**ASTM Designation: D 1590 – 60 (Reapproved 1977)[ε2]**

# Standard Test Method for Surface Tension of Water[1]

This standard is issued under the fixed designation D 1590; 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.

[ε1] NOTE—Editorial changes were made in the title, throughout the text, and by adding two sections in July 1977.
[ε2] NOTE—1.3 was added editorially in February 1989.

## 1. Scope

1.1 This test method covers quantitative measurement of the surface tension of water and waste water. The test method is based on instrumental measurement by the ring method and offers the most precise and accurate determination.

1.2 This test method is not intended to show any direct relationship between surface tension and concentration of surface-active agents.

1.3 *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems 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:*
D 1066 Practice for Sampling Steam[2]
D 1129 Definitions of Terms Relating to Water[2]
D 1192 Specification for Equipment for Sampling Water and Steam[2]
D 1193 Specification for Reagent Water[2]
D 3370 Practices for Sampling Water[2]
E 380 Metric Practice[3]

## 3. Summary of Test Method

3.1 The test method is based on measurement of the force required to detach a ring from the surface of the sample.

## 4. Definitions

4.1 The term *surface tension* in this test method is defined in accordance with Definitions D 1129 as follows:

4.1.1 *surface tension*—a property arising from molecular forces of the surface film of all liquids which tend to alter the contained volume of liquid into a form of minimum superficial area.

NOTE 1—Surface tension is numerically equal to the force acting normal to an imaginary line of unit length in a surface. It is also numerically equal to the work required to enlarge the surface by unit area. The usual unit of measurement is dynes per centimetre.[4]

4.2 For definitions of other terms used in this test method, refer to Definitions D 1129. For an explanation of the metric system including units, symbols, and conversion factors, see Standard E 380.

## 5. Apparatus

5.1 *Tensiometer*[5]—A sensitive torsion balance provided with means for applying a slowly increasing force to a platinum-iridium ring in contact with the surface of the sample. The apparatus shall be provided with a graduated scale to give readings in dynes of force when properly calibrated.

5.2 *Ring*, accurately constructed of platinum-iridium wire. The ring shall be circular, in one plane, free of bends or irregularities. The circumference and ratio of diameter of the ring, $R$, to the diameter of the wire, $r$, shall be known to the third significant figure. The ring shall be suspended vertically from the instrument so that the plane of the ring is parallel to the surface of the sample being tested.

5.3 *Measurement Vessel*, no smaller than 60 mm in diameter, and such that the ring will be in a flat area of the sample surface and well removed from the meniscus effect near the edge of the container. A crystallizing dish having approximate dimensions of 60 by 35 mm has been found satisfactory.

5.4 *Centrifuge*—Heavy-duty type equipped with suitable head to carry four 100-mL capacity tubes and having a minimum operating speed of 1500 rpm.

## 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.[6] Other grades may be used, provided it is first ascertained that the

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[1] This test method is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D19.09 on Saline Water and Water for Subsurface Injection.
Current edition effective Sept. 19, 1960. Originally issued 1958. Replaces D 1590 – 58 T.
[2] *Annual Book of ASTM Standards*, Vol 11.01.
[3] *Annual Book of ASTM Standards*, Vol 14.02.

[4] The surface tension of pure water is given in the International Critical Tables as 72.75 dynes/cm at 20°C.
[5] Either the du Nouy precision tensiometer equipped with a 4-cm circumference ring or the du Nouy interfacial tensiometer with a 6-cm ring may be used for this purpose.
[6] "Reagent Chemicals, American Chemical Society Specifications," Am. Chemical Soc., Washington, D.C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N.Y., and the "United States Pharmacopeia."

reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

6.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Specification D 1193, Type II.

## 7. Sampling

7.1 Collect the samples in accordance with Specification D 1192, Practice D 1066, and Practices D 3370 as applicable.

7.2 Use only glass-stoppered vessels as sample containers.

7.3 Clean with chromic-sulfuric acid cleaning solution all glassware that will come in contact with the sample and rinse thoroughly with water for each sample.

NOTE 2—The recommended cleaning procedure comprises a 1-h soak in chromic-sulfuric acid, five rinses with water after acid is removed by distilled water, and storage in water overnight. Glassware for this test should be kept segregated and stored in water. On removal from storage and just prior to use, ten rinses with water are recommended.

7.4 To avoid potential errors that may result from suspended solids or free oil in the samples as collected, centrifuge an appropriate volume for 30 min at 1500 r/min. Pipet the actual sample portion to the measurement vessel directly from the centrifuge tubes.

## 8. Calibration and Standardization

8.1 Level the tensiometer and adjust the length of the torsion arm by means of weights and the adjustments provided in accordance with the manufacturer's directions. This calibration procedure adjusts the instrument so that each unit of the graduated scale represents a pull on the ring of 1 dyne/cm.

8.2 From the calibration weight and instrument reading, calculate the grams of pull on the ring represented by each scale division. Use this value for calculating the conversion factor, F, which is employed to give corrected surface tension values.

## 9. Procedure

9.1 After the tensiometer has been calibrated, check the level and insert the freshly-cleaned platinum ring (Note 3). Level the plane of the ring and set the measuring dial at zero. Adjust the ring to the zero position.

NOTE 3—For each sample, the platinum ring must be freshly cleaned by immersion in methyl ethyl ketone, permitted to dry, then immersed in hydrochloric acid ((1 + 6) 1 volume of HCl (sp gr 1.19) mixed with 6 volumes of water) and rinsed thoroughly in water. The ring is again immersed in methyl ethyl ketone, permitted to dry and then heated to a white heat in the oxidizing portion of a gas flame. Successive measurements on the same sample will require cleaning and flaming the ring for each determination.

9.2 Place the sample to be tested in the thoroughly cleaned measurement vessel on the sample platform. Raise the sample platform by means of the adjusting screw until the ring is completely submerged, but not to exceed 3 mm.

9.3 Permit the sample surface to age for 30 ± 5 s.

9.4 Lower the platform slowly by means of the adjusting screw, at the same time increasing the torque of the ring

system by means of the dial adjustment. These two simultaneous adjustments must be carefully made so that the ring system remains constantly in the zero position. Record the dial reading when the ring breaks free of the water film. Complete the break within 60 ± 5 s after starting measurement.

9.5 Make at least two measurements each on separate sample portions, making additional measurements in accordance with the magnitude of the overall variation of the first two.

9.6 Measure and report temperatures of tested sample portions.

## 10. Calculation

10.1 Calculate the corrected surface tension of the sample as follows:

$$\text{Surface tension, dynes/cm} = PF$$

where:
$P$ = scale reading in dynes/cm when film breaks, and
$F$ = correction factor.

10.2 Values of $F$ in terms of two compounded parameters, $R^3/V$ and $R/r$ have been compiled and tabulated by Harkins and Jordan.[7] In order to look up $F$ in the tables, the values of these two parameters must be calculated. Values for $R$, the mean radius of the ring in centimetres, and $r$, the radius of the wire in the ring in centimetres, are furnished by the manufacturer with each ring. Calculate the value of $V$ as follows:

$$V = M/(D - d)$$

where:
$M$ = weight of liquid raised above free surface of the liquid (equivalent to dial reading multiplied by factor derived in 8.2),
$D$ = density of liquid, and
$d$ = density of air saturated with vapor of the liquid.

## 11. Report

11.1 Report the results as surface tension, dynes per centimetre, at the sample temperature in degrees Celsius.

11.2 If it is desirable to convert the surface tension values to some standard temperature, a correction factor of 0.14 dynes/cm·deg C may be used. This correction is subtracted when the test temperature is lower than the reporting standard temperature and is added if the test temperature is higher.

## 12. Precision and Bias[8]

12.1 The precision of this test method is 0.3 dyne/cm.

12.2 No limit of bias can be stated because of the absence of experimental data.

[7] Harkins, W. D., and Jordan, H. F., "A Method for Determination of Surface and Interfacial Tension from the Maximum Pull on a Ring," *Journal of the American Chemical Society*, JACSA, Vol 52, 1930, p. 1751. These tables are also published in *Physical Methods of Organic Chemistry*, Interscience Publishers, Inc., New York, N.Y., Vol. 1, 1945, pp. 182–184.
[8] Supporting data for this test method have been filed at ASTM Headquarters. Request Research Report RR: D19-157.