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Standard Test Methods for Particle Size (Sieve Analysis) of Plastic Materials[1]

This standard is issued under the fixed designation D 1921; 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 These test methods cover the measurement of the particle size of plastic materials in the powdered, granular, or pelleted forms in which they are commonly supplied. As these test methods utilize dry sieving, the lower limit of measurement is considered to be about 38 µm (No. 400 sieve). For smaller particle sizes, sedimentation test methods are recommended.

1.2 Two test methods are described:

1.2.1 *Test Method A*—This test method uses multiple sieves selected to span the particle size of the material. The mean particle diameter and distribution can be determined by this test method.

1.2.2 *Test Method B*—This test method is an abbreviated version of Test Method A conducted with a few specific sieves. This test method determines “percent passing” or “percent retained” on a given sieve. Test Method B is applicable to materials which do not have a normal particle size distribution such as pellets and cubes.

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

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.*

NOTE 1—There is no technically equivalent ISO standard.

2. Referenced Documents

2.1 *ASTM Standards:*

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[2]

E 691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method[2]

3. Summary of Test Methods

3.1 A dry mass of plastic material is placed on a series of sieves arranged in order of increasing fineness and the mass is divided into fractions corresponding to the sieve opening.

4. Significance and Use

4.1 These test methods can be used to determine particle size distribution and therefore are useful for determining lot-to-lot uniformity.

4.2 The particle sizes of plastic materials affect the handling characteristics and may affect the processing characteristics of some polymers.

5. Interferences

5.1 Some materials develop a static charge during sieving. This charge interferes with the sieving process and results in a coarse bias. Use of an antistat is necessary to obtain meaningful results.

5.2 The choice of antistat (or slip agent) will affect the coarse bias. Some materials are more effective in aiding the fines to separate from the mass.

5.3 Too much material on a sieve causes mass blinding and results in a coarse bias. The sieve selection and charge weight must be chosen to avoid overloading any sieve.

5.4 Wavy, improperly stretched wire-cloth may allow wires to separate without being visually damaged. Sieves with wavy or torn wires should be discarded, as they no longer conform to Specification E 11.

6. Apparatus

6.1 *Balance*, 500-g minimum capacity with 1⁄10-g sensitivity.

6.2 *Mechanical Sieving Device and Time Switch*—A mechanical sieve-shaking device equipped with an automatic time switch. This device shall be capable of imparting uniform rotary motion and a tapping action at a rate of 150 ± 10 taps/min.

6.3 *Wire Cloth Sieves*, woven wire cloth conforming to Specification E 11, as shown in Table 1, mounted in 8-in. (203-mm) frames. The number of sieves and the choice of sizes shall be selected for the material being tested. A cover and a bottom pan are also required.

6.4 *Accessories for Cleaning the Screens*:

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[1] These test methods are under the jurisdiction of ASTM Committee D-20 on Plastics and are the direct responsibility of Subcommittee D20.70 on Analytic Methods (Section D20.70.01).

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This revision adds an ISO equivalency statement, includes Table 1 showing sieve size openings, and has wording changes in Sections 10, 12, 13, and 15.

[2] *Annual Book of ASTM Standards*, Vol 14.02.

TABLE 1 Nominal Dimensions, Permissible Variations for Wire Cloth of Standard Test Sieves (U.S.A.) Standard Series

Sieve Designation		Nominal Sieve Opening, in.[A]	Permissible Variation of Average Opening from the Standard Sieve Designation	Opening Dimension Exceeded By Not More Than 5 % of the Openings	Maximum Individual Opening	Nominal Wire Diameter, mm[B]
Standard[C]	Alternative					
(1)	(2)	(3)	(4)	(5)	(6)	(7)
125 mm	5 in.	5	±3.70 mm	130.0 mm	130.9 mm	8.00
106 mm	4.24 in.	4.24	±3.20 mm	110.2 mm	111.1 mm	6.30
100 mm[D]	4 in.[D]	4	±3.00 mm	104.0 mm	104.8 mm	6.30
90 mm	3½ in.	3.5	±2.70 mm	93.6 mm	94.4 mm	6.30
75 mm	3 in.	3	±2.20 mm	78.1 mm	78.7 mm	6.30
63 mm	2½ in.	2.5	±1.90 mm	65.6 mm	66.2 mm	5.80
53 mm	2.12 in.	2.12	±1.60 mm	55.2 mm	55.7 mm	5.00
50 mm[D]	2 in.[D]	2	±1.50 mm	52.1 mm	52.6 mm	5.00
45 mm	1¾ in.	1.75	±1.40 mm	46.9 mm	47.4 mm	4.50
37.5 mm	1½ in.	1.5	±1.10 mm	39.1 mm	39.5 mm	4.50
31.5 mm	1¼ in.	1.25	±1.00 mm	32.9 mm	33.2 mm	4.00
26.5 mm	1.06 in.	1.06	±800 mm	27.7 mm	28.0 mm	3.55
25.0 mm[D]	1.00 in.[D]	1	±800 mm	26.1 mm	26.4 mm	3.55
22.4 mm	⅞ in.	0.875	±700 mm	23.4 mm	23.7 mm	3.56
19.0 mm	¾ in.	0.750	±600 mm	19.9 mm	20.1 mm	3.15
16.0 mm	⅝ in.	0.625	±500 mm	16.7 mm	17.0 mm	3.15
13.2 mm	0.530 in.	0.530	±410 mm	13.83 mm	14.05 mm	2.80
12.5 mm[D]	½in.[D]	0.500	±390 mm	13.10 mm	13.31 mm	2.50
11.2 mm	7⁄16 in.	0.438	±350 mm	11.75 mm	11.94 mm	2.50
9.5 mm	⅜ in.	0.375	±300 mm	9.97 mm	10.16 mm	2.24
8.0 mm	5⁄16 in.	0.312	±250 mm	8.41 mm	8.58 mm	2.00
6.7 mm	0.265 in.	0.265	±210 mm	7.05 mm	7.20 mm	1.80
6.3 mm[D]	¼in.[D]	0.250	±200 mm	6.64 mm	6.78 mm	1.80
5.6 mm	No. 3½[E]	0.223	±180 mm	5.90 mm	6.04 mm	1.60
4.75 mm	No. 4	0.187	±.150 mm	5.02 mm	5.14 mm	1.60
4.00 mm	No. 5	0.157	±.130 mm	4.23 mm	4.35 mm	1.40
3.35 mm	No. 6	0.132	±.110 mm	3.55 mm	3.66 mm	1.25
2.80 mm	No. 7	0.110	±.095 mm	2.975 mm	3.070 mm	1.12
2.36 mm	No. 8	0.0937	±.080 mm	2.515 mm	2.800 mm	1.00
2.00 mm	No. 10	0.0787	±.070 mm	2.135 mm	2.215 mm	0.900
1.7 mm	No. 12	0.0661	±.060 mm	1.820 mm	1.890 mm	0.800
1.4 mm	No. 14	0.0556	±.050 mm	1.505 mm	1.565 mm	0.710
1.18 mm	No. 16	0.0469	±.045 mm	1.270 mm	1.330 mm	0.830
1.00 mm	No. 18	0.0394	±.040 mm	1.080 mm	1.135 mm	0.560
850 µm[F]	No. 20	0.0331	±35 µm	925 µm	970 µm	0.500
710 µm	No. 25	0.0278	±30 µm	775 µm	815 µm	0.450
600 µm	No. 30	0.0234	±25 µm	660 µm	695 µm	0.400
500 µm	No. 35	0.0197	±20 µm	550 µm	585 µm	0.315
425 µm	No. 40	0.0165	±19 µm	471 µm	502 µm	0.280
355 µm	No. 45	0.0139	±16 µm	396 µm	426 µm	0.224
300 µm	No. 50	0.0117	±14 µm	337 µm	363 µm	0.200
250 µm	No. 60	0.0098	±12 µm	283 µm	306 µm	0.160
212 µm	No. 70	0.0083	±10 µm	242 µm	263 µm	0.140
180 µm	No. 80	0.0070	±9 µm	207 µm	227 µm	0.125
150 µm	No. 100	0.0059	±8 µm	174 µm	192 µm	0.100
125 µm	No. 120	0.0049	±7 µm	147 µm	163 µm	0.090
106 µm	No. 140	0.0041	±6 µm	126 µm	141 µm	0.071
90 µm	No. 170	0.0035	±5 µm	108 µm	122 µm	0.063
75 µm	No. 200	0.0029	±5 µm	91 µm	103 µm	0.050
63 µm	No. 230	0.0025	±4 µm	77 µm	89 µm	0.045
53 µm	No. 270	0.0021	±4 µm	66 µm	76 µm	0.036
45 µm	No. 325	0.0017	±3 µm	57 µm	66 µm	0.032
38 µm	No. 400	0.0015	±3 µm	48 µm	57 µm	0.030
32 µm	No. 450	0.0012	±3 µm	42 µm	50 µm	0.028
25 µm[D]	No. 500	0.0010	±3 µm	34 µm	41 µm	0.025
20 µm[D]	No. 635	0.0008	±3 µm	29 µm	35 µm	0.020

[A] Only approximately equivalent to the metric values in Column 1.

[B] The average diameter of the wires in the *x* and *y* direction, measured separately, of any wire cloth shall not deviate from the nominal values by more than ±15 %.

[C] These standard designations correspond to the values for test sieve openings recommended by the International Standards Organization, Geneva, Switzerland, except where noted.

[D] These sieves are not in the standard series, but they have been included because they are in common usage.

[E] These numbers (3½ to 635) are the approximate number of openings per linear inch, but it is preferred that the sieve be identified by the standard designation in millimetres or micrometres.

[F] 1000 µm—1 mm.

6.4.1 *Brush*[3],
6.4.2 *Vacuum Cleaner*, and
6.4.3 *Air Hose*.

7. Reagents and Materials

7.1 Antistat (or slip) agent suitable to the material being tested.

8. Hazards

8.1 The sieving operation and cleaning of the sieves can introduce dust from the plastic material and antistat agent into the atmosphere. Taking precautions to avoid breathing these particles may be necessary with some materials.

9. Sampling

9.1 Plastic materials may segregate by particle size during handling. Homogenize the lot where possible before removing the test sample.

10. Preparation of Apparatus

10.1 Thorough cleaning and inspection of the sieve are required prior to initiating a test. Carefully clean the sieves with a brush and vacuum cleaner or compressed air, or both. Periodic washing with soap and water or suitable solvent may be required with some materials.

10.2 Tare each sieve and the pan. Record tare weights to the nearest ¹⁄₁₀-g.

10.3 Assemble sieves so that the sieve openings decrease in size in sequence from the top of the stack. Place the pan at the bottom.

10.4 Use full- or half-size screens to accommodate the holder in the shaker.

11. Conditioning

11.1 The plastic material must be in a free-flowing condition.

11.2 If possible, the material should be conditioned to the laboratory temperature and humidity.

TEST METHOD A

12. Procedure

12.1 Select sieves in sufficient number to cover the expected range of particle sizes, and nest them together in order of diminishing opening with the coarsest sieve on top and the pan on the bottom.

NOTE 2—Select sieves in sufficient number to have significant measurable quantities on four or more sieves. Weigh the sieves on a balance accurate to 0.1 g. Record these sieve masses as their tare masses, respectively.

12.2 Weigh 50 g of sample to the nearest 0.1 g and transfer it to the top of the stack. Record the sample weight used. A larger sample size could cause screen blinding and skew the results to the coarse particle size. A screen can be considered blinded if it is holding 20 or more g. For repeatable results, use a smaller sample size.

NOTE 3—For some materials an antistat (or slip agent) is needed. Add 1% of the antistat (or slip agent) to the sample and mix in with a spatula. State in the report the agent used. With polyvinyl chloride resins, it has been found that the distribution will skew to either the fine or the coarse particle size depending on the antistat used. Record the antistat (or slip agent) used.

12.3 Cover the stack and place it in the mechanical sieve shaker. Start the shaker and run for 10 min. Longer times may be required depending on the efficiency of the shaker.

12.4 After shaking, carefully separate the stack of sieves, beginning at the top, and weigh each sieve with powder to the nearest ¹⁄₁₀ g. Determine the net weight of the powder remaining in each sieve by subtracting the sieve tare masses from the total weight of the sieve and the powder in that sieve.

12.5 If the cumulative total of actual weight is less than 98 %, carefully check the weights and operations and repeat the work if necessary.

13. Analysis of Particle Distribution

13.1 *Calculation of Particle Distribution*:

13.1.1 Obtain net weight of material retained on each sieve. Calculate percentage by dividing net weight by total sample weight × 100.

13.1.2 Repeat for each sieve.

13.2 *Calculation of Mean Particle Size*:

13.2.1 Obtain net weight of material retained on each sieve.

13.2.2 Determine an average particle size for each sieve. The average particle size is defined as the nominal opening size of that sieve plus the nominal opening size of the next larger sieve in the stack divided by two.

13.2.3 For materials that have a normal distribution, calculate the mean particle size as

$$D_m = \Sigma(P_i \times D_i)$$

where:
D_m = mean particle diameter, µm,
P_i = material retained on sieve (or pan), %, and
D_i = average particle size of material on sieve, µm.

14. Report

14.1 Report the following information:

14.1.1 Percentage of material retained on each sieve, with its corresponding sieve size,

14.1.2 Sample weight,

14.1.3 Antistat (or slip agent) used, and

14.1.4 Mean particle size.

TEST METHOD B

15. Procedure

15.1 Choose the sieve(s) to be used and weigh each of them on a balance accurate to 0.1 g. Record these sieve masses as their tare masses, respectively. If a single sieve is being used, stack it on the pan and transfer a sample weighing 100 ± 0.1 g to that sieve. If two sieves are to be used in the analysis of the sample, stack the coarse sieve over the fine sieve and transfer the weighed sample to the coarse sieve. For those finely

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[3] Type 8577 (W. S. Tyler) Brush, available from W. S. Tyler, Inc., 8200 Tyler Blvd., Mentor, OH 44060, has been found satisfactory for this purpose.

divided powders which tend to clog the sieves, add 1.0% of an antistat (see Note 2 and Note 3).

15.2 Cover the stack and place it in the mechanical sieve shaker. Start the shaker and run for 10 min ± 15 s.

15.3 After shaking, carefully separate the stack of sieves, beginning at the top, and weigh each sieve with powder to the nearest one tenth of a gram.

16. Report

16.1 Report the following information:

16.1.1 Percentage of material retained on each sieve, with its corresponding sieve size,

16.1.2 Sample weight, and

16.1.3 Antistat (or slip agent) used.

17. Precision and Bias

17.1 *Precision*—Table 2 and Table 3 are based on a round robin conducted in 1985 in accordance with Practice E 691, using D1921 – 89, involving four materials tested by three laboratories. For each material, all the samples were prepared at one source, but the individual specimens were prepared at the laboratories that tested them. Each test result was the result of one individual determination. Each laboratory obtained two test results for each material.

TABLE 3 Calculated Mean Particle Diameter

Material	Average of Calculated Mean Particle Diameters	Values, µm			
		S_r[A]	S_R[B]	I_r[C]	I_R[D]
Acrylic powder	196	0.8	13	2.3	36.8
Polyethylene powder	291	0.6	4.8	1.7	13.6
PolyVinyl chloride with carbon black	137	2.2	1.8	6.2	5.1
PolyVinyl chloride with hi-sil	137	2.2	1.6	6.2	4.5

[A] S_r = within-laboratory standard deviation of the average,
[B] S_R = between-laboratories standard deviation of the average,
[C] I_r = 2.83 S_r, and
[D] I_R = 2.83 S_R.

NOTE 4—**Caution:** The explanations of *r* and *R* (17.2-17.2.2) are only intended to present a meaningful way of considering the approximate precision of this test method. The data in Table 2 and Table 3 should not be applied to acceptance or rejection of materials, as these data apply only to the materials tested in the round robin and are unlikely to be rigorously representative of other lots, formulations, conditions, materials, or laboratories. Users of this test method should apply the principles outlined in Practice E 691 to generate data specific to their materials and laboratory (or between specific laboratories). The principles of 17.2-17.2.2 would then be valid for such data.

17.2 *Concept of r and R in Table 3*—If S_r and S_R had been calculated from a large enough body of data, and for test results that were averages from testing seven specimens for each test result, then the following would apply:

17.2.1 *Repeatability*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more

TABLE 2 Percent Retained on Each Sieve of Screen Pack

Material	USA Sieve Number	Values in Units of Percent				
		Mean Retained on Sieve	S_r[A]	S_R[B]	I_r[C]	I_R[D]
Acrylic powder	40	13.5	0.1	1.2	0.3	3.4
	60	15.0	0.2	1.4	0.6	4.0
	80	9.3	0	0.4	0	1.1
	100	6.6	0.1	0.7	0.3	2.0
	200	22.9	0.1	1.2	0.3	3.4
	325	16.2	0.2	1.6	0.6	4.5
	PAN	16.5	0.1	3.6	0.3	10.2
Polyethylene powder	40	11.4	0.6	2.6	1.7	7.4
	60	47.8	0.6	2.9	1.7	7.6
	80	18.0	0.1	0.8	0.3	2.3
	100	7.5	0.1	0.7	0.3	2.0
	PAN	15.3	0.1	1.3	0.3	3.7
Polyvinyl chloride powder with carbon black antistat	40	0	...	...	...	...
	60	0.1	0.1	0.1	0.3	0.3
	80	5.4	0.9	0.9	2.5	2.5
	100	28.4	2.1	2.2	5.9	6.2
	140	53.7	1.3	1.6	3.7	4.5
	200	11.4	1.7	1.5	4.8	4.2
	PAN	0.9	0.3	6.3	0.9	0.9
Polyvinyl chloride powder with hi-sil antistat	40	0	...	...	...	...
	60	0	...	...	...	...
	80	4.2	0.7	0.6	2.0	1.7
	100	30.3	2.9	2.9	8.2	8.2
	140	52.6	2.0	2.2	5.7	6.2
	200	11.3	1.3	1.3	3.7	3.7
	PAN	1.5	0.3	0.3	0.9	6.9
Polystyrene cubes	20	99.9	...	...	...	...
	PAN	0.06	...	0.04	...	0.1

[A] S_r = within-laboratory standard deviation of the average (median/other function),
[B] S_R = between-laboratories standard deviation of the average median,
[C] I_r = 2.83 S_r, and
[D] I_R = 2.83 S_R.

than the *r* value for that material; *r* is the interval representing the critical difference between two test results for the same material obtained by the same operator using the same equipment on the same day in the same laboratory.

17.2.2 Any judgment in accordance with 17.2.1 would have an approximate 95% (0.95) probability of being correct if an adequate number of laboratories had participated.

17.3 There are no recognized standards by which to estimate the bias of these test methods.