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Standard Practice for Estimating Critical Surface Tensions¹

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1. Scope

1.1 This practice covers procedures for estimating values of the critical surface tension of surfaces by observing the wetting and dewetting of a series of liquids (usually organic solvents) applied to the surface in question.

1.2 Another technique, measurement of the contact angles, θ , of a series of test liquids and plotting $\cos \theta$ versus surface tension (Zisman plots), provides data that allow the determination of more exact values for critical surface tension.

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

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

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:*²

D2578 [Test Method for Wetting Tension of Polyethylene and Polypropylene Films](#)

2.2 *Nordtest Standards:*³

NT poly 176 [Spreading Surface Tension by the Applied Droplet Method.](#)

3. Terminology

3.1 *Definitions:*

3.1.1 *critical surface tension, n* —the surface tension of a hypothetical liquid that would just spontaneously spread if applied as a drop to the surface in question; any liquid with a surface tension lower than the critical surface tension will spread spontaneously.

4. Summary of Practice

4.1 In this practice, a series of liquids of gradually increasing surface tension are applied to a surface in the form of drops, narrow strips, or spots. Drops may be applied using a dropper, syringe or other device capable of producing individual drops. Liquid strips or spots are applied to the surface by swabbing with saturated cotton swabs or by another type of applicator, such as one that is similar to a marker pen. In the case of the drop, the observer determines whether the drop stays in place or spreads. In the case of the liquid strip or spot, the question is whether the liquid stays in place or dewets and crawls. In each case, the break point between wetting and dewetting provides the critical surface tension.

5. Significance and Use

5.1 Knowledge of the critical surface tension of substrates, primers and other coatings is useful for explaining or predicting wettability by paints and other coatings applied to those surfaces. Surfaces with low critical surface tensions usually are prone to suffer defects such as crawling, picture framing, cratering and loss of adhesion when painted. Low or irregular values, or both, often are indicative of contamination that could reduce adhesion. Surfaces with high critical surface tensions are easy to wet and usually provide an excellent platform for painting.

5.2 The swab, marking pen and draw-down tests all simulate the application of a film

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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 Hansen, C. M., *J. Coat. Technol.*, 44 (570), 57 (1972).

³ For Nordtest standards, see www.nordcinnovation.net/nordtest.cfm or contact Nordtest, Tekniikantie 12, FIN-02150 Espoo, Finland.

5.3 The swab and marking pen techniques are simple and rapid and are particularly useful for testing in the field or on curved, irregular or porous surfaces where contact angles cannot be measured. The drop test does not work well on such surfaces and the draw-down method requires a flat specimen that is relatively large.

5.4 The estimation of critical surface tension has been useful in characterizing surfaces before and after cleaning processes such as power washes and solvent wipes in order to evaluate the efficiency of the cleaning.

5.5 One or more of these techniques could be the basis of a go/no-go quality control test where if a certain liquid wets, the surface is acceptable for painting, but if that liquid retracts and crawls, the surface is not acceptable.

5.6 Another go/no go test is possible where the test liquid is a paint and the surface is a substrate, primer or basecoat. A form of this test has been used for coatings for plastics.

6. Interferences

6.1 The specimen must be clean in order for results to be meaningful. The surface must not be touched or rubbed.

6.2 The surface tensions of test liquids, especially those that are mixtures, are subject to change with time. Test liquid surface tensions should be confirmed before they are first used, measured periodically after that and whenever change is suspected.

6.3 Test liquids may become contaminated, in which case results with them will be meaningless. Test liquid surface tensions should be confirmed before they are first used, measured periodically after that and whenever contamination is suspected.

6.4 High ambient temperature may cause rapid evaporation of test liquids and make it difficult to determine whether retraction has occurred or shrinkage is due to evaporation.

7. Apparatus

7.1 Several of one of the following types of applicators:

7.1.1 *Cotton swab* (small ball of cotton at the end of a stick).

7.1.2 *Marker pen type applicator*.

7.1.3 *Dropper or syringe*.

7.1.4 Other device with the ability to apply a drop, strip, or spot.

7.2 *Drawdown Bar*—only for draw-down test.

7.3 *Instrument or devices for measuring temperature and humidity*.

8. Materials

8.1 Swab, drop and draw-down tests.

8.1.1 Test liquids.

8.1.1.1 The original publication on the swab test⁴ specified the liquids in Table 1 (listed along with their surface tensions). This set of liquids has a large surface tension gap between 24 and 35 dynes/cm.

8.1.1.2 Test Method D2578 specifies mixtures of formamide and ethylene glycol monomethyl ether (both reagent grade). Mixtures can be designed so as to produce any combination of surface tension values.

8.1.1.3 The drop test publications^{5, 6} specify mixtures of ethanol and water, but do not give details of the proportions.

8.1.1.4 Other liquids covering a range of surface tensions could be used. If possible, highly volatile solvents should be avoided as it is difficult to tell whether they are dewetting or just evaporating.

8.1.1.4 Nordtest Method NT poly 176³ includes a table of surface tensions for ethanol/water mixtures at 23°C, which gives values ranging from 22 to 72 mN/m in 2 mN/m intervals.

8.1.1.5 Other liquids covering a range of surface tensions could be used. If possible, highly volatile solvents should be avoided as it is difficult to tell whether they are dewetting or just evaporating.

TABLE 1 Test Liquids and Their Surface Tensions

Liquid	Surface Tension mN/m (= dynes/cm)
Acetone	23.7
Dimethyl formamide	35.2
2-pyrrolidone	37.6
N-methyl-2-pyrrolidone	39.0
Dimethyl sulfoxide	43.0
Ethylene cyanohydrin	44.4
Formamide	56.0
Water	72.8

⁴ Hansen, C. M., *European Coatings J.*, 94, 838 (1994). *J. Coat. Technol.*, 44 (570), 57 (1972).

⁵ Hansen, C. M., *Pigment and Resin Technol.*, 27, 374 (1998). *European Coatings J.*, 94, 838 (1994).

⁶ Hansen, C. M., *Pigment and Resin Technol.*, 27, 374 (1998).