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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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THE DEVELOPMENT OF STANDARD SIEVE SPECIFICATIONS IN THE UNITED STATES

The subject of sieve standardization is of considerable interest at the present time and the story of the development of sieve specifications is judged to be of sufficient interest to warrant making it available to the public.

The users of sieves, by expressing their desire for sieves which are accurate and definite as to opening rather than as to mesh and wire diameter, were largely responsible for the development of a universal screen scale in the United States. With progress in the precision of producing materials in the form of small particles, and increased efficiency in many manufacturing processes, there developed a definite need for certified sieves. The United States was for a number of years the only country having complete sieve standardization with specifications including tolerances for standard sieves and provision for test of these sieves and certification of those found to conform to the specifications.

Specifications for No. 100 and No. 200 sieves used in cement testing, adopted in 1904, were the first American sieve specifications. Although these were designated in the specifications as No. 100 and No. 200 sieves, they were more commonly referred to as 100-mesh and 200-mesh sieves, the two methods of designation being for years entirely interchangeable. It was not until 1919 that the sieve number became an arbitrary one, not necessarily identical with the mesh. There were previously screen scales of various organizations, manufacturers, societies, etc., but no tolerances or specifications were attached to these scales.

The size of opening is the element of fundamental importance in a testing sieve, but in 1904 sieves were designated by mesh and the opening of course varied with the diameter of the wire used. It thus was difficult to obtain sieves with openings of known definite size, and persons involved in the same problem in different parts of the country could not compare their work because they had used sieves of the same mesh but not of the same size opening. In these first sieve requirements an endeavor was made to control the variation in opening by regulation and varying the mesh and wire diameter rather than the opening directly. The 1904 specifications were

prepared by the committee on uniform methods on tests of cement of the American Society of Civil Engineers and were attached as an auxiliary requirement to standard cement specifications adopted by the American Society of Civil Engineers, The American Society for Testing Materials, American Institute of Architects, American Railway Engineering and Maintenance of Way Association, and the American Association of Portland Cement Manufacturers. The specifications are as follows:

> "The sieves should be circular, about 20 cm (7.87 in.) in diameter, 6 cm (2.36 in.) high, and provided with a pan 5 cm (1.97 in.) deep and a cover.
>
> "The wire cloth should be woven (not twilled) from brass wire having the following diameters: No. 100, 0.0045 in., No. 200, 0.0024 in. This cloth should be mounted on the frames without distortion; the mesh should be regular in spacing and be within the following limits:
>
> No. 100, 96 to 100 meshes to the linear inch
>
> No. 200, 188 to 200 meshes to the linear inch."

Although the specifications as first printed and adopted excluded twilled cloth, this exception was omitted in the printed specifications of following years without apparently any action having been taken by the societies interested.

The above specifications, even though they applied to cement sieves only, were very elementary and difficult to interpret. For example: Does the mesh requirement refer to average mesh or to inch intervals? Is the given wire diameter that of the wire before or after weaving, and what tolerance should be applied in the actual testing of the wire diameters? With a knowledge of the shortcomings of the sieves on the market, the Bureau thought it advisable to interpret the specifications rather liberally, and, for the permitted variations of mesh, adopted wire tolerances of ±0.0003 inch for the No. 100 and ±0.0002 inch for the No. 200 sieve. In spite of these liberal tolerances, however, no sieve tested by the Bureau of Standards up to September 1911 was found to pass the specifications. Even later, from a group of nine sieves made from cloth manufactured to conform to the 1904 specifications and imported at the request of members of the American Society of Civil Engineers, only five were found to conform to the specifications.

The impracticability of the 1904 specifications indicated that a revision was necessary. It was realized that, although it was desirable to reduce tolerances to a minimum, it was also necessary to consider difficulties of manufacture and to frame

specifications so that if the sieves in use were satisfactory a reasonable number could be found to conform to the specifications. And so in September, 1911, in connection with the preparation and unification of specifications for the purchase of Portland cement by the National Government, a conference of Government engineers took up the question of changes in the sieve specifications. In determining the new requirements and tolerances, data obtained from measurements of sieves from 1904 to 1911 were used. The specifications were designed to eliminate the previous misunderstandings and were broadened to include the 20- and 30-mesh sand sieves. The new specifications, which follow, were adopted by a departmental conference on February 13, 1912, and incorporated with the United States specifications for Portland cement. They were put into effect for all Government construction work by executive order of April 30, 1912.

1912 Sieve Specifications:

"Wire cloth for standard sieves for sand and cement shall be woven (not twilled) from brass, bronze, or other suitable wire, and mounted on the frames without distortion.

"The sieve frames shall be circular about 20 cm (7.87 in.) in diameter, 6 cm (2.36 in.) high and provided with a pan about 5 cm (1.97 in.) deep, and a cover.

"The No. 100 cement sieves (0.0055 inch opening) should have 100 wires per inch and shall conform to the following specifications for diameter of wire and size of mesh:

The diameter of the wires in the sieve should be 0.0045 inch and the average of such wires as may be measured shall not be outside the limits 0.0042 to 0.0048 inch for either warp or shoot wires. The number of warp wires per whole inch as measured at any point of the sieve shall not be outside the limits 98 to 101 per inch, and of the shoot wires 96 to 102 per inch. For any interval of 0.25 to 0.50 inch, in which the mesh may be measured, the mesh shall not be outside the limits 95 to 101 wires per inch for the warp wires and 93 to 103 wires per inch for the shoot wires.

"The No. 200 cement sieve (0.0029 inch opening) should have 200 wires per inch and shall conform to the following specifications for diameter of wire and size of mesh:

The diameter of the wires in the sieve should be 0.0021 inch and the average diameter of such wires as may be measured shall not be outside the limits 0.0019 to 0.0023 inch for either warp or shoot wires. The number of warp wires per whole inch as measured at any point of the sieve shall not be outside the limits 195 to 202 per inch and of the shoot wires 192 to 204 per inch. For any interval of 0.25 to 0.50 inch, in which the mesh may be measured, the mesh shall not be outside the limits 192 to 203 wires per inch for the warp wires and 190 to 205 wires per inch for the shoot wires.

"The No. 20 sand sieve (0.0335 inch opening) shall have between 19.5 and 20.5 wires per whole inch of the warp wires and between 19 and 21 wires per inch of the shoot wires. The diameter of the wire should be 0.0165 inch and the average as measured shall not vary outside the limits 0.0160 to 0.0170 inch.

"The No. 30 sand sieve (0.0223 inch opening) shall have between 29.5 and 30.5 wires per whole inch of the warp wires and between 28.5 and 31.5 wires per whole inch of the shoot wires. The diameter of the wire should be 0.0110 inch and the average as measured shall not vary outside the limits 0.0105 to 0.0115 inch."

It must be emphasized again that specifications are a product of development, so that it is impossible always to anticipate difficulties in their operation, and, when difficulties are seen it is not always easy to eliminate them. The sieve specifications of 1912 were known not to be perfect, but were the best which at that time could be offered with the available facilities for manufacture. Considerable discrepancies were known to exist in the sieving values of standard No. 200 sieve (or "200-mesh" as they were commonly designated) in the sieving of Portland cement, probably because of the range in size of the openings of the cloth. The next step in the development of the specifications, therefore, was to supplement measurements made on the sieve cloth by actual sieving tests. Owners throughout the country of the so-called 200-mesh sieves which had been certified by the Bureau, were sent standard samples of cement and requested to make sieving tests on their sieves according to the Bureau's specific directions. Practically all those persons requested to cooperate did so. On the basis of these results, supplemented by investigations conducted by the Bureau of Standards, sieving tests for No. 200 cement sieves were developed and were incorporated in a revised specification for standard No. 200 sieves and adopted by the Bureau of Standards October 1, 1914, these specifications replacing those for No. 200 sieves issued in 1912. The revised specifications are as follows:

"Wire cloth for standard sieves for cement shall be woven (not twilled) from brass, bronze, or other suitable wire and mounted on frames without distortion. The sieve frames shall be circular, about 20 cm (7.87 inches) in diameter, 6 cm (2.36 inches) high, and provided with a pan about 5 cm (1.97 inches) deep and a cover.

"The No. 200 cement sieve (0.0029 inch opening) should have 200 wires per inch and the same number of wires in any whole inch shall not be outside the limits 192 to 208. No opening between adjacent parallel wires shall be more than 0.0050 inch in width.

"The diameter of the wire should be 0.0021 inch, and the average diameter shall not be outside the limits 0.0019 to 0.0023 inch.

"The sieving value of the sieve, as determined by sieving test made in conformity with the standard specifications for these tests on a standardized sample of cement which has a fineness of 75 to 80% passing the No. 200 sieve, or on other similarly graded material, shall not show a variation of more than 1.5% from the standards maintained at the Bureau of Standards.

"The Bureau also 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."

Numerous industries other than the cement industry began to feel the need of standard sieves, with the result that in 1914 the question of specifications for other than sand and cement sieves was referred to the Bureau of Standards by the executive committee of the American Society for Testing Materials. Considerable thought and study were given to possible screen scales, that is, to series of sieves having definite relations between consecutive sieves, and on April 20, 1916, a conference of representatives of various scientific and technical societies, government bureaus and private firms, was called to consider the various screen scales suggested. The conference selected as preferable a series of sieves having the ratio of $\sqrt{2}$: 1 between openings of successive sieves coarser than one millimeter, and the ratio $\sqrt{2}$: 1 between openings of successive sieves finer than one millimeter. The conference also appointed a committee to consider details of diameter sizes, tolerances, etc.

As a result of the work of this committee the conference adopted the so-called 1916 scale and, in the interests of securing uniformity of usage, they recommended that the scale be adopted by the industries. The scale was made broad enough, it was thought, to embrace the needs of all industries and the tolerances were made as generous as was thought permissible in an endeavor to include in the series as many sieves on the market as possible. Thus it was hoped to abandon the old "10, 20, 30" scale based on a system of round numbers of meshes per linear inch without reference to the size of wire or of opening and without definite relation between successive sieves. The new scale fortunately provided a number of sieves having the old integral equivalent numbers, so that users could easily become familiar with the scale. It was recommended by the committee that the sieves be designated by their openings rather than by their mesh. This new scale provided sieves having openings from 8 mm to 0.044 mm and was much more comprehensive than any other scale for which there were sieves on the market, even more so than the Tyler scale, although the Tyler series had the ratio $\sqrt{2}$: 1 between successive openings and also included the old 200-mesh sieve in the series.

The W. S. Tyler Company adopted the ratio $\sqrt{2}$: 1 between successive openings of their sieve scale in 1910. Their sieves were very much used, but there were also sieves made to other scales so that it was thought advisable to coordinate the scales as well as possible and to include in a standard screen scale as many of the sieves on the market as possible. In endeavoring to do this the nominal wire diameters of the Standard Specifications were made to vary slightly from those of Tyler, but the sieve openings of the series were essentially the same. In recent catalogues, the W. S. Tyler Company has published tables of the Tyler Screen Scale in which the ratio $\sqrt[4]{2}$: 1 is used throughout the series.

The question of the general adoption of the 1916 screen scale was dropped with our entrance into the War so that very little progress was made with it.

In 1919 the Bureau of Standards made slight amendments to the 1916 scale and formally adopted the scale in June 1920 as the Bureau's standard. The amendments consisted in making the sieve openings an exact geometric series, the ratio $\sqrt[4]{2}$: 1 being used throughout the series, regardless of existing sieves, in a revision of the wire diameters to give a regular increase in the ratio of wire diameter to opening throughout the series, in limiting the tolerances to percentage variations in the average sieve openings, the average wire diameter and the maximum sieve opening, and in the elimination entirely of the word "mesh" in designating the sieve. In these specifications the sieves are designated by arbitrary numbers which approximate the mesh of the sieve but no reference is made to the word mesh.

Sieves are now designated by the Bureau of Standards as No. 6 or No. 200, etc. The American Society for Testing Materials designates these same sieve sizes by the sieve opening in microns. The two different designations of the same sieves is unimportant because each is specific. The specifications of this date were gradually adopted by all organizations and committees until in 1924 they were generally adopted by the American Society for Testing Materials and throughout the United States following a slight increase by the Bureau of Standards in the tolerances on average wire diameter and in a few cases on maximum openings. It had been proven experimentally that these factors could be made more liberal without noticeably affecting the sieving value of the sieve. The 1924 specifications are the same as the 1919 specifications except for these slight changes in tolerances.

Specifications are a product of evolution, and while it is not claimed that the 1924 scale is perfect, at the present time it seems basically correct, and the fact that the majority of the sieves now tested are found to be within the tolerances seems to indicate that the tolerances are reasonable. With further experimentation and with further development of testing and manufacture, desirable changes, particularly in tolerance, may become advisable, but the important point is that all users of precision sieves in all lines are using sieves selected from one sieve scale, these sieves all being known by their size of opening rather than by some other less important factor.

The 1924 specifications, generally adopted by the American Society for Testing Materials and others in the United States desiring precision sieves are as follows:

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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 either about 5 cm (2 inches) or 2.5 cm (1 inch) between the top of the frame and the cloth. Sieves having a height of 5 cm (2 inches) are designated as full-height sieves; those having a height of 2.5 cm (1 inch) are designated as half-height sieves.

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 attached 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. Sieves may be rejected 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.

(1) Sieve number	(2) Sieve opening	(3) Sieve opening	(4) Wire diameter	(5) Wire diameter	(6) Tolerance in average opening	(7) Tolerance in wire diameter	(8) Tolerance in maximum opening
	Millimeters	*Inches*	*Millimeters*	*Inches*	*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

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