Introduction

Standard test sieves are an accepted means for determining the classification, according to particle size, of divided solid material from its raw state through the various stages of processing, crushing, pulverizing, and screening to the finished product. By the use of a series of sieves, with apertures embracing the size range of the material being tested, complete information on the particle size distribution in the sample can be quickly and accurately obtained.

Because of the widely different properties of the various materials to be sieved, such as size of particles, density, moisture, hygroscopic properties, particle shape, friability, abrasiveness, cohesiveness, etc., it is not possible to specify a single procedure to follow in making all sieve tests. Fortunately, standard sieve test procedures have been established for many important materials and groups of similar materials, and, whenever such standard procedures exist, it is important that they be followed to the letter by all laboratories or individuals making sieve tests of the materials the standards cover. For a list of published ASTM standards pertaining to sieve analysis and sampling procedures, see Tables 7 and 8 in the Appendix of this manual.

In spite of the considerable standardization work that has been done, there are hundreds of granular materials for which sieve analysis data are desired but for which standard test procedures have not been established or published. One of the objectives of this manual is to meet this need for supplementary procedures for specific materials by summarizing the most accepted general procedures for making sieve tests and also by providing guidelines for developing new standard sieve analysis procedures when none are available.

1. Wire Cloth Sieves

1.1 Standard test sieves that conform to ASTM Specifications E 11 (Table 1) should always be used. This series of test sieves, based on the principal of a fixed ratio of $\sqrt[4]{2}$ to 1 between the sieve openings, was first introduced in the United States in 1910 and since has achieved worldwide use. The number of sieves in the series and the spacing of the apertures in the scale have been proved, by over fifty years experience, to be ideal for the great mass of sieve analysis work. Since 1910, many countries have adopted national sieve standards based on the same fixed ratio as the U.S. series.[1]

1.2 The International Standards Organization (ISO), with the USA participating, adopted in 1969, a Recommended Series of Apertures for Test Sieves for universal use. In 1970, the USA Standard Sieve Series, ASTM Specification E 11 was revised for full compatibility with the ISO Recommended Aperture Designations, while retaining the basic $4\sqrt{2}$:1 ratio between the sieve openings.

1.3 For most sieve tests, where the largest particle in the sample does not exceed 1 in. (25 mm), standard 8-in. (203-mm)-diameter, 2-in. (50-mm)-deep sieves are recommended. For special cases and with small samples 3-in. (76-mm) and 6-in. (152-mm)-diameter sieves are available. All three diameters of sieves are also available with half-height frames 1 in. (25 mm) deep. These half-height sieves are very useful when working with small samples, or when using intermediate nesting pans between sieves in the stack to make multiple simultaneous tests with a mechanical shaker.

1.4 Standard 8-in. (203-mm) test sieves normally are available with brass frames with brass wire cloth for the coarser sieves and phosphor bronze wire cloth for the finer sieves. Stainless steel sieve cloth is available and is increasing in popularity because of its greater strength, durability, and resistance to abrasion and corrosion. Stainless steel sieves can be specified with either brass or stainless steel frames.

1.5 For tests of samples with large size particles, larger diameter frames, such as 10 in. (254 mm), 12 in. (305 mm), 16 in. (406 mm), 18 in. (457 mm), are available; the latter three sizes also are available with square frames.

1.6 For more complete details of standard test sieves, including methods of checking and calibrating the sieves, see the complete ASTM Specifications E 11.

2. Perforated Plate Sieves

2.1 Perforated plate sieves, made to conform to ASTM Specification E 323 (Table 2) are available with square apertures from 125 to 3.35

[1] Including Canada, United Kingdom, Netherlands, Australia, New Zealand Japan, India, Argentina, Chile, and Uruguay.

mm (5 to 0.127 in.) and with round apertures from 125 to 1 mm (5 to 0.039 in.) The sizes of successive apertures in the series follow the same ratio as in the standard ASTM Specification E 11 for sieves.

2.2 Standard frames for perforated plate sieves with apertures 4.00 mm and larger are made of hardwood or steel to hold 12 in. (305 mm), 16 in. (406 mm), or 18-in. (457-mm) square sieve plates. For apertures smaller than 4.00 mm, 8-in. (203-mm) circular frames as well as the above larger square frames may be used.

2.3 In general, round hole sieves are used only when the product specification is based on round hole apertures. Where perforated sieves and wire cloth sieves are to be used in the same test, or where results with perforated sieves might be compared with results with wire cloth sieves, it is recommended that only square aperture sieves be used. Results with a given square aperture and with the same diameter round aperture are *not* compatible.

3. Precision Electroformed Sieves

3.1 Precision electroformed sieves, made to conform to ASTM specification E 161 (Table 4), are available with apertures as fine as 5 micron. With the use of proper care and the special procedures outlined in the instructions following Table 4 (Appendix), sieve analysis results can be obtained in the range of 40 to 5 micron that is unattainable by any other sieving means. Electroformed sieves, when properly calibrated and used are sometimes employed as a reference standard in the range of 1820 microns to 5 microns.

3.2 Because of the delicacy of the electroformed sheet from which the sieves are made, they must be handled with extreme care, and the same procedures as for tests with the wire cloth sieves cannot be used.

3.3 Because of the small size of the sieves, 3 in. (76 mm) and their very limited open area, especially in the sieves apertures, very small size samples, .002 g in many cases, must be used together with very sensitive analytical balances that are capable of weighing to + − 1 mg. Eight inch (203 mm) sieves are also available and they require sensitive analytical balances, but proportional large sample, can be made. All precision electroformed sieves are matched sieves.

4. Centerline Sieves

4.1 ASTM Specifications E-11 specify certain manufacturing tolerances permitting a slight plus or minus variation in the average opening for each sieve. Where extreme accuracy is desired on very closely sized material more closely graded sieves may be required.

At least one sieve manufacturer has available Centerline Sieves. The openings of a test sieve can be very accurately measured on a mass basis through the use of a computerized optical comparator.

Thus when greater accuracy is required equipment of this type enables the manufacturer to select sieves whose openings fall as near as possible on the centerline of the allowable tolerances. Contact ASTM Committee E-29.01 for information of those suppliers who provide this service.

4.2 It is obviously impractical, especially in the finer meshes, to select sieves having all openings with near zero tolerances by measurement, as there are literally millions of openings to measure in each sieve.

4.3 ASTM Specification E 11 calls attention to the availability and usefulness of "matched sieves." Matched sieves are selected by a rigid procedure of actual sieve analyses with the particular material for which the sieves are to be used; the results obtained are compared with a master set of measured sieves. Sieves of this type are the most accurate obtainable, and the comparability of results using "matched sieves" far exceeds those obtainable with sieves which are merely "certified" to be within the specifications and tolerances of the ASTM Specification E 11.

5. Samples and Sampling

5.1 Accurate sampling is of the greatest importance and is the basic requirement for reliable sieve analyses. Great care should be taken to obtain samples that are truly representative of the batch or lot being tested. The greatest cause of inconsistencies in test results is improper sampling that does not truly represent the material. Therefore, once the sampling procedure is established, this same procedure should always be followed.

5.2 *How to Take Samples*—It is not practicable to specify a single method of sampling since the character of the material and the form in which it is available will affect the selection of the procedure to be used. For example, the material may be fine, medium, or coarse, and it may be in a pile, railroad cars, bags, or a continuous stream. Sampling procedures for a variety of materials are described in the ASTM standards listed in Table 7 and should be used for all materials which they cover. For other materials, generally accepted procedures are outlined in this manual.

5.3 *Size of Gross Sample*[2]—The size of a gross sample will depend not only on the character of the material and the form in which it is available (see Paragraph 5.2) but also on whether the test is to determine the particle size distribution of a pile, batch, shipment, day's production, or short span of time for production control. The range of size of a gross sample is very wide. It may be as much as several thousand pounds (or kilograms) and may be as little as a fraction of a

[2] In this manual the primary sample taken for a sieve analysis test is referred to as the "gross sample," while the sample that has been reduced to the size for the sieve test is referred to as the "test sample."

pound (or kilogram). For detailed sampling instructions and suggested gross sample sizes for specific materials, see Tables 6 and 7.

5.4 *Sampling from a Chute or Belt*—Good accuracy in sampling is obtained where material is flowing from a chute or a belt conveyor. The ideal place to take the sample is just where the material drops from the chute or belt. When taking the sample, if the stream is small enough, use a pail or other suitable receptacle which can be swung completely across the flowing stream in a brief interval of time and with a uniform movement. Under no circumstances should the sampling receptable be allowed to overflow, because the overflow would tend to reject a higher proportion of the larger particles than exist in a representative sample. Mechanical sampling devices are available for selecting samples automatically from a stream at uniform spaced intervals of time.[3]

5.5 *Sampling from a Pile*—In sampling from a pile, particularly material like crushed stone or coal containing large particles, it is extremely difficult to secure samples that are truly representative. At the apex of a conical pile, the proportion of fines will be greater, while at the base, the percentage of coarse particles will be greater. Therefore, neither location will be representative of the whole. In a shoveling process, every fifth or tenth shovel, etc., should be taken depending on the amount of the sample desired. The sample should consist of small quantities taken at random from as many parts of the pile as are accessible and taken in a manner that the composite will have the same grading as the larger amount.

5.6 *Sampling from Carload Shipments of Coarse Bulk Materials*—For coarse materials, such as crushed stone and gravel, shipped in railroad cars, a recommended method is to dig three or more trenches at least 1 ft (30.38 cm) deep and approximately 1 ft (30.38 cm) wide at the bottom. Equal portions are taken at seven equally spaced points along the bottom of the trench by pushing a shovel downward into the material and not by scraping horizontally. Samples from trucks, barges, or boats should be taken in the same manner as from railroad cars, except that the number of trenches should be adjusted to the size of the transportation unit and tonnage involved.[4]

5.7 *Sampling from Carload Shipments of Fine Bulk Materials*—One established method for sampling a carload of bulk granular material is to take eight samples of equal size (approximately 700 to 1000 g each) from the bottom of a 1-ft (30.48-cm) conical excavation. Samples

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[3] Mechanical sampling devices are described in ASTM Methods for Mechanical Sampling of Coal (D 2234).

[4] For further details on procedures for sampling from carload shipments of coarse and fine materials, see ASTM Methods of Sampling Stone, Slag, Gravel, Sand, and Stone Block for Use as Highway Materials (D 75).

should be suitably spaced to represent the length and width of the car and then combined into a single gross sample.[5]

5.8 *Sampling Bulk Shipments of Fine Material with a Sampling Tube*—An alternate and simpler method of sampling a carload, or other bulk quantity of fine or granular material is by the use of a sampling tube which, for this purpose, should be 1½ in. (31.75 mm) by approximately 6 ft (1.829 m). Five or six insertions of the tube will produce approximately a 10-lb (907-g) sample.[4]

5.9 *Sampling from a Carload of Bagged Material*—One method of sampling a carload of material shipped in bags is to select, at random, a number of bags equal to the cube root of the total number of bags in the car and to take suitable portions (800 to 1000 g for minus 6-mm material) from each of the selected bags for a combined gross sample.[5]

5.10 *Reduction of Gross Sample to Test Size for Sieve Analysis*—After the gross sample has been properly taken, the next step is to reduce it to a suitable size for the sieve analysis test without impairing in any way the particle size distribution characteristics of the original sample. This phase of the operation should follow the applicable ASTM published standards, or the procedures described in the succeeding sections, and should be performed with as much care as was used in the collection of the gross sample and in making the sieve test.

5.11 *Coning and Quartering*—Pile the gross sample in a cone (Fig. 1), place each shovelful at the apex of the cone, and allow it to run down equally in all directions. This will mix the sample. Then spread the sample in a circle and walk around the pile, gradually widening the circle with a shovel until the material is spread to a uniform thickness. Mark the flat pile into quarters, and reject two opposite quarters. Mix again into a conical pile, taking alternate shovelfuls from the two quarters saved. Continue the process of piling, flattening, and rejecting two quarters until the sample is reduced to the required size.[6]

5.12 *Sample Splitters and Reducers*—Gross samples, if not too large, may be reduced to test sample size by one or more passes through a sample splitter or Jones type riffler (Fig. 2), which will divide a sample in half while maintaining the particle size distribution of the original sample. By repeated passes, the sample can be split into quarters, eighths, etc, until the size of the sample desired is obtained. For larger gross samples, sample reducers are available which will select a representative 16th part with a single pass (Fig. 3). By just two passes through such a unit, a representative 1-lb sample can be obtained from an original 256 lb. Three passes will give a 1-lb sample from two tons

[5] For further details on sampling from carload shipments of fine granular materials in both bulk and bagged form, see ASTM Test for Sieve Analysis of Granular Mineral Surfacing for Asphalt Roofing and Shingles (D 451).

[6] The operations of mixing, coning, and quartering are illustrated and described in detail in Method of Sampling Coke for Analysis (D 346).

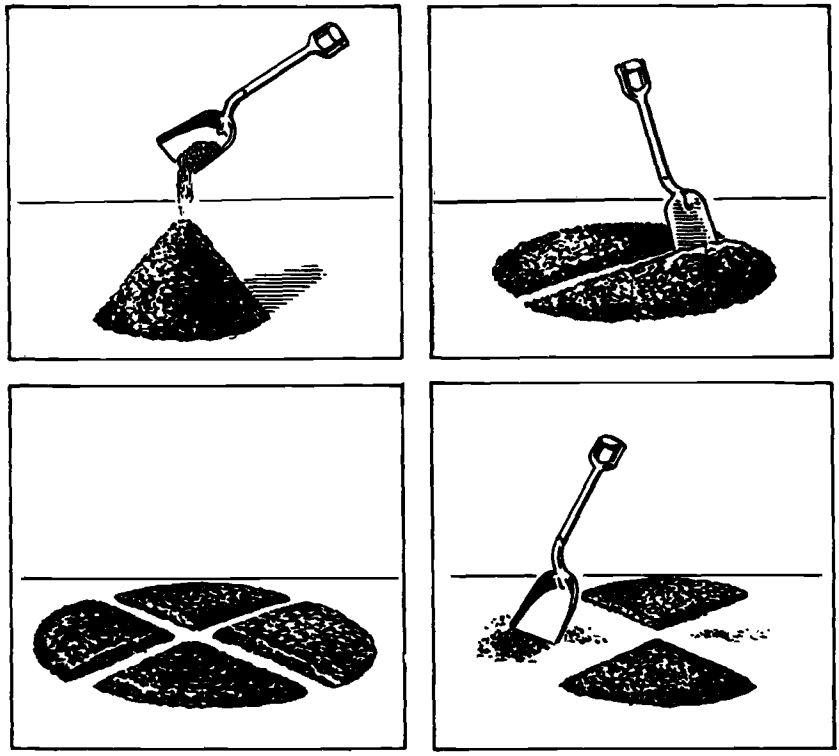


FIG. 1—*Coning and quartering of sample.*

of material. Always make sure that the passages in the splitter or reducer are at least three times the size of the largest particle in the sample. Do not attempt to arrive at exactly the amount of material specified for the test. If a 50-g sample is desired, arrive as near to this amount as practicable, because it will make no difference in the test percentage results whether the sample is slightly larger or smaller. In attempting to arrive at an exact weight, the tendency is to discriminate by the removal of sizes which are not representative of the whole, thus destroying the representative quality of the sample.

5.13 *Size of Test Sample*—If the size of the test sample for the sieve analysis has not been established by a published standard, or otherwise, it may be determined by the following suggestions. In deciding on the size of a test sample, consideration must be given to the character of the material, its screenability, and the range of particle sizes present. For example, in making a sieve analysis of a material representing the stream to a fine screen or a product from a crusher, which contains a range of small particle sizes, a sample of from 500 to 1000 g may be required, while for a coarse aggregate up to 20 kg or more might be

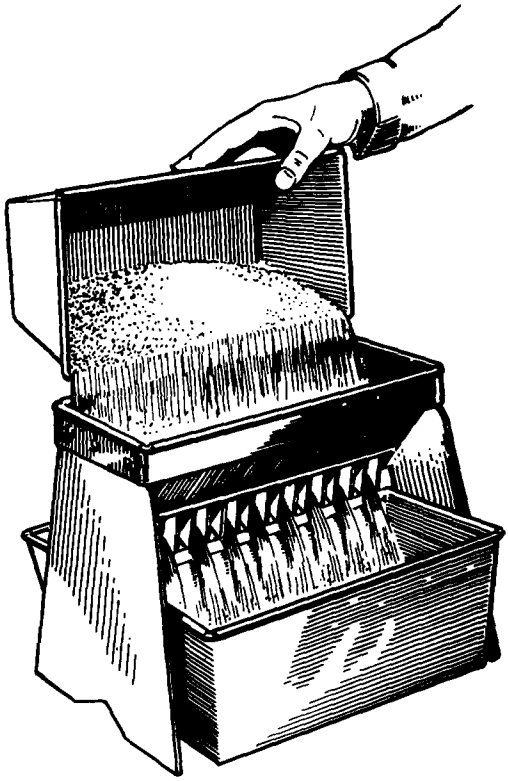


FIG. 2—*Sample splitter.*

necessary. For a finely ground product, a sample of 25 to 100 g could be sufficient.

5.14 *Sample Weight Limits*—In determining the suitable size of the test sample, the weight per cubic unit of the material is very important. For example, as may be seen from Table 5, a 100-cm^3 sample of powdered iron would weigh approximately 390 g, while the same volume of diatomaceous earth would weigh only 50 g. The volume of the test sample should be such that no sieve is overloaded to a point where there is a crowding of oversize and near-mesh particles on the sieve surface. Overloading is most likely to occur in tests of materials which have a concentration of particles close to one size, or where the entire sample is within a narrow size range, for example, if a large proportion of the particle sizes would be between a 2-mm sieve and a 500-μm sieve. In such a case, the size of the sample should be determined by the capacity (without overloading) of the sieve retaining the largest amount of the sample. At the same time, the sample must be large enough to permit a measurable amount of the material to be retained on each sieve, particularly on the control sieves. In making a sieve analysis of medium or

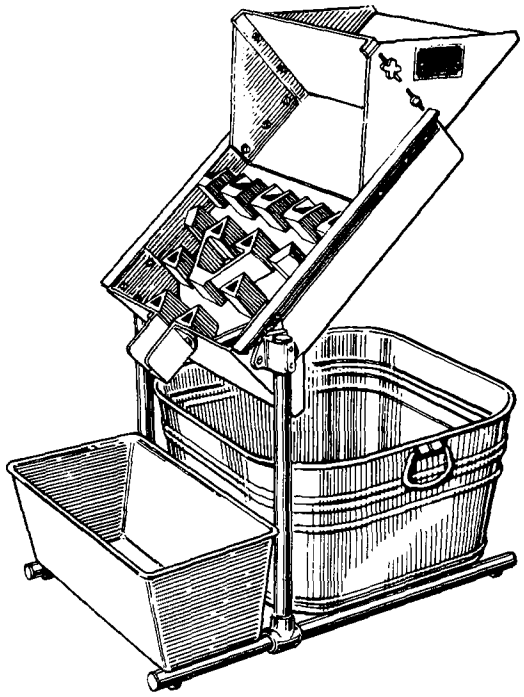


FIG. 3—*Sixteen to one sample reducer.*

fine material, it is best not to use too large a sample. A smaller sample properly taken and carefully reduced will usually give more accurate and consistent results than a larger sample which might overload one or more of the sieves. The reverse may be true when testing coarse materials, such as coarse aggregates where larger samples are required to constitute a representative portion.

5.15 *Determination of Test Sample Size*—As a check method to determine the correct size of a sample, the following procedure is suggested. With a sample splitter, accurately split samples of varying weights, such as 25, 50, 100, and 200 g. Then run these various samples on the sieves selected for a period of approximately 5 min, preferably on a mechanical sieve shaker. A comparison of these results will show the most suitable size sample to use. For example, if the test with the 100-g sample shows approximately the same percentage passing the finer sieves as the 50-g sample, whereas the 150-g sample shows a lower percentage through the finest sieve, this would be an indication that a 150-g sample would be too large, but a 100-g sample would be satisfactory. Once the correct size sample is determined for a particular test, this same size sample should be used for all such tests.

5.16 *Table of Suggested Sample Sizes*—A useful table of recom-

mended sample sizes for tests with 8-in. or 200-mm sieves is given in Table 4. Note that the table gives sample sizes by volume. Recommended sample weights (in grams) can be determined by mutiplying the values in Columns 3 and 4 by the bulk density (in grams per cubic centimeter) of the material to be tested, rounded out within a tolerance of ± 25 percent. If the actual bulk density of the material being tested has not been determined, the typical density factor for the most nearly similar material listed in Table 5 may be used. The values in Table 4 are a useful guide where standard test sample sizes have not already been established, but it is suggested that the sample sizes obtained by the use of Table 4 be verified by the procedure outlined above before adopting them as standard.

6. General Test Sieving Procedure

6.1 If the test sample is not dry and free flowing because of moisture, it should be dried to a constant weight usually at a temperature of 230 ± 9 F (110 ± 5 C), except in cases where such temperature might have some adverse effect on the material.

6.2 Weigh and record the weight of the test sample to an accuracy (in general) of 0.1 percent.

6.3 Select the sieves to be used in the test from the ASTM standard sieve series listed in the Appendix. Most sieve analyses are made with a nest of sieves, and it is desirable that this nest consist of as few sieves as possible and still give adequate information on the size distribution of the material being tested. For example, for a minus 1-in. (25-mm) material, every other sieve or every third sieve could be used, provided such a selection gives the desired information and does not result in the overloading of any of the sieves. In some cases, coarser sieves are used in the nest to protect the finer sieves from excessive wear or overloading. For graded materials with a narrow particle size range, such as abrasives, filter sand, etc., every sieve in the fourth root of two ratio in the series should be used. In other cases, such as a test for production control, it may be that only one sieve is needed. Where high precision and close comparability of test results are desired, matched sieves (see Section 4) should be used.

6.4 Nest the selected sieves in sequence with the coarsest sieve at the top and the solid pan at the bottom. Place the test sample on the top sieve and close the nest with a cover. Proceed with the test using either the hand sieving method (see Section 7) or the mechanical sieve shaker method (see Section 8).

6.5 *Grain-Size Analysis of Soils*—Making sieve analysis tests of soils is a highly specialized procedure, and it is recommended that such tests be made using the procedures outlined in ASTM method for Dry Preparation of Soil Samples for Grain-Size Analysis and Determination of Soil Constants (D 421); Method for Grain-Size Analysis of Soils

(D 422); Test for Amount of Material in Soils Finer Than the No. 200 Sieve (D 1140); and Method for Wet Preparation of Soil Samples for Grain-Size Analysis and Determination of Soil Constants (D 2217).

7. Hand Sieving Method

7.1 Hand sieving is the original basic method of making sieve analyses. In hand sieving, the tests are made, or at least completed, on one sieve at a time. The best procedure is to place the test sample on a clean dry sieve with the pan attached. While holding the uncovered sieve and pan in both hands, sieve with a gentle rotary motion until most of the fine material has passed through and the residue looks fairly clean. This operation usually takes only 1 or 2 min for sieves coarser than No. 100 and 3 or 4 min for sieves No. 100 and finer. When the residue appears clean, place the cover on the sieve, turn it upside down, and remove the pan. Then, with the sieve and cover held firmly in one hand, gently tap the side of the sieve with the handle of the brush used for cleaning sieves. Dust adhering to the sieve and particles in the mesh will be dislodged, and the underside on the sieve may be brushed clean. Empty the pan and thoroughly wipe it with a cloth or waste, replace it on the sieve, restore the assembly to an upright position, and carefully remove the cover. Replace on the sieve any coarse material that has been caught in the cover during the tapping. Continue the sieving without the cover, as described above, until not more than 1 percent by weight of the residue passes any sieve during 1 min. The gentle sieving motion involves no danger of spilling the residue, which should be kept well spread out on the sieve. Continuously rotate the sieve during the sieving.

7.2 *"End-Point" Tests*—Hold the sieve, with pan and cover attached, in one hand at an angle of about 20 deg from the horizontal. Move the sieve up and down in the plane of inclination at the rate of about 150 times per minute, and strike the sieve against the palm of the other hand at the top of each stroke. Perform the sieving over a white paper to avoid losing particles that may pass between the lid and the sieve. Return any material collecting on the paper to the sieve. After every 25 strokes, turn the sieve about one sixth of a revolution in the same direction. As an aid to proper sieve rotation, the sieve cover may be marked with three straight lines, intersecting at 60 deg through the center, with one of the lines marked with an arrowhead to indicate the starting point. Continue the sieving operation until the additional material which passes through in 1 min of continuous sieving fails to change the amount on that sieve by more than 1.0 percent. In reporting sieve tests, calculations should be carried out to 0.1 percent.

7.3 *Procedure with a Stack of Sieves*—In hand sieving, when a number of sieves are to be used in the test, arrange the sieves in a stack (include a bottom pan) with the coarsest sieve at the top, and place the

sample to be sieved on the top sieve. Give the whole nest of sieves a preliminary shaking for 2 or 3 min. The most practical way to do this is to place the stack on a table and shake the sieves with a circular motion accompanied by a tapping action. After this preliminary shaking, shake each sieve separately starting with the coarsest, to complete the separation as described in Paragraph 7.2. Add all material passing in each individual sieve to the next smaller sieve in the sequence.

7.4 *Consistency Important in Hand Sieving*—The operator should try to be consistent with the hand sieving method to always reproduce the same circular motion and tapping action. If hand sieving is to be used for repeated tests by more than one laboratory, it is important that a detailed hand sieving procedure be established and specified.

7.5 *Hand Sieving as a Referee*—In general, in case of doubt or dispute on the correctness of the results of a sieve analysis, the questioned figures should be checked against results obtained by hand sieving, using the procedures described under Paragraphs 7.1 and 7.2, which shall be final.

8. Mechanical Sieve Shaker Method

8.1 Mechanical sieve shakers are used in practically all laboratories where frequent tests are made. They not only eliminate much tedious hand labor, but, when properly used, will produce more consistent results.

8.2 There are several general types of mechanical sieve shakers. One type is designed to simulate hand sieving by using a circular motion combined with a tapping action. Figures 4 and 5 are examples of this type.

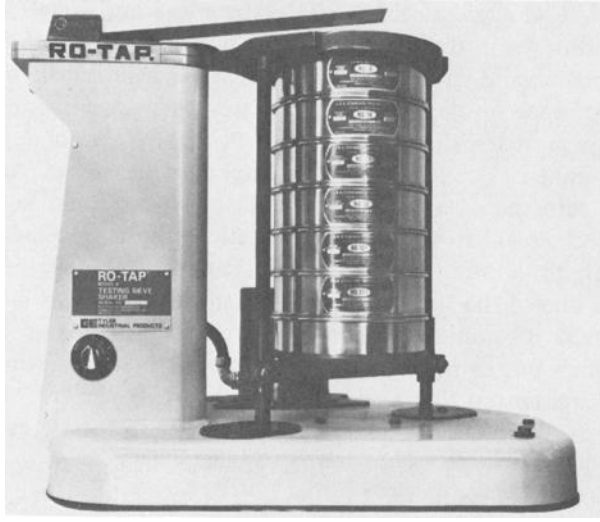


FIG. 4—*Mechanical sieve shaker with tapper.*

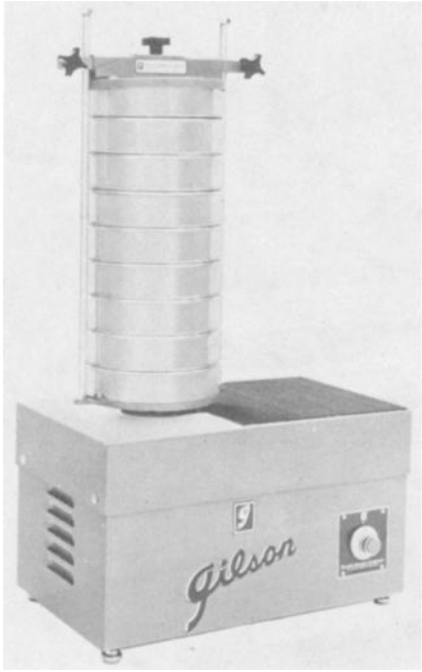


FIG. 5—*Mechanical sieve shaker.*

8.3 A type of sieve shaker which will handle a stack of 18-in. (45.7-cm) square sieves is shown in Fig. 6. This type produces a vigorous agitation especially suitable for handling large samples of coarse materials such as crushed stone, gravel, etc.

8.4 Another type uses an electromagnetically induced high-speed short-stroke vibration with a control to vary the intensity of the sieving action. This type is illustrated by Figs. 7 and 8.

8.5 A distinct method for obtaining particle distribution, operating on a different principle than any of those previously described is shown in Fig. 9. This type uses an oscillating column of air developed within the stack of sieves to effect classification of the test sample. The "lift" action of the air column is adjustable. The unit uses 3-in. (76.2-mm) sieves and is limited to testing small samples of not over 30 g by weight or 10 cm^3 by volume. Wire cloth and electroformed type sieves can be used, with dry separations down to 5 micron.

8.6 In using mechanical sieve shakers, it is necessary to determine the length of sieving time best suited to the type of materials being tested, and, for shakers with variable controls, it is necessary to determine and establish the exact setting of the controller for best results.

8.7 For routine plant control tests, 3 to 5 min is usually sufficient to give the desired result, while for more difficult materials a sieving time of from

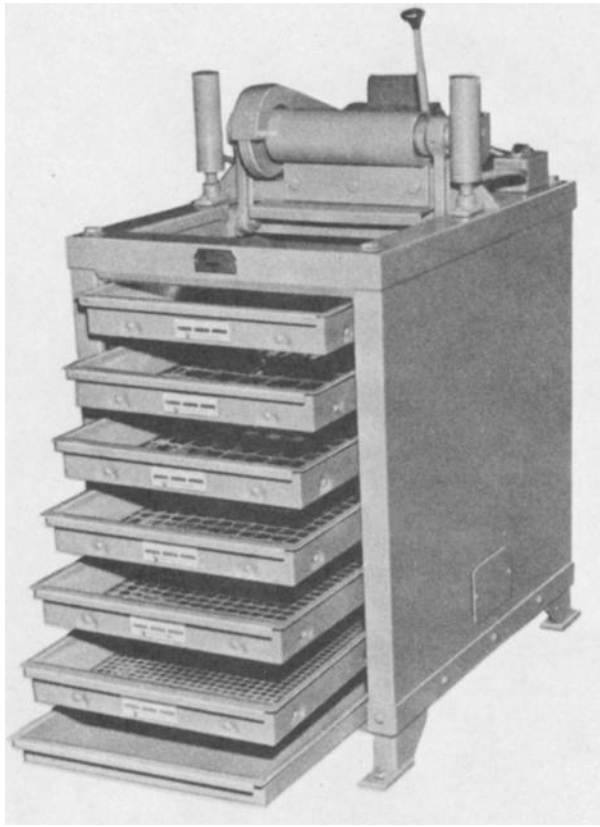


FIG. 6—*Mechanical shaker for large sieves.*

10 to 30 min may be necessary. Prolonged sieving time should be avoided when testing friable materials subject to degradation.

8.8 To determine the sieving time necessary to produce close analysis results, use the following procedure: From a gross sample, with a sample splitter select three or four samples of a suitable weight or volume for the test. Sieve one of these samples for 5 min, one for 10 min, one for 15 min, and a fourth for 20 min. Tabulate the results of these tests by the percentages retained on each sieve, and the length of sieving time required to stabilize the sieving result will be readily apparent and can be established.

8.9 For most tests, a satisfactory end-point is considered to have been reached when an additional 1 min of sieving fails to change the weight on any of the sieves used by more than 1.0 percent.

8.10 Sieve tests where the ultimate in accuracy is desired can be set up on the basis of shaking the nest of sieves until not more than 0.5 percent of the material on the finest sieve passes that sieve in a 5-min

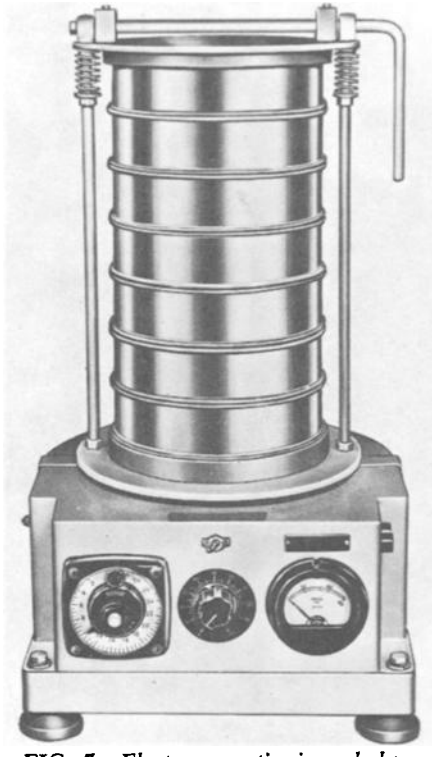


FIG. 7—*Electromagnetic sieve shaker.*

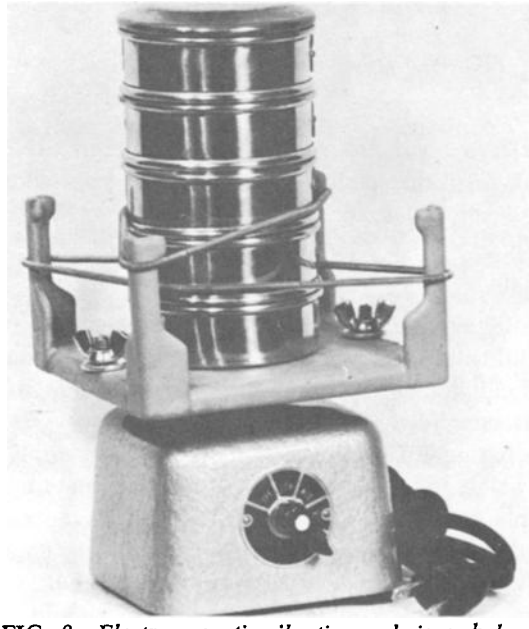


FIG. 8—*Electromagnetic vibration pad sieve shaker.*

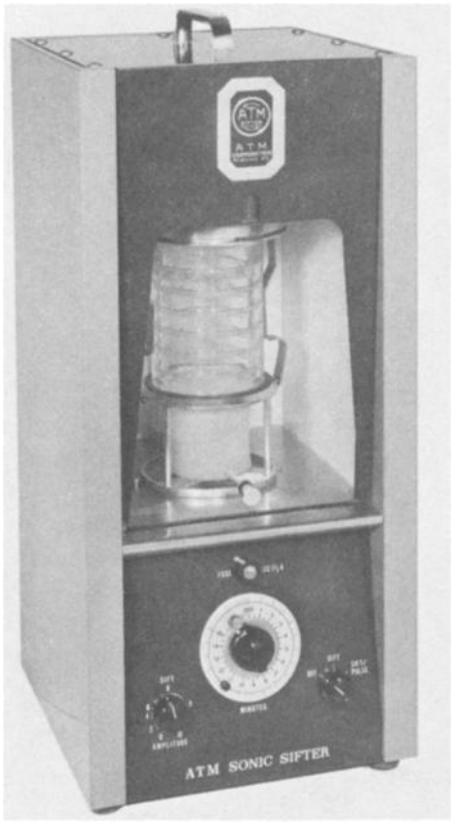


FIG. 9—*Oscillating air column type sieve shaker.*

period. This is a good procedure to follow when no control can be made on the type of mechanical sieve shaker to be used, or if hand and mechanical sieving are used interchangeably.

9. Wet Testing

9.1 If at all possible, test sieving should be done on dry material; however, if difficulty is encountered in obtaining reproducible results on materials difficult to screen and if the material is not soluble in water, accurate tests can be made by the wet method.

9.2 In preparing for a wet test, first dry the sample to a constant weight and weigh to the nearest 0.1 g. If the material readily mixes with water, place the test sample on the finest sieve, and wash it back and forth with a gentle stream from a hose in such a way that there is no loss by rising dust or splashing. When the water passing through the sieve is clear, the sieve containing the residue should be dried, in an oven if possible, to a constant weight and at a temperature not to

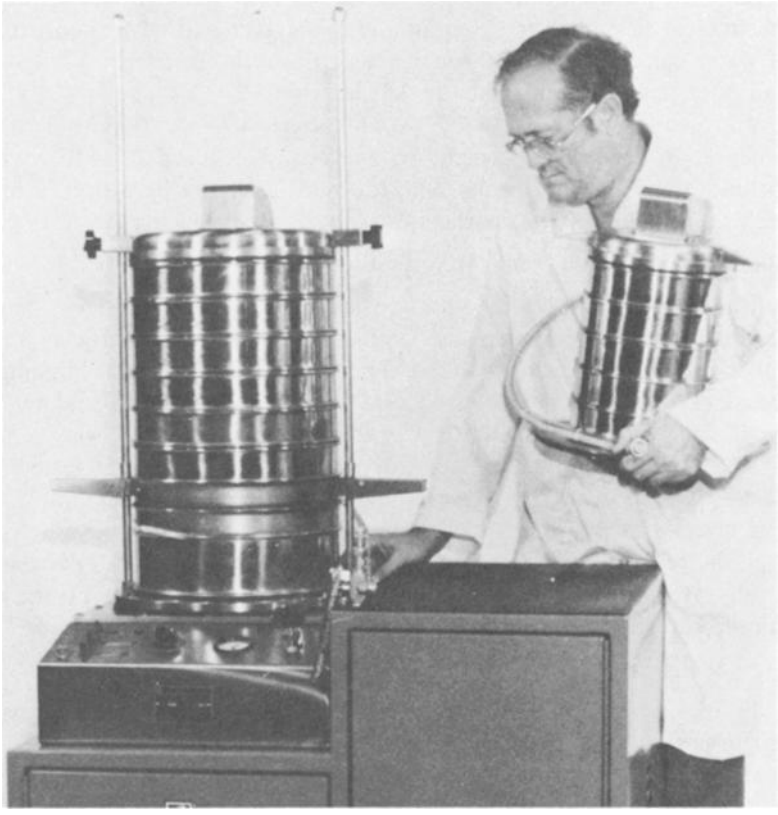


FIG. 10—*Wet test setup with mechanical sieve shaker.*

exceed about 230 F (110 C). Weigh the residue. This procedure is repeated on the next coarser sieve.

9.3 This drying time will vary with the size of the sample and the characteristics of the material and should be established by a series of

weight checks at intervals until no significant change occurs. If an oven is not available, an infrared lamp set at a distance of about 12 in. (30.48 cm) may be used.

9.4 If the material does not mix well with water, first place the dried, accurately weighed sample in a quart (see Paragraph 1.1) jar and fill the jar about three quarters full of water. Shake contents vigorously to mix the material with the water. This mixture can then be dumped onto the sieve and the washing process performed as described above.

9.5 A small quantity of sodium pyrophosphate or tri-sodium phosphate (TSP) added to the water will aid in dispersing the solid particles. If available, an ultrasonic probe can be immersed in the jar to break up the agglomerates and disperse the particles.

9.6 It is possible to perform wet sieving with a nest of sieves with a mechanical sieve shaker by equipping the shaker so that a small stream of water can be received through the top and drained from the bottom pan after passing through the nest (Fig. 10).

9.7 *Special Wet Test for Hydraulic Cement*—See ASTM Test for Fineness of Hydraulic Cement by the No. 325 Sieve (C 430), which includes details of the special 2-in. (50-mm)-diameter by 3-in. (76-mm)-high sieve including the special spray nozzle designed for the test.

10. Combined Wet and Dry Testing

10.1 When a sieve analysis to be made with a nest of sieves cannot be done on a dry basis because of the presence of fine particles which either agglomerate, adhere to the coarser particles, or cause blinding to the sieve openings, it is best to remove the fine particles first by wet sieving and then perform the rest of the analysis on a dry basis.

10.2 In the combined wet and dry method, the sample is tested first on the finest sieve using the wet method described in Paragraph 9.2. The coarse residue is then dried at 230 F (110 C) and sieved dry in accordance with the appropriate method in Section 7 or 8. Percentage results are expressed in terms of the original dry weight of the test sample before wet testing.

11. Weighing

11.1 After completion of the agitation of the sieves, the entire nest of sieves should be brought to the weighing station for recording of the analysis. Weighing should always be done, in grams for most tests, on a balance accurate to 0.1 percent of the weight of the test sample. One suitable type of balance for sieve analysis work is shown in Fig. 11. The material retained on each sieve should be weighed separately. The material passing through the finest sieve into the pan should also be weighed to provide an overall check. Since the weight of each fraction is determined to within 0.1 percent of the total sample weight, the maximum error for the test should not exceed 0.1 percent times the number of weighings. If the sum of the weights of the material retained on the

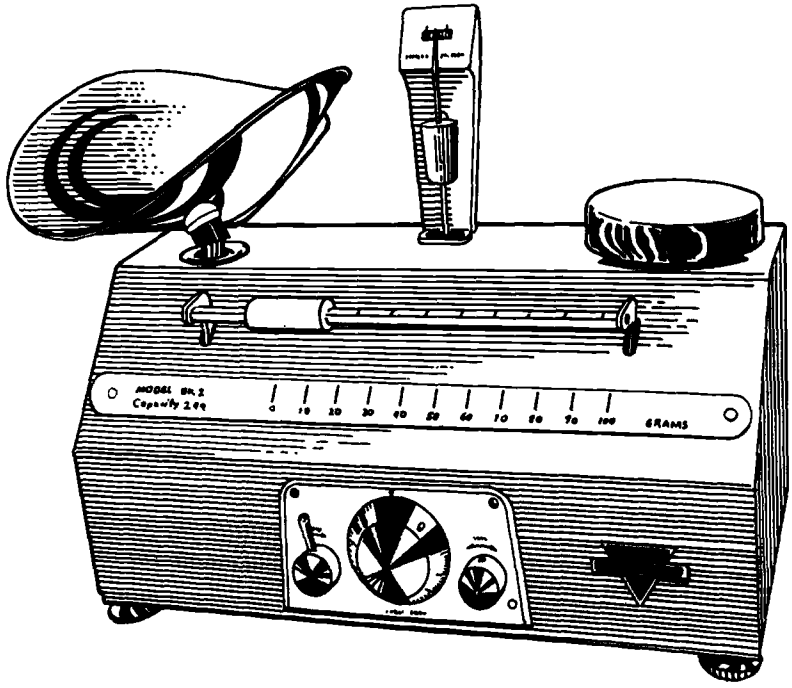


FIG. 11—*Balance.*

various sieves plus that in the pan does not deviate from the weight of the original sample by more than the above tolerance, the sum of the weights, rather than the original sample weight, can be used as 100 percent for calculation of the sieve analysis percentages. Another common practice is to assume that a deficiency of up to a maximum of 0.5 percent in the sum of the fraction weights compared to the weight of the original sample is "dust loss" and can be added to the pan fraction. If the variation is greater than the above tolerance, the figures should be rechecked for possible errors in weighing, calculation, blinding of the sieve apertures, or accidental spillage loss. (In wet sieving, the material through the finest sieve is usually lost, and this check is not possible.)

11.2 When working with small samples and using 3-in. (76-mm) sieves, it is often desirable to determine a tare weight for each sieve and pan to permit determination of weights without removal of the retained fractions. With small fractions there is great danger that loss of material during removal from the sieve will upset the accuracy of the test (see Table 4).

12. Calculation

12.1 The weights of the material retained on each sieve and the weight of the original test sample are the basic data from which percen-

tages are calculated (see Paragraph 11.1). These weights are not usually reported. The results are presented in the form of percentages of the total test sample retained on, or passing through, each sieve.

12.2 The percentage retained on each sieve is calculated by dividing the "total weight coarser" than that sieve by the total weight of the test sample. The total weight coarser includes the material retained on that particular sieve plus all material on all coarser sieves. This cumulative percentage is very useful as it represents the total percentage of the test sample coarser than the aperture of that particular sieve.

Most sieve test tabulations are set up on the basis of the percentage of material retained on each sieve; however, it is also acceptable to set up the specifications and report test results on the basis of the per-

LABORATORY REPORT OF SIEVE ANALYSIS

NAME JOHN DOE SLATE CO. Test No. 18-500

Material SLATE DUST Description Sample

Largest Particle Time 10 Minutes

Remarks FEED TO SCREEN NO. 1

						Weights on or Between Sieves		Total Percentage	
	Mesh	U. S. No.	Opening Ins.	Mesh	U. S. No.	Grams	Per Cent	On	Passing
	3								
	4	4							
	6	6							
	8	8							
	10	12							
	14	16							
	20	20				.2	.4	.4	99.6
	28	30				2.6	5.2	5.6	94.4
	35	40				8.6	17.1	22.7	77.3
	48	50				7.6	15.3	38.0	62.0
	65	70				6.0	12.0	50.0	50.0
	100	100				6.0	12.0	62.0	38.0
	150	140				5.5	11.0	73.0	27.0
	200	200				3.5	7.0	80.0	20.0
	Pan	Pan				10.0	20.0	100.0	
		Totals				50.0	100.0		

By

FIG. 12—*Laboratory form for recording sieve test results.*

centage passing each sieve. Figure 12 shows a typical laboratory report form for recording the results of a sieve test, while Fig. 13 shows a typical form for reporting a group of sieve analysis results.

13. Graphic Presentation of Test Results

13.1 Sieve analyses often are presented graphically for comparison with specification requirements, or for general evaluation. By interpolation on the sieve analysis graph, percentage retained on or passing sieves not actually used in the test can be estimated. Similarly, the size of aperture which would theoretically retain or pass a selected percentage can be estimated even though that sieve size was not used in the test or, for that matter does not even exist.

13.2 The abscissa of the sieve analysis graph usually represents the sieve sizes and the ordinate the percentages retained or passing. Scales used for the coordinates depend upon the use to be made of the results and the preferences of the user. The scale for sieve sizes may be linear (arithmetic) or logarithmic. The latter has the advantage of representing standard sieve sizes, which relate to one another by powers of the

SIEVE TESTS
MADE WITH

U. S. SIEVE SERIES SIEVES

Name JOHN DOE SLATE CO. Date Test Number 18-500

Address Made by E.B.

Material SLATE DUST Moisture NONE

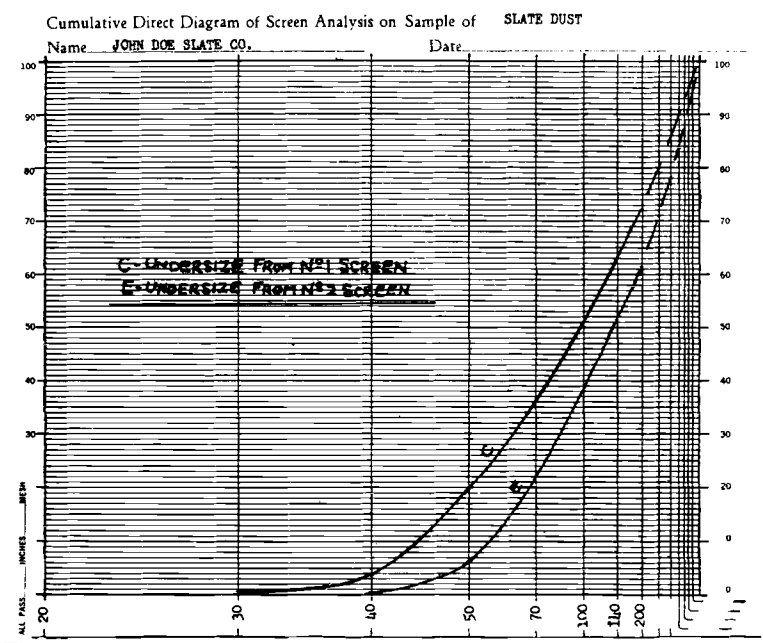
		(A) FEED TO NO. 1 SCREEN Time: 10 Minutes			(B) OVERSIZE FROM NO. 1 SCREEN Time: 10 Minutes			(C) UNDERSIZE FROM NO. 1 SCREEN Time: 10 Minutes			(D) FEED TO NO. 2 SCREEN Time: 10 Minutes			(E) OVERSIZE FROM NO. 2 SCREEN Time: 10 Minutes			(F) UNDERSIZE FROM NO. 2 SCREEN Time: 10 Minutes		
Mesh	U.S. No.	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)	Weight Between Sieves	% Between Sieves	Cum. % (Total % on each Sieve)
3																			
4	4																		
6	5																		
8	8																		
10	12																		
14	16																		
20	20		.4	.4		1.0	1.0					.4	.4		1.4	1.4			
28	30		5.2	5.6		15.1	16.1					5.2	5.6		28.5	29.9		.3	.3
35	40		17.1	22.7		44.6	60.7		.2	.2		17.1	22.7		57.2	87.1		3.5	3.8
48	50		15.3	38.0		31.3	92.0		5.9	6.1		14.4	37.1		11.8	98.9		16.8	20.0
65	70		12.0	50.0		6.8	98.8		15.9	22.0		12.0	49.1		.5	99.4		16.0	36.0
100	100		12.0	62.0		1.0	99.8		16.2	38.2		10.7	59.8					15.0	51.0
150	140		11.0	73.0					13.1	51.3		7.0	66.8					12.0	63.0
200	200		7.0	80.0					10.2	61.5		4.3	71.1					9.0	72.0
Pan	Pan		20.0	100.0		.2	100.0		38.5	100.0		28.9	100.0		.6	100.0		28.0	100.0
	Totals		100.0			100.0			100.0			100.0			100.0			100.0	

REMARKS

By E. B.

Note: Sieves omitted may be indicated with a dash (—) in weight columns.

FIG. 13—*Form for reporting a group of sieve analyses results.*



Openings Inches	Openings Millimeters	Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights
		3			C						E	
		4	4									
		6	6		UNDERSIZE FROM						UNDERSIZE FROM	
		8	8									
		10	12		NO. 1 SCREEN						NO. 2 SCREEN	
		14	16									
		20	20									
ON		28	30									
"		35	40	.2	.2					.3	.3	
"		48	60	5.9	6.1					16.8	20.0	
"		65	70	15.9	22.0					16.0	36.0	
"		100	100	16.2	38.2					15.0	51.0	
"		150	140	13.1	51.3					12.0	63.0	
"		200	200	10.2	61.5					9.0	72.0	
Pass 200		200	200	38.5	100.0					28.0	100.0	
			Totals	100.0						100.0		

FIG. 14—*Typical linear (arithmetic) type of graph.*

fourth root of two on an equally spaced scale (for example, the distances between the No. 4 and No. 8, the No. 8 and No. 16 and the ¾ in. and ⅜ in. are all the same since the larger sieve in each case has an aperture twice that of the smaller). The scale for percentages is usually linear but may occasionally be logarithmic. On the linear scale, equal differences in percentage are depicted as the same distance.

13.3 Examples of the two principal types of graph used for sieve analysis work are shown in Figs. 14 and 15. Figures 16 and 17 show the use of interpolation percentages that would pass or be retained on a screen opening other than the one used in the test to determine the size opening that would pass or retain a given percentage.

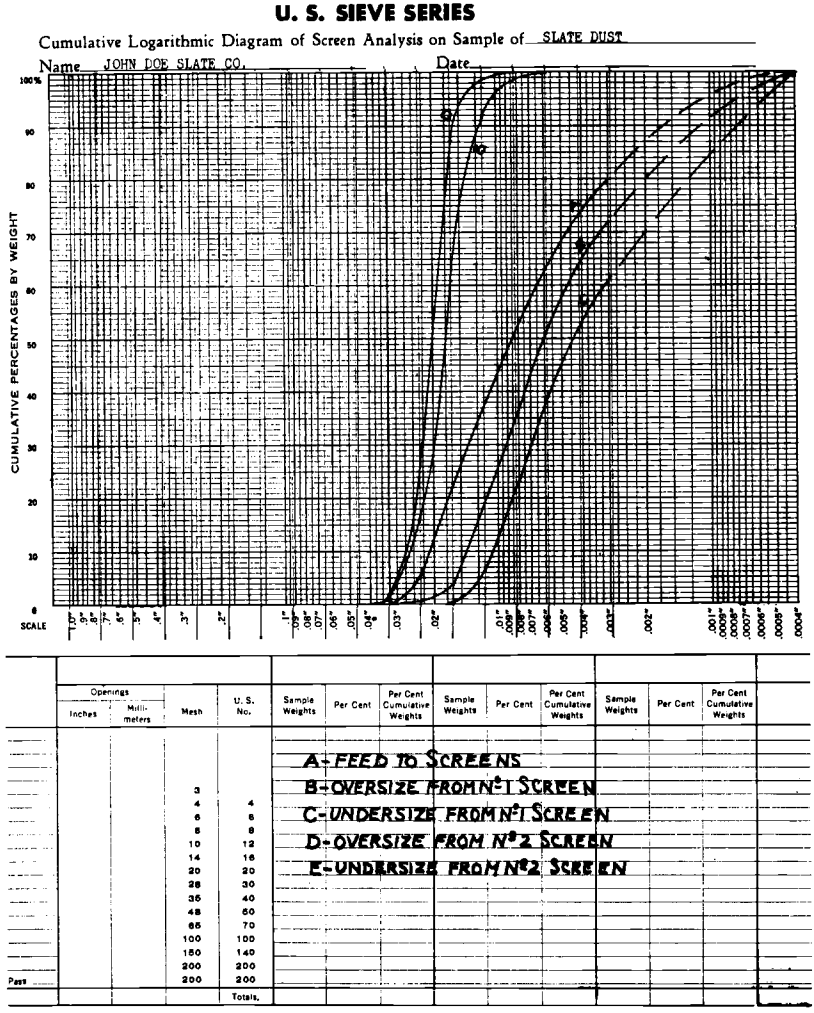
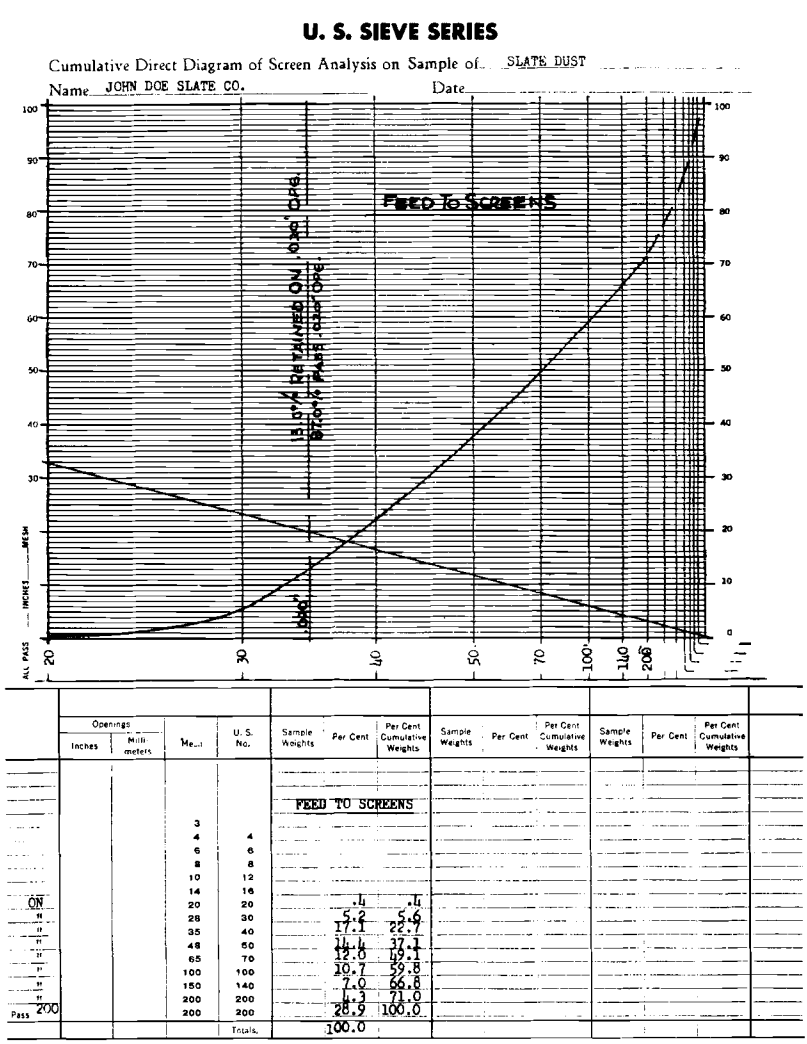


FIG. 15—*Typical logarithmic type of graph.*

14. Care and Cleaning of Test Sieves

14.1 Test sieves should be kept thoroughly clean and dry. After each sieve analysis test, the sieves should be carefully cleaned and stored in a cabinet. For cleaning the sieves, a soft brass brush (Fig. 18) is used for sieves coarser than No. 100 (149 μm) and a nylon brush (Fig. 19) for sieves finer than No. 100 (149 μm). This is done by brushing the underside of the wire cloth with a circular motion taking care not to exert too much pressure against the wire cloth. The frame of the sieve may be gently tapped with the wooden handle of the brush, taking care not to batter the edges of the frames and pans as this will interfere with the proper fitting together of the sieve, pan, and cover.



Openings Inches	Openings Millimeters	Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights
				FEED TO SCREENS								
		3										
		4	4									
		6	6									
		8	8									
		10	12									
ON		14	16									
		20	20		.4	.4						
"		28	30		5.2	5.6						
"		35	40		17.1	22.7						
"		48	50		14.4	37.1						
"		65	70		12.0	49.1						
"		100	100		10.7	59.8						
"		150	140		7.0	66.8						
"		200	200		4.3	71.0						
Pass 200		200	200		28.9	100.0						
			Totals		100.0							

FIG. 16—*Example of interpolation to determine percentage that would pass or be retained on openings other than those used in the test.*

Under no circumstances should embedded particles be forced out of the openings with a pick or needle.

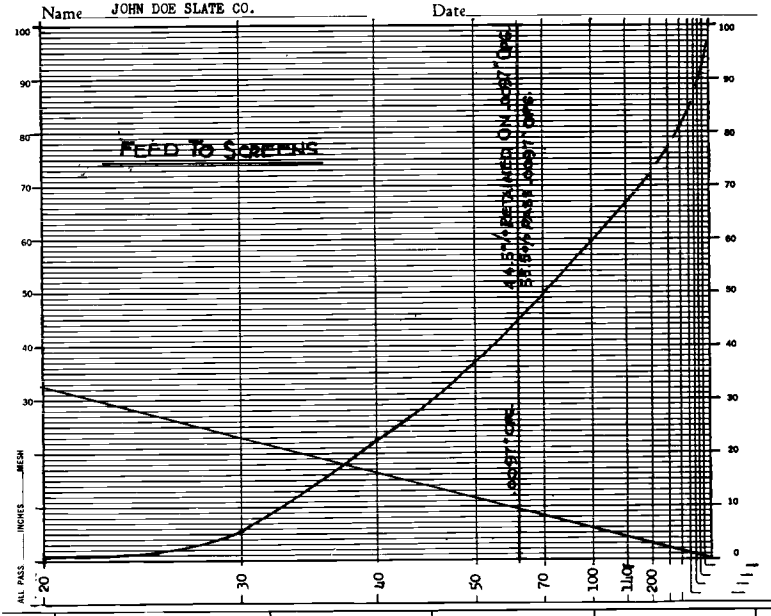
14.2 *Washing*—Occasionally it may be necessary to wash the sieves in a warm soap and water solution to remove the near-mesh particles. The underside of the sieve can be carefully brushed while in the water to aid in the cleaning action. Most acid solutions are not recommended for cleaning sieves, as the acid will reduce the diameter of the wire and enlarge the openings. Also, it will loosen the weave in the wire cloth and destroy the accuracy of the sieve.

If the above methods fail, the safest method is to dip the sieves into

U. S. SIEVE SERIES

Cumulative Direct Diagram of Screen Analysis on Sample of SLATE DUST

Name JOHN DOE SLATE CO. Date



Openings Inches	Openings Millimeters	Mesh	U. S. No.	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights	Sample Weights	Per Cent	Per Cent Cumulative Weights
				FEED TO SCREENS								
		3										
		4	4									
		6	6									
		8	8									
		10	12									
		14	16									
ON		20	20		.1	.1						
"		28	30		5.2	5.6						
"		35	40		17.1	22.7						
"		48	50		14.4	37.1						
"		65	70		12.0	49.1						
"		100	100		10.7	59.8						
"		150	140		7.0	66.8						
"		200	200		4.3	71.0						
Pass	200	200	200		29.9	100.0						
			Totals.		100.0							

FIG. 17—*Example of interpolation to determine the opening that would pass or retain a given percentage of the sample.*

a 5 percent solution of boiling acetic acid and, after brushing the particles from the openings, wash the sieves thoroughly in water to remove all traces of the acid.

14.3 *New Sieves*—New sieves should be cleaned with benzol or other suitable solvent to remove any grease or oil before making the tests. Alcohol is not recommended because it will attack the protective coating of lacquer usually used on the sieve frames.

14.4 Ultrasonic cleaners are available and are very useful for cleaning sieves. Here the sieves are immersed in a detergent solution in the ultrasonic cleaner, which does a remarkable job of cleaning the open-

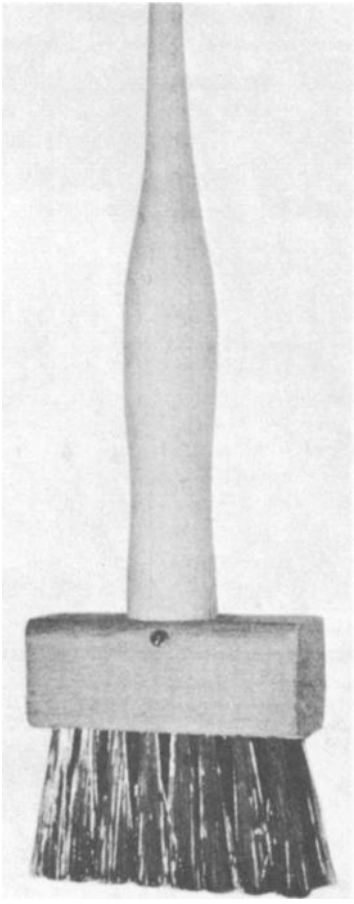


FIG. 18—*Brass wire brush.*

ings of near-mesh particles.

14.5 Sieves should be examined frequently for defects in the cloth. Holes or breaks are sometimes indicated by very noticeable irregularities in the end-point weighings. Often these small holes can be repaired by soldering, but soldering must be done with great care so that the wire cloth is not injured by excessive heat or harmful flux.

14.6 If properly handled, a test sieve should retain the accuracy of its openings throughout the life of the sieve, since ordinary wear is on top of the knuckles of the wire cloth and no measurable wear occurs in the openings.

15. Miscellaneous Suggestions

15.1 *Overloading*—A sieve is considered overloaded when there is a crowding of oversize and near-mesh particles on the sieve surface after the material finer than one half the sieve opening has passed through.

FIG. 19—*Nylon bristle brush.*

On an overloaded sieve, the weight of the oversize material will tend to wedge the near-mesh particles into the openings, thus blocking these openings from any further usefulness until the wedged particles are removed when the sieve is cleaned.

15.2 *Avoid Sieving "Aids"*—Avoid the use of all so-called aids to sieving, such as balls, shot, chains, washers, etc. They are not only destructive to the sieve, but also may cause degradation of the sample, thereby giving an incorrect result. If the material being tested is not free sieving, or the fines tend to agglomerate or adhere to the larger particles, then the operator should consider using the wet or wet-dry method which, while it may be a little more trouble, will give more reliable results than the use of balls, chains, etc.

15.3 *Control of Static in Test Sieving*—When sieving fine powders, such as plastics, which charge themselves with static electricity, the addition of a small amount of powdered magnesium carbonate, tricalcium phosphate, or similar aid, usually solves the problem and makes it unnecessary to resort to wet testing. For a 50-g sample, add 0.5 g of either of the above chemicals, mix the sample thoroughly so that the particle surfaces are coated with the magnesium or other chemical, and then proceed with the test.

15.4 *Worn or Damaged Sieves*—Do not continue to use a test sieve when the wire cloth is worn; loose, or damaged. Unless facilities are available for installing a whole new sieve cloth with proper tautness without distortion, replacement should not be attempted.