Designation: D3825 – 09

StandardTest Method for Dynamic Surface Tension by the Fast-Bubble Technique[1]

This standard is issued under the fixed designation D3825; 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 the determination of the specific free energy of a liquid-gas surface a short time after formation of the surface.

1.2 It is applicable to liquids with vapor pressures up to 30.0 kPa (225 torr) and kinematic viscosities up to 4.0 mm/s (4.0 cSt) at the test temperature. Higher viscosities have not yet been investigated.[2]

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

1.4 **Warning—**Mercury has been designated by EPA and many state agencies as a hazardous material that can cause central nervous system, kidney, and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury-containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website (http://www.epa.gov/mercury/faq.htm) for additional information. Users should be aware that selling mercury or mercury-containing products, or both, in your state may be prohibited by state law.

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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see 7.3, 7.4, and 7.5.

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D1193 Specification for Reagent Water

D1331 Test Methods for Surface and Interfacial Tension of Solutions of Paints, Solvents, Solutions of Surface-Active Agents, and Related Materials

E1 Specification for ASTM Liquid-in-Glass Thermometers

3. Terminology

3.1 *Definitions:*

3.1.1 *surface tension (γ)*—the specific surface free energy of a liquid gas interface, millinewton per metre (ergs/cm^2).

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bubble frequency (S)*—bubbling rate, s^{-1}.

3.2.2 *bubble pressure (ΔP)*—difference between maximum pressures for the wide capillary (P_1) and the narrow capillary (P_2), Pa.

3.2.3 *dead time (t_o)*—time required from start to completion of a bubble, ms.

3.2.4 *dead time %*—fraction of a cycle ($t + t_o$) in the dead state, %.

3.2.5 *surface age (t)*—time required to start a new bubble, ms.

3.3 *Symbols:*

γ	=	surface tension, millinewtons per metre (dynes/cm)
S	=	bubble frequency, s^{-1}
t_o	=	dead time, ms
t	=	surface age, ms
D	=	density, kg/m^3
r	=	radius, mm
ΔP	=	difference between maximum pressures, Pa
P_1	=	maximum pressure for the wide capillary, Pa
P_2	=	maximum pressure for the narrow capillary, Pa

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.L0.07 on Engineering Sciences of High Performance Fluids and Solids (Formally D02.1100).

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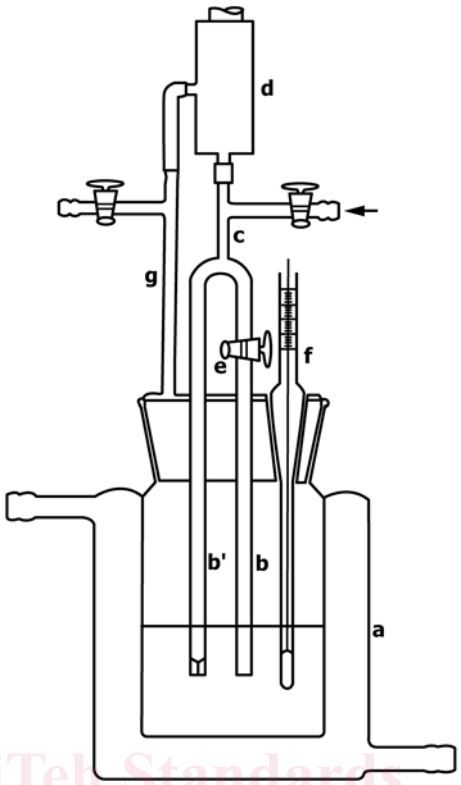
[2] Kloubek, J., "Measurement of the Dynamic Surface Tension by the Maximum Bubble Pressure Method, III," *Journal of Colloid and Interface Science*, Vol. 41, October 1972, pp. 7–16.

[3] 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.



Tips of *b* and *b'* shall be cut squarely at exactly the same level, and finely ground (for example, 44 µm S;C (320 mesh S;C).

FIG. 1 Bubbler Unit

4. Summary of Test Method

4.1 The pressure required for bubble formation at a capillary tip immersed in the liquid is measured at gas flow rates that provide a series of bubble frequencies. The pressure and a calibration constant are used to calculate the dynamic surface tension at various surface ages.

5. Significance and Use

5.1 While this test method can be applied to pure liquids, it is especially designed for use with mixtures in which one or more components migrate to the surface.

5.2 Data of this type are needed for the design of equipment for processing mixed liquids, such as in distillation towers.

6. Apparatus

6.1 *Bubbler Unit,* water-jacketed, as shown in Fig. 1.

6.2 *Thermostat,* circulating water, to hold bubbler at specified temperature.

6.3 *Oven,* adjustable to 378 K (105°C), explosion-proof.

6.4 *Pressure Transducer,* diaphragm-resistive unbonded strain gage, time constant 25 ms or less, 0 to 2000 Pa, accuracy ±2 %.[4,5]

6.5 *Bridge Power Supply,* for the strain gage.

6.6 *Oscilloscope,* capable of sweep times down to 0.020 s.

6.7 *Filtered (5-µm) Air Supply,* with pressure regulator capable of 0 to 724 kPa (0 to 105 psig) above ambient.

NOTE 1—Nitrogen shall be used in place of air if there is any problem of oxidizing the liquid.

6.8 *Thermometer,* appropriate range, conforming to Specification E1. The thermometers specified in Specification E1 are mercury-in-glass instruments. Thermocouples, resistance thermometers, or liquid-in-glass devices of equal precision are acceptable.

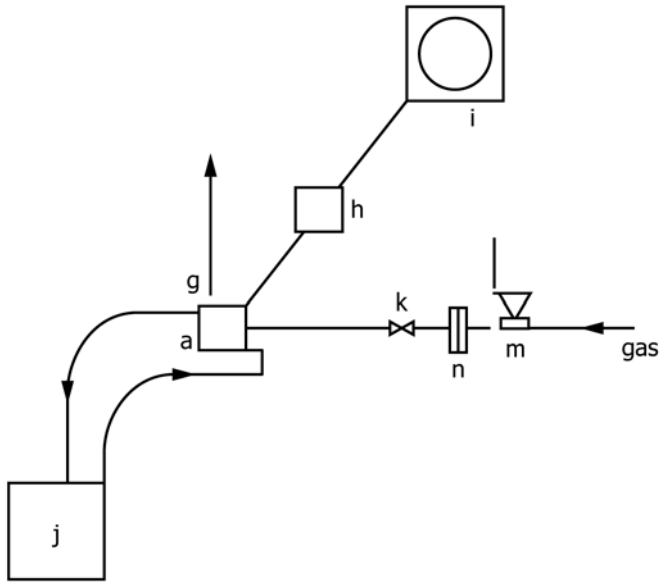
7. Reagents and Materials

7.1 *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 specification of the Committee on Analytical Reagents of the American Chemical Society,[6]

[4] Razouk, R. "Surface Tension of Propellants," JPL Quarterly Technical Review Vol 2, 1972, pp. 123–133.

[5] Razouk, R. and Walmsley, D., "Surface Tension Measurement by the Differential Maximum Bubble Pressure Method Using a Pressure Transducer," *Journal of Colloid and Interface Science*, Vol. 47, 1974, pp. 515–519.

[6] *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. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.



a—water jacket, *b*—wide capillary (inside diameter = 2.0± 0.1 mm), *b'*—narrow capillary (inside diameter = 0.11 ± 0.1 mm), *c*—inlet manifold, *d*—pressure transducer, *e*—stopcock, *f*—thermometer, *g*—vent line, *h*—bridge supply, *i*—oscilloscope, *j*—thermostat, *k*—needle valve, *m*—pressure reguator, *n*—filter, 5 µm.
[A] Do not use silicone grease on stopcocks or taper joint.

FIG. 2 Set-up of Apparatus[A]

where such specifications are available. 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.

7.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Specification D1193, Type III.

7.3 *Calibration Liquids,* reagent grade, covering a wide range of surface tension. Acetone, toluene, ethanol, and methanol have been found satisfactory for this purpose.

7.3.1 *Acetone*—(**Warning—**Extremely flammable. Vapors may cause flash fire. See Annex A1.1.)

7.3.2 *Toluene*—(**Warning—**Flammable. Vapor harmful. See Annex A1.6.)

7.3.3 *Methanol*—(**Warning—**Flammable. Vapor harmful. See Annex A1.5.)

7.3.4 *Ethanol*—(**Warning—**Flammable. Denatured. See Annex A1.4.)

7.4 *Cleaning Solution,* Chromic-sulfuric acid. (**Warning—**Causes severe burns. A recognized carcinogen strong oxidizer, contact with organic material can cause fire. Hygroscopic. See Annex A1.2.)

7.5 *Nitrogen,* of purity suitable to avoid reaction with test liquid and less than 100 ppm CO_2 with amines. (**Warning—**Compressed gas under high pressure. See Annex A1.3.)

8. Calibration and Standardization

8.1 Clean the bubbler with cleaning solution, and rinse with water. (**Warning—**Causes severe burns. A recognized carcinogen. Strong oxidizer, contact with organic material may cause fire. Hygroscopic. See Annex A1.2.) Condition by soaking in water for 48 h followed by a final rinse with water.

8.2 Set up the apparatus as shown in Fig. 2, and bring the thermostat to the desired temperature.

NOTE 2—If a test temperature is not specified, 298 ± 0.1 K (25 ± 0.1°C) is recommended.

8.3 Calibrate the transducer and the oscilloscope vertical scale against a suitable timer.

8.4 Measure the inner radius (*r*) of the wide capillary (*b*) by any suitable means to ±5 %.

8.5 Half-fill the bubbler with water; then connect it to thermostat and equilibrate it until the test temperature is reached.

8.6 Pass gas through the narrow capillary (*b'*) at a rate to give $S = 0.5\ s^{-1}$ and record the pressure maximum as P_2. (**Warning—**Compressed gas under high pressure. See Annex A1.3.)

8.7 Open the stopcock (*e*) to the wide capillary and record the pressure as P_1.

8.8 Empty the bubbler and dry in the oven.

8.9 Half-fill the bubbler with ethanol or methanol and repeat 8.5 – 8.8.

8.10 Repeat 8.9 with three other calibration liquids.

8.11 Calculate the calibration constant (*A*) for each of the five liquids by:

$$(A = \gamma/\Delta P\ (1 + 675\ rD/\Delta P)) \quad (1)$$

Average the results.