Distilled or Deionized Water*, conforming to Type II or III of Specification D 1193. At 20°C,  $n_D = 1.3330$ ; at 25°C,  $n_D = 1.3325$ ; and at 30°C,  $n_D = 1.3319$

7.4.3 *2,2,4-trimethylpentane, 99 mol % Minimum Purity*, at 20°C,  $n_D = 1.3915$ ; at 25°C,  $n_D = 1.3890$ .

7.4.4 *Methylcyclohexane, 99 mol % Minimum Purity*, at 20°C,  $n_D = 1.4231$ ; at 25°C,  $n_D = 1.4206$ .

7.4.5 *Toluene, 99 mol % Minimum Purity*, at 20°C,  $n_D = 1.4969$ ; at 25°C,  $n_D = 1.4941$ . (**Warning**—2,2,4-trimethylpentane, methylcyclohexane, and toluene are all flammable. Their vapor can be harmful.)

NOTE 5—Other pure materials may be used to calibrate the instrument as primary reference material, as long as they can be obtained in 99 mol % minimum purity and accurate values of their refractive indices at specific temperatures are available. The precision of the test method (see 15.1 and 24.1) were obtained using distilled water as the calibrant.

7.5 *Secondary Reference Materials*, for calibrating the instrument.

7.5.1 *Mineral Oil Calibration Standards*, measured and certified by suppliers for specific refractive index ranges and temperatures.

## 8. Sampling

8.1 A sample of at least 0.5 mL is required. The sample shall be free of suspended solids, water, or other materials that may settle onto the prism surface and affect the measured reading. Water can be removed from hydrocarbons by treatment with calcium chloride followed by filtering or centrifuging to remove the desiccant. The possibility of changing the composition of the sample by action of the drying agent, by selective adsorption on the filter, or by fractional evaporation, shall be considered. (**Warning**—Volatile hydrocarbon samples are flammable.)

## 10. Preparation of Apparatus

10.1 The refractometer shall be kept scrupulously clean at all times. Dust and oil, if allowed to accumulate on any part of the instrument, will find their way into the moving parts, causing wear and eventual misalignment; if permitted to collect on the prism, dust will dull the polish, resulting in hazy lines.

10.2 Thoroughly clean the prism faces with a swab of surgical-grade absorbent cotton saturated with a suitable solvent such as toluene. Pass the swab very lightly over the surface until it shows no tendency to streak. Repeat this procedure with

## 9. Preparation of Apparatus

9.1 The refractometer shall be kept scrupulously clean at all times. Dust and oil can impair the optical component of the instrument. Thoroughly clean the prism faces with toluene, followed by *n*-pentane until both the glass and the adjacent polished metal surfaces are clean. Do not dry the prism faces by rubbing with dry cotton.

10.3 Adjust the thermostat so that the temperature indicated by the refractometer temperature measuring device is within 0.02°C of the desired value; turn on the sodium vapor lamp, and allow it to warm up 30 min. *n*-pentane (see Note 4) (**Warning**—These materials are extremely flammable. Harmful if inhaled. Vapors may cause flash fire.) using cotton swabs, fresh clean lens tissue, or similar material, in accordance with manufacturer's instructions. Do not dry the prism faces by rubbing with dry cotton.

9.2 Adjust the thermostat bath/circulator settings or the electronic temperature control system so that the temperature indicated by the refractometer temperature measuring device is within 0.1°C of the desired value. Turn on the light source and allow the refractometer to equilibrate for 30 min.

NOTE 6—An error of 0.02°C in temperature of the sample will cause an error of  $1 \times 10^{-5}$  in the refractive index of methylcyclohexane.

## 11. Standardization of Apparatus and Technique

11.1 Thoroughly clean the prism faces and surfaces of the solid reference standard as described in 10.2, finally brushing the surfaces with a clean camel's hair brush. Fix the hinged part in a wide-open position. Apply a drop of monobromonaphthalene, about 1.5 mm in diameter, to the center of the polished surface of the reference standard. Press the reference standard against the surface of the stationary prism with the polished end toward the light. If the proper amount of contacting liquid has been used, a continuous film of liquid will form between the prism and the reference standard, and the field will appear evenly illuminated. If not, irregular dark spots will appear in the illuminated field of the telescope when the knurled knob is turned and the light is in line with the longitudinal axis of the telescope. Gently manipulate the reference standard by pressure on one edge or another

until the interference bands, as seen with the aid of the auxiliary lens, appear to extend horizontally in the rectangular contact area. It is well to keep the liquid wedge at such an angle that three to five bands can be seen, and the fringe pattern should appear centered in the exit pupil of the telescope.

**Note 7**—If there is any trace of roughness as the contact is being made, remove the reference standard and clean all surfaces again. More damage can be done to the prism surface in this operation than in weeks of use with liquids, if grit comes between the two surfaces during this contact. The amount of liquid should be just enough to fill the contact area completely, leaving no liquid at the front edge of the reference standard.

11.2 Set the instrument to the scale reading corresponding to the refractive index engraved on the solid reference standard. Rotate the sodium lamp base while viewing the telescope until a sharp vertical line appears in the illuminated field and does not move with the rotation of the lamp. Adjust the eyepiece of the telescope to bring the cross hairs into sharp focus.

11.3 Move the alidade by means of the hand wheel until the critical line on the left side of the band intersects the cross hairs, and read the scale. Repeat the setting at least twice, and between settings, shift the lamp slightly while observing the critical line to make sure a false line is not being observed. Average the scale readings for all the settings.

11.4 Convert the average scale reading to refractive index by means of the table for the sodium *D* line. To give correct readings, without application of corrections, the average value obtained may differ from that engraved on the test specimen by more than 0.00002.

11.5 If adjustment is necessary, set the scale to the reading corresponding to the value engraved on the solid reference standard, by means of the hand wheel on the side of the instrument. If the critical line is to the left of the intersection of the cross hairs, loosen the small screw on the left of the telescope and slowly tighten the one on the right until the lines coincide; if the critical line is to the right of the intersection, use the opposite procedure. At the final adjustment, both screws should be snug but not tight. Again check the setting as in 11.3. **6**—The constancy of the prism temperature can be seriously affected by variations in ambient conditions such as air drafts or changes in room temperature. Reasonable precautions should be taken to minimize these factors.

## **10. Calibration of Refractometer Using Solid Reference Standard**

10.1 Thoroughly clean the prism faces and surfaces of the solid reference standard (see 7.4.1). Open the prism assembly. Apply a drop of 1-bromonaphthalene contact liquid, about 1.5 mm in diameter, to the center of the polished surface of the solid reference material. Press the reference standard against the surface of the prism face with the polished end towards the light source.

10.2 Follow the manufacturer's instructions on how to calibrate the instrument using the solid reference standard.

10.3 If the observed refractive index differs from the value engraved on the solid reference standard by more than 0.0001, adjust the refractometer's scale reading to match the certified value, following manufacturer's instructions.

## **11. Calibration of the Refractometer Using Liquid Reference Standards**

11.1 Using the procedure described in Section 12, determine the refractive index of any of the Reference Materials specified in 7.4 or 7.5 for a specific test temperature. If the observed refractive index for the chosen reference material at a specified test temperature differs by more than 0.0001 of the listed value, make adjustment to the instrument following manufacturer's instructions so that the observed refractive index corresponds to the listed value.

11.2 For optimum accuracy, use a reference material whose refractive index is close to the desired refractive index range and temperature to calibrate the instrument.

## **12. Standardization with Reference Liquids**

12.1 Measure the refractive indexes of each of the primary liquid standards listed in 8.2 for the *D*, *F*, and *C* lines, at the test temperature 20, 25, or 30°C, following the procedure described in Section 13. If the values obtained do not agree with the certified values within 0.00003, determine a correction curve for each wavelength from an average of five independent determinations on each of the three certified liquid standards. A plot of the average error against refractive index provides a correction for all observed indexes between these points. Procedure

12.1 Ensure that the prism faces are clean and dry. Check that the prism temperature is within 0.1°C of the desired temperature.

12.2 Unlock (if necessary) and open the prism assembly.

12.3 Place one or two drops of the sample on the lower prism face. Close the prism assembly and lock (if necessary). Turn on the light source. Allow 3 min temperature equilibration time.

12.4 Look through the eyepiece and observe the field consisting of a light and dark portion. Follow manufacturer's instructions to adjust the instrument so that the boundary between the light and dark portions of the field is as sharp as possible.

12.5 Following manufacturer's instructions, make any additional adjustment until the sharp boundary line intersects the midpoint of the crosshairs superimposed on the field.

12.6 Read the refractive index on the scale. Repeat 12.5 at least four times, approaching from either side of the sharp boundary line, and average the scale readings.

12.7 Record and report the average refractive index value.

12.8 If instrument is capable of determining refractive dispersion, change the light source to a light source with different wavelength. Determine the refractive index at the secondary wavelength following 12.4-12.7.

**Note 8**—This does not imply that the refractive index engraved on the test specimen is necessarily inaccurate, but tends to correct an error introduced in the determination by the failure to obtain grazing incidence in the case of liquid samples. This fault, and other instrumental errors, if present, are

inherent in the refractometer design and their magnitude varies with the refractive index of the liquid and different instruments.

12.2 To observe any changes with time and use in the relative positions of prism and alidade, each operator shall check the instrument with the calibrated solid reference standard before his use of the instrument.

### 13. Procedure

13.1 Thoroughly clean the prism faces as described in 10.2. Adjust the thermostat so that the temperature indicated by the refractometer thermometer is within 0.02°C of the desired value.

13.2 In testing nonviscous liquid samples, close the prism box and let stand for 4 to 5 min to ensure temperature equilibrium between the prisms and the circulating water. By means of a small pipet or medicine dropper, introduce a small quantity of sample into the tubulation between the prism faces. Turn the knurled head at the base of the telescope so as to bring the auxiliary lens into the light path, and observe through the face of the working prism. If the space between the prisms is completely filled with liquid, the field will be uniformly illuminated; bubbles or unfilled spaces will appear black. If the space is not completely filled, open the prism box slightly several times and add more liquid. Do not attempt to measure refractive indexes until the space between the prisms is completely filled.

13.3 In testing viscous liquids, open the prism box and apply the sample to the faces of both prisms, spreading evenly with a round wooden applicator stick. Never use metal or glass for this purpose as these may scratch the prism faces. Close the prism box slowly to avoid straining the hinge and locking mechanism.

13.4 Adjust the illuminant to be in line with the telescope, and bring the border line approximately to the reticle. While viewing the rear prism face by means of the auxiliary lens, rotate the lamp bracket to the right until only the extreme left side of the prism appears to be illuminated. If this rotation is carried too far, vertical interference lines will appear in the back face. These are generally irregular and rather faint. The best adjustment for contrast and illumination seems to be the point just before these fringes become distinct.

13.5 Adjust the eyepiece of the telescope so as to bring the cross hairs into sharp focus, set the cross hairs on the critical edge, and read the scale of the instrument. Readjust the position of the vapor lamp and repeat at least four times, approaching from either side of the critical edge, and record the average scale reading. (To avoid the possibility of using a false edge, it is best to adjust the position of the light source each time a setting is made rather than make four settings on one positioning of the lamp.)

13.6 Without changing the position of the prism assembly, place other desired light sources into the angular position (with respect to the rear face of the refracting prism) occupied by the sodium lamp. Take average scale readings for the desired lines in the manner described in 13.4.

13.7 In testing volatile samples, clean the prism faces without changing the position of the prism assembly or the lamp, recharge with sample, and read immediately. 7—When determining refractive dispersion, it is expected that the instrument would have been calibrated at both wavelengths used.

### 13. Quality Control

13.1 Confirm the performance of the test procedure by analyzing a quality control (QC) sample, which is stable and representative of the sample of interest.

13.1.1 When quality control/quality assurance (QC/QA) protocols are established in the testing facility, these may be used to confirm the reliability of the test result.

13.1.2 When there are no QC/QA protocols established in the testing facility, Appendix X4 can be used to provide guidelines in performing this function.

### 14. Calculation and Report

14.1 Convert the observed scale readings to refractive indexes by use of the tables supplied with the instrument, and report these values and the temperature at which the test was made, distinguishing between the various spectral lines used (for example, “ $n_D=1.000$ ” or “ $n_{589}^{1.000}$ ”).

14.2 To obtain refractive dispersion, subtract,  $n_{\lambda 2}$  Calculation and Report

14.1 Report the average refractive index to four decimal places and the test temperature at which the test was made, for example:

$$n_D = x.xxxx \text{ at } 20^\circ\text{C} \text{ or } n_{589} = x.xxxx \text{ at } 20^\circ\text{C} \quad (1)$$

where  $D$  or the 589 signifies that the sodium  $D$  spectral line was used.

14.2 If a refractive dispersion measurement was made, calculate the absolute value of the difference between the refractive indices at the two wavelengths and multiply the difference by 10 000. Report the calculated value and the test temperature, for example:

$$|(n_g - n_D)| \times 10^4 \text{ at } t = 20^\circ\text{C} \quad (2)$$

where  $g$  and  $n_{\lambda 1}$ . Report the result and the temperature at which the test was made (for example “ $(n_F - n_C) \times 10^4$  at  $t = \dots$ ” or “ $(n_g - n_D) \times 10^4$  at  $t = \dots$ ”).  $D$  signifies that the mercury  $g$  and sodium  $D$  spectral lines were used in the measurement.