



Designation: D 3132 – 84 (Reapproved 1996)

Standard Test Method for Solubility Range of Resins and Polymers¹

This standard is issued under the fixed designation D 3132; 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 determination of the solubility of resins and polymers in terms of the region of solubility parameter and hydrogen bonding of solvents in which complete solution occurs. In some cases dipole moment of the solvents may also be required to delineate more exactly the boundaries of solubility.

1.2 This test method is applicable only if the test solutions are of sufficient clarity and freedom from color to allow accurate visual judgement of complete solubility and of low enough viscosity for solution to take place.

1.3 *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 a specific hazard statement see Note 1 in 6.2.

2. Terminology

2.1 Definitions:

2.1.1 The solubility parameter δ of a substance is defined as the square root of the “cohesive energy density,” or energy of vaporization per unit volume:

$$\delta = (\Delta E / V)^{1/2} \quad (1)$$

where:

ΔE = energy of vaporization, and

V = molar volume.

The value of δ for a volatile liquid can be calculated accurately from the latent heat of vaporization, or approximately from its boiling point. Solubility parameter values for large number of solvents are available in Table 1.

2.1.2 Solvents are also classified according to their hydrogen bonding power, γ . Numerical values for γ may be derived from spectroscopic analysis. In one method,² γ is defined as one-tenth the wavenumber shift observed by Gordy’s tech-

nique,³ and values range from 0 to about 25. Another method,⁴ which limits values of γ to the range of 2.2 to 10, defines γ by the following equation:

$$\gamma = (0.0359 \times \Delta\nu) + 2.2 \quad (2)$$

where ν is the wavenumber shift as determined by Gordy’s method. Hydrocarbons, halogenated hydrocarbons and nitrohydrocarbons have low values of γ ; esters, ethers, etheralcohols, and ketones are intermediate; and alcohols, amines, and acids have high values.

2.1.3 The solubility parameter δ_m , of a mixture of solvents having parameters, δ_1 , δ_2 , etc., is a function of the molar fraction and molar volume of the components:

$$(\delta_1 x_1 V_1 + \delta_2 x_2 V_2) / (x_1 V_1 + x_2 V_2) \quad (3)$$

in which x_1 and V_1 , x_2 and V_2 , etc., are the corresponding molar fractions and volumes, respectively. If the components have the same molar volumes ($V_1 = V_2$),

$$\delta_m = x_1 \delta_1 + x_2 \delta_2 \quad (4)$$

Thus, in a mixture of two components A and B having the same molar volumes and solubility parameter values of δ_A and δ_B

$$\delta_m = \frac{(\text{volume percent A} \times \delta_A) + (\text{volume percent B} \times \delta_B)}{100} \quad (5)$$

2.1.4 Similarly, the hydrogen bonding value, γ_m , of a mixture is determined by:

$$\gamma_m = \frac{(\text{volume percent A} \times \gamma_A) + (\text{volume percent B} \times \gamma_B)}{100} \quad (6)$$

and dipole moment by:

$$\mu_m = \frac{(\text{volume percent A} \times \mu_A) + (\text{volume percent B} \times \mu_B)}{100} \quad (7)$$

3. Summary of Test Method

3.1 Solubility of resinous and polymeric materials is dependent upon the solubility parameter, hydrogen bonding, and dipole moment of the solvents. Solubility parameter is the most important property of the three, followed by hydrogen bonding. Consequently, the solubility of most materials is sufficiently

¹ This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.33 on Polymers and Resins.

Current edition approved Aug. 31, 1984. Published January 1985. Originally published as D 3132 – 72. Last previous edition D 3132 – 72 (1984).

² Crowley, J. D., et al., “A Three Dimensional Approach to Solubility,” *Journal of Paint Technology*, JPIRA, Vol 38, No. 496, 1966, p. 269; Vol 39, No. 504, 1967, p. 19.

³ Gordy, W., “Spectroscopic Evidence of Hydrogen Bonds,” *Journal of Chemical Physics*, JCPSA, February 1939, February 1940, March, 1941.

⁴ E. I. du Pont de Nemours & Co., Bulletin PA 12-770, “Solvent Formulating Maps for Elvacite Acrylic Resins, Serial A-70562, July 1970.



defined by the area of solubility parameter and hydrogen bonding of true solvents. A material is insoluble or incompletely soluble in a solvent if its solubility parameter and hydrogen bonding properties fall outside this region.

3.2 In this test method, the material is tested separately in solvents that cover the entire solubility diagram so that boundaries of complete solubility can be determined.

4. Significance and Use

4.1 This test method is useful for an empirical determination of the solvent(s) in which a resin or polymer may be dissolved. This test method is also applicable to estimate the solvents that may be useful for further dilution of a polymer or resin solution without formation of haze or without polymer or resin precipitation.

TABLE 1 Solvent or Solvent Mixtures

No.	Solvent or Solvent Mixture (Mixture Given in Volume Percent)	Solubility Parameter, δ	Hydrogen Bonding		Dipole Moment, ^A μ
			γ^B	γ^C	
1*	Diisopropyl ether	6.9	11.7	6.6	1.3
2	<i>n</i> -Pentane	7.0	0	2.2	0
3*	<i>n</i> -Heptane	7.3	0	2.2	0
4	50 % Diisobutyl ketone	7.4	10.1	5.9	2.0
	50 % Diisopropyl ether				
5*	Diethyl ether	7.4	13.0	6.9	1.2
6*	50% <i>n</i> -Heptane	7.6	4.2	3.7	1.4
	50 % Diisobutyl ketone				
7	25 % <i>n</i> -Heptane	7.7	6.3	4.5	2.0
	75 % Diisobutyl ketone				
8	Methyl cyclohexane	7.8	0	2.2	0
9	66.7 % <i>n</i> -Heptane	7.8	2.9	3.3	0.6
	33.3 % <i>n</i> -Butyl Acetate				
10*	Diisobutyl ketone	7.8	8.4	5.2	2.7
11*	57 % Diethyl ether	7.9	11.2	6.3	1.5
	43 % <i>n</i> -Butyl acetate				
12	66.7 % Diethyl ether	8.1	14.9	7.6	1.4
	33.3 % 2-Ethylhexanol				
13*	Cyclohexane	8.2	0	2.2	0
14	40 % <i>n</i> -Heptane	8.2	5.3	4.1	1.1
	60 % <i>n</i> -Butyl acetate				
15	71 % Cyclohexane	8.4	1.3	2.7	0.1
	29 % Toluene				
16*	<i>n</i> -Butyl acetate	8.5	8.8	5.4	1.9
17*	40 % Cyclohexane	8.6	2.7	3.2	0.2
	60 % Toluene				
18	50 % Cyclohexane	8.7	0	2.2	0
	50 % Benzene				
19	50 % <i>n</i> -Butyl acetate	8.7	6.7	4.6	1.2
	50 % Toluene				
20	50 % EGMBE (See No. 23)	8.7	10.9	6.2	1.8
	50 % <i>n</i> -Butyl acetate				
21*	33.3 % Diethyl ether	8.8	16.8	8.2	1.5
	66.7 % 2-Ethylhexanol				
22*	Toluene	8.9	4.5	3.8	0.4
23	2-Butoxyethanol	8.9	13.0	6.9	1.6
24*	Benzene	9.2	0	2.2	0
25	Propylene oxide	9.2	10.0	5.8	1.8
26	56 % EGMBE	9.2	15.5	7.8	1.6
	44 % 2-Ethylhexanol				
27	50 % Methylene chloride	9.3	3.0	3.3	1.0
	50 % Toluene				
28*	50 % Toluene	9.4	7.1	4.8	0.4
	50 % Dioxane				
29*	2-Ethylhexanol	9.5	18.7	8.9	1.7
30	Methyl acetate	9.6	8.4	5.2	1.7
31*	Methylene chloride	9.7	1.5	2.7	1.5
32	66.7 % Methylene chloride	9.8	4.2	3.7	1.1
	33.3 % Dioxane				
33	50 % Dioxane	9.8	5.6	4.2	1.0
	50 % Methylene chloride				
34*	Dioxane	9.9	9.7	5.7	0.4
35	Cyclohexanone	9.9	11.7	6.4	2.7
36*	2-Ethoxyethanol	9.9	13.0	6.9	1.6
37	75 % EGME	9.9	14.4	7.4	1.6
	25 % Methyl isobutyl carbinol				
38*	Carbon disulfide	10.0	0	2.2	0
39	30 % EGME	10.0	17.0	8.2	1.7
	70 % Methyl isobutyl carbinol				
40	Methyl isobutyl carbinol	10.0	18.7	8.8	1.7
41	66.7 % Methylene chloride	10.2	1.8	2.2	2.2