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A STUDY OF SIEVE SPECIFICATIONS

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By Lewis V. Judson

ABSTRACT

An account is given of a study made on sieves tested at the Bureau of Standards. The investigation showed the desirability of changes in the specifications for the United States Standard Sieve Series. As the wire diameter appeared to have only a second order effect in actual sieving, the tolerance in wire diameter was made very liberal. The relation of other measured dimensions of sieve cloth to the sieving results is also discussed. The revised specifications are given in Letter Circular No. 74.

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I. DESIRABILITY OF STUDY OF SIEVE SPECIFICATIONS

The specifications for the United States Standard Sieve Series were drawn up several years ago after a careful study of all the sieve data then available. It was realized then and has been stated from time to time that these specifications were subject to such changes as the increase in knowledge of sieves might show necessary. The considerable number of sieves tested in the past few years was one of the causes which led to a belief at the Bureau of Standards that the time was ripe to reconsider the specifications in some detail.

The question of a change of any specifications is one which needs a most careful study before the change is made. The new specifications may be intrinsically better than the old, and yet the change may not be a wise one to be made at the time when it is proposed. A consideration of vital importance with reference to specifications is their acceptance and use; that is, the general acceptance and use of a reasonably good specification is more to be desired than the nominal adoption of a perfect specification which is not generally acceptable, and is, therefore, not used.

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A study of the specifications for sieves was, therefore, made at the Bureau of Standards with a view toward making the United States Standard Sieve Series more effective. In this study it was sought, first, to ascertain the essential merits and defects of the specifications of the Bureau of Standards then in effect; second, to determine the main causes for the rejection of sieves under these specifications; third, to study other existing specifications; and, lastly, to determine what changes, if any, should be made.

One of the principal uses of a set of sieves is to make a series of fineness determinations for the purpose of ascertaining the suitability of a material for certain specified uses. Since in most cases the suitability involves a question of chemical or other action which varies as the surface area of the particles sieved, it is most convenient and desirable that the successive sieves in a series should have openings in which the linear distances between the wires are in a ratio of $\sqrt{2} : 1$. In order to provide for a closer grading of material, it is preferable to adopt as the ratio of linear dimensions of openings of successive sieves in a series the value $\sqrt[4]{2} : 1$. The areas of individual openings of successive sieves then vary as $\sqrt{2} : 1$, or, if every other sieve be taken, this variation is as $2 : 1$.

The series adopted as the United States Standard Sieve Series has openings which vary in the nominal dimension of the distance between parallel wires in the ratio $\sqrt[4]{2} : 1$, and therefore contains sieves which are sufficiently closely graded as to meet practically all needs of science and industry in the range over which the sieves extend.

This series of sieves includes a sieve having nominal openings 1 mm square and also a sieve having nominally 200 wires to the linear inch. It may, therefore, be regarded as essentially based on the millimeter or on the inch system, according to personal preference. In reality it is independent of any particular system of units. The dimensions may be expressed in any units desired.

The series of wire diameters selected for these sieves are those which experience has shown to be best adapted for precision testing sieves and which represent, as nearly as is practicable, existing sieve practice.

II. GENERAL STUDY OF THE PROBLEM

The requirement in the various sieve-using industries is that sieves be obtainable varying from these nominal dimensions only by a small amount necessitated by the sieve-making process. This variation must be sufficiently small as not to vitiate the results of the screening to be done with the sieves.

Correspondence and tests at the Bureau of Standards showed that the sieve situation was not entirely satisfactory to either manufac-

turer or user, and it seemed desirable to determine whether the specifications were too strict or whether the requisite care was not being used by sieve manufacturers. As a basis for this work an analysis was made of the results of the sieve tests made at the Bureau of Standards.

The specifications as they were originally drawn up by the Bureau of Standards were based very largely upon a knowledge gained from the test of so-called 20, 30, 100, and 200 mesh sieves. Since 1916 a considerable number of sieves of all degrees of fineness have been submitted for test, and it seemed probable that a study of the results of these tests would furnish valuable information.

It had appeared at first that the sieves of the United States Standard Sieve Series could be placed in five groups of nearly equal size not only because this arrangement serves as a possible aid to the memory, but also because the tolerance seemed to fall into such a grouping. From a survey of our data this grouping has been found to be undesirable for two reasons, first, the precentage tolerances on sieves coarser than No. 8 can not be smaller than those on No. 8 to No. 18, inclusive, and, second, a 60 per cent tolerance in maximum opening which seems very just for No. 140, No. 170, and No. 200 sieves is inadequate at the present stage of development of the weaving for the three finer sieves. Only two No. 325 sieves have been tested which conformed to the specifications which were in force prior to April 15, 1924, and only a very few No. 230 or No. 270. The chief cause for rejection has been irregularity of weaving, some openings being from 60 to 90 per cent greater than the nominal value, while a few were greater than would be permitted under a 90 per cent tolerance, so that 90 per cent seems to be a fair value for the tolerance on maximum opening. Every effort on the part of the manufacturers should be made to perfect the weaving of fine sieve cloth so that a smaller tolerance, though impracticable now, may be adopted later.

III. EFFECT OF WIRE DIAMETER AND SIZE OF OPENINGS ON SIEVING PERFORMANCE

From the standpoint of the manufacture and inspection of sieves, the best that can be done is to set definite dimensional limits on the wire diameter and on the spacing of the wires; and any sieve which comes within these specified dimensional limits should be regarded as a standard sieve so far as the sieve cloth is concerned.

Before such a standard sieve can be used, however, with complete knowledge as to its sieving performance on a given material it is necessary to test it with that particular material. For example, a No. 200 cement sieve which meets all dimensional specifications for a standard sieve may be found to have a sieving correction which

can not be disregarded if results which are accurate to 0.5 per cent or less are required. The sieving correction for this particular sieve, when used with cement, should be determined by carrying out a standardized sieving test with a standard sample of cement.

If used with a material other than cement, with particles of a widely different character, the sieving correction for the same sieve may be quite different from that for cement. However, since sieving tests have been confined largely to cement not much information as to other materials is available.

In general, the sieving correction will be relatively small for sieves which meet the bureau's specifications as to wire diameter, average opening, and maximum opening. For example, out of over 500 No. 200 sieves of various makes tested by the bureau during the last seven years (1920–1927) only 23 sieves which have been certified as conforming to dimensional specifications have been found to have cement sieving corrections greater than 2.5 per cent, and no certified sieve has been found to have a sieving correction as great as 4 per cent. However, since it has been shown that certified sieves may have sieving corrections of 2 per cent or more, and since many of them have corrections of from 1 to 2 per cent, it is apparent that in case greater precision than this is required it will be necessary to carry out sieving tests to determine the sieving correction to be applied to each sieve when used with the particular material in question. By the use of specially prepared samples of cement, cement laboratories are enabled to determine this correction for each sieve. When suitable samples are available, a similar procedure can be followed with other materials.

Up to this time it has not been found possible accurately to predict the sieving correction from a knowledge of the wire diameter and the average and maximum openings between the wires; especially if the spacing is irregular.

A search failed to show any correlation of wire diameter with sieving value of No. 200 sieves. Indeed, there does not appear to be on record at the Bureau of Standards any results showing a variation in sieving value definitely ascribable to differences in wire diameter. Doubtless the diameter of the wire of a sieve does have its influence on the sieving results, but the variation in opening has such a marked effect that this masks the relatively slight effect due to the wire diameter. Large variations from the nominal wire diameter of the United States Standard Sieve Series, however, have been found by the Bureau of Standards to be disadvantageous—if the wires are too small they break too easily; if too large they tend to form pockets and cause the sieving operation to be a tedious one with results not as consistent as would be desirable.

Further investigation of the interrelation between the measured physical dimensions of No. 200 sieves and their sieving values showed that a few excessively large openings in a sieve always produce a marked difference in sieving value, amounting in some cases to as much as 5 per cent. It also appears that a fair approximation to sieve correction for No. 200 sieves using a standard cement sample can be predicted from the measured dimensions of the openings only if the spacing is uniform.

IV. SIZE OF SIEVE

The question has been raised a number of times as to the proper size of sieves. Special specifications were drawn up for 3-inch sieves for paint pigment fineness testing, using the analytical balance to weigh the sieve and sample under test both before and after sieving. This work has been successful at the bureau and elsewhere. The use of a 3-inch sieve, when feasible, has the advantage—rather important in the case of No. 325 cloth—of not being nearly so expensive as the 6 or 8 inch sieve. Where the results obtained, say, with a 6-inch sieve, are to be compared with work in another laboratory using a standard 8-inch sieve, there is some question as to the extent to which the results are affected by the use of a different area of sieving surface. With the data at present on hand it has not seemed advisable to the bureau to consider other than the 8-inch sieves as standard. The effect of the size of sieves on their sieving performance needs investigation.

V. CAUSES OF REJECTION OF SIEVES

From the studies which have just been discussed it appeared that several changes in the specifications were worthy of consideration. The fact that the bureau's specifications on wire diameter were believed to be more rigid than was necessary formed a frequent point of attack against the specifications. To this was charged the failure of some users to get the sieves desired, while to it was also charged by manufacturers their failure to produce sieves conforming to the specifications. As a matter of fact, the records of tests carried out at the Bureau of Standards show that there has been little difficulty, except in a few isolated cases, in obtaining any of the sieves with wires conforming to the tolerances in force at the Bureau of Standards for the past several years. Of the many sieves made by one concern which have been tested at the Bureau of Standards in recent years not a single one has been rejected because the wires were not within the prescribed tolerance. The records of the tests of sieves of another manufacturer show only three rejections for wire diameter on sieves finer than No. 16 and only seven for coarser sieves. Other manufacturers have not been as successful as these two, but in every case

rejections because of incorrect openings far outnumber those due to the wire diameter being outside the specified limits. Hence, the real difficulty in securing sieves has been getting the openings, both the average and the maximum in a sieve, to be within the specifications; nor is this difficulty due, in the majority of cases, to the specifications being too strict. If No. 60 and No. 80 sieves can be and are so made that nearly all of them conform to specifications, there does not seem to be any reason why No. 70 sieves, which are between them, should not conform to the same specifications, and yet there have been an excessive number of No. 70 sieves rejected, whereas the majority of No. 60 and No. 80 sieves submitted have passed.

VI. SIEVE-TESTING APPARATUS

The bureau has devised an apparatus for testing sieves which is both simple and effective. This apparatus, which was described in the Journal of the Optical Society of America and Review of Scientific Instruments,[1] consists of a projection apparatus, whereby the shadow of a wire may be thrown upon a ground-glass screen at a magnification of 250 diameters by the use of a 16 mm microscope objective and a Ramsden eyepiece. If sieve manufacturers would use such an apparatus to examine their cloth, preferably before making it into sieves, the percentage of sieves rejected at the Bureau of Standards would be greatly reduced. In many instances sieves have been submitted to the bureau which would be rejected on an inspection that could just as well be made at the factory.

In Figure 1 is shown a microphotograph with a magnification of 60 diameters of a portion of a sieve having some very large openings. In Figure 2 is shown a portion of a sieve of uniform weave.

VII. REVISED SPECIFICATIONS, APRIL 15, 1924

This then was the situation in the early months of 1924: The nominal values for the United States Standard Sieve Series were subject to but very little adverse criticism; the tolerances of average opening of a few very coarse sieves and of maximum opening for the three finest sieves needed slight modification; the specifications were being severely criticized by some as having a tolerance in wire diameter which was too strict; and a few sieves were being rejected because of tolerances in average and in maximum opening which were generally admitted as just. As a result of these and other studies made at the Bureau of Standards, the bureau adopted the following revised specifications on April 15, 1924,[2] and issued them as Letter Circular No. 74.

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[1] L. V. Judson and R. E. Gould, Sieve testing apparatus, J. Optical Soc. of Am., **6**, p. 719; September, 1922.

[2] The same specifications were adopted as tentative specifications of the American Society for Testing Materials and published under the designation E 11-25T.

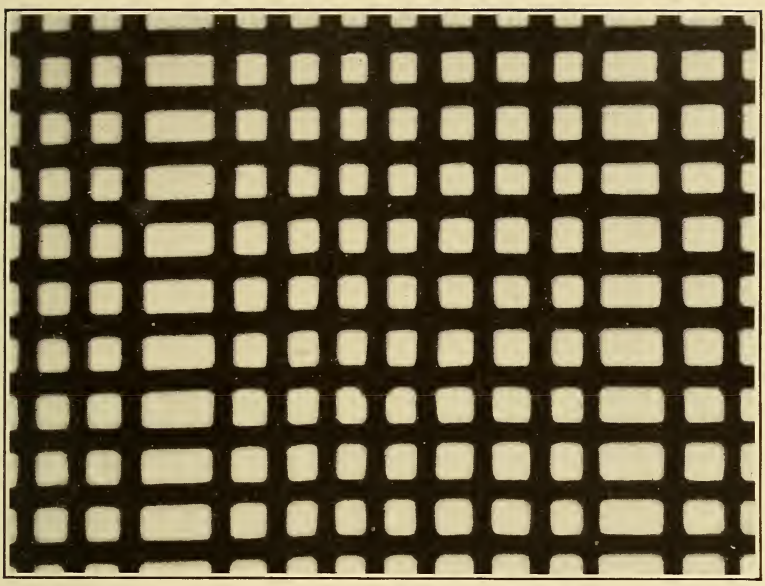

FIG. 1.—*Microphotograph of sieve cloth showing excessively large openings*

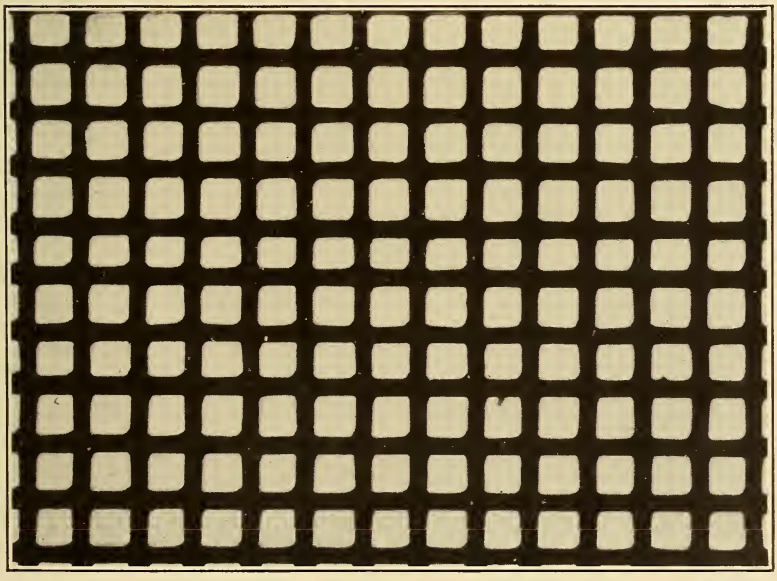

FIG. 2.—*Microphotograph of sieve cloth showing uniform weaving*

1. STANDARD SPECIFICATIONS FOR SIEVES

(a) United States Standard Sieve Series

1. Wire cloth for standard sieves shall be woven (not twilled, except that the cloth of No. 230, No. 270, and the No. 325 sieve may be twilled until further notice) from brass, bronze, or other suitable wire and mounted on the frames without distortion. To prevent the material being sieved from catching in the joint between the cloth and the frame, the joint shall be smoothly filled with solder, or so made that the material will not catch. The sieve frames should be circular, about 20 cm (8 inches) in diameter and about 5 cm (2 inches) or 2.5 cm (1 inch) between the top of the frame and the cloth.

2. The average opening between the adjacent warp and the adjacent shoot wires, taken separately, shall be that given in column 2 of the following table, within the "tolerance in average opening" given in column 6. The average diameter of the warp and of the shoot wires, taken separately, of the cloth of any given sieve shall be that given in column 4 of the table within the "tolerance in wire diameter" given in column 7. The maximum opening between adjacent parallel wires shall not exceed the nominal width of opening for that sieve by more than the "tolerance in maximum opening" given in column 8 of the table.

3. The Bureau of Standards reserves the right to reject sieves for obvious imperfections in the sieve cloth or its mounting, as, for example, punctured, loose, or wavy cloth, imperfections in soldering, etc., also for an excessive number of large openings.

4. Full-height number 200 sieves will be given a sieving test with a standard sample of cement and the sieving correction thus obtained will be incorporated in the certificate or report unless it is indicated in the request for the test of the sieves that they are not intended for cement testing and that the sieving test is not required.

Sieve number (1)	Sieve opening (2)	Sieve opening (3)	Wire diameter (4)	Wire diameter (5)	Tolerance in average opening (6)	Tolerace in wire diameter (7)	Tolerance in maximum opening (8)
	mm	*Inch*	*mm*	*Inch*	*Per cent*	*Per cent*	*Per cent*
4	4.76	0.187	1.27	0.050	±3	−15 to +30	10
5	4.00	.157	1.12	.044	±3	−15 to +30	10
6	3.36	.132	1.02	.040	±3	−15 to +30	10
7	2.83	.111	.92	.036	±3	−15 to +30	10
8	2.38	.0937	.84	.0331	±3	−15 to +30	10
10	2.00	.0787	.76	.0299	±3	−15 to +30	10
12	1.68	.0661	.69	.0272	±3	−15 to +30	10
14	1.41	.0555	.61	.0240	±3	−15 to +30	10
16	1.19	.0469	.54	.0213	±3	−15 to +30	10
18	1.00	.0394	.48	.0189	±3	−15 to +30	10
20	.84	.0331	.42	.0165	±5	−15 to +30	25
25	.71	.0280	.37	.0146	±5	−15 to +30	25
30	.59	.0232	.33	.0130	±5	−15 to +30	25
35	.50	.0197	.29	.0114	±5	−15 to +30	25
40	.42	.0165	.25	.0098	±5	−15 to +30	25
45	.35	.0138	.22	.0087	±5	−15 to +30	25
50	.297	.0117	.188	.0074	±6	−15 to +35	40
60	.250	.0098	.162	.0064	±6	−15 to +35	40
70	.210	.0083	.140	.0055	±6	−15 to +35	40
80	.177	.0070	.119	.0047	±6	−15 to +35	40
100	.149	.0059	.102	.0040	±6	−15 to +35	40
120	.125	.0049	.086	.0034	±6	−15 to +35	40
140	.105	.0041	.074	.0029	±8	−15 to +35	60
170	.088	.0035	.063	.0025	±8	−15 to +35	60
200	.074	.0029	.053	.0021	±8	−15 to +35	60
230	.062	.0024	.046	.0018	±8	−15 to +35	90
270	.053	.0021	.041	.0016	±8	−15 to +35	90
325	.044	.0017	.036	.0014	±8	−15 to +35	90

The merit of the new specification is that well-made sieves made of wires differing considerably from the nominal diameter and with considerable latitude in mesh will be found to be standard if the regularity and correct spacing of the wires are such that the average and maximum openings do not differ from the nominal dimensions by more than the amount specified. The specifications emphasize those points which are found essential in actual sieving.

Several American sieve manufacturers have shown that sieves of precision meeting the bureau's specifications can be produced commercially. In several recent tests of No. 100, No. 200, and other sieves, with as many as 60 sieves in a single shipment, either every sieve or nearly every sieve was found to be within the requirements, and most of them were evenly woven sieves well within the tolerances. During the same period, however, some very poorly woven cloth has been sent to the bureau in sieves supposedly precise. By the use of proper inspection equipment, and by a fuller cooperation of all concerned, it is believed that the manufacturers and dealers will be enabled to furnish sieves meeting these specifications in a satisfactory manner.

Credit is due to American sieve manufacturers not only for undertaking with considerable success the making of the fine sieve cloth, but also for putting into practice the theoretical standardization which had previously been suggested. The complete Tyler Standard Screen Scale is a series of sieves varying in width of opening by $\sqrt[4]{2}$ as in these specifications, and nominally identical in all respect except a few wire diameters with the United States Standard Sieve Series.[3]

A final word seems in order as to the specifications. Occasionally the question is raised as to the permanency of the specifications, and it may be pointed out that the revisions which have taken place in these specifications have in nearly every case been changes in the tolerances rather than in the nominal values, and hence have not in any essential detail changed the series but rather have increased its availability and usefulness. The sieves must be sufficiently exact to serve their purpose; they must be obtainable without undue expense or delay. These two conditions are being increasingly met by the United States Standard Sieve Series.

Washington, May 1, 1926.

[3] This series of sieves is produced by the W. S. Tyler Co., Cleveland, Ohio. The Bureau of Standards specifications would appear to be applicable to this series of sieves as well as to sieves made by other manufacturers: Audubon Wire Cloth Co. (Inc.), Audubon N. J.; Howard & Morse, 1197-1211 De Kalb Avenue, Brooklyn, N. Y.; Multi-Metal Co., 801 East One hundred and thirty-eighth Street, New York, N. Y.; Newark Wire Cloth Co., 222-228 Verona Avenue, Newark, N. Y.; and possibly others.