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DEPARTMENT OF MINES AND TECHNICAL SURVEYS
MINES BRANCH

MASTER SIEVES AT THE MINES BRANCH

FOR STANDARDIZATION OF THE SIEVES OF THE MINING INDUSTRY

by

J. BRANNEN and L. E. DJINGHEUZIAN

MINERAL DRESSING AND PROCESS METALLURGY DIVISION

Price 25 cents

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Abstract

At the request of the mining industry the ore dressing laboratories of the Mines Branch undertook to establish master sieves for standardization of sieves of the mining industry. The purpose of this work was to establish a standardized screening technique, thus placing all the operators of grinding plants on one basis of sizing.

Three sieves of each of the following Tyler meshes were purchased: 48, 65, 100, 150, 200, 270 and 325. The Lake Shore method of standardizing the above testing sieves was used. After a series of self-checking tests with each sieve was made, the three sieves of each mesh were marked in the order of their decreasing fineness as master screen No. 1, No. 2 and No. 3.

Three different ores were used for standardization of the 48, 65 and 100 mesh sieves, and four different ores for the 150, 200, 270 and 325 mesh screens.

In the concluding paragraphs of the report, the results are summarized, conclusions are drawn, and suggestions are made to mill operators who wish to have their screens standardized.

CONTENTS

MASTER SIEVES AT THE MINES BRANCH FOR STANDARDIZATION OF SIEVES OF THE MINING INDUSTRY

by

J. Brannen* and L. E. Djingheuzian**

I. INTRODUCTION

For many years scientific investigators and grinding engineers have been trying to establish a reliable formula or method from which efficiencies of grinding plants could be calculated on a comparative basis. In his article "The Third Theory of Comminution", Fred C. Bond[1] enunciated the idea of total work as a fundamental concept in comminution. From this he arrived at the concept of work index as a criterion for comparative efficiencies in comminution.

To obtain an accurate value for work index, the power input, size of feed and size of product should be determined with painstaking accuracy. Since accurate meters for reading power input are available, the chief concern of the grinding engineer appears to be accurate sizing of feed and product.

Assuming that samples are representative and that screening is properly standardized, the accurate determinations of feed and product sizes will depend on accurate screens, or, since these might not be available, on having master screens which can be used for standardizing the screens used for everyday work. The indispensability of master screens[1] is realized when, for instance, 200-mesh screens in two adjacent plants are compared: it will usually be found that these screens differ, sometimes to a large extent.

Two years ago, one of the leading Canadian mineral dressing engineers visited Ottawa. He was emphatic in saying "due to recent progress in developing a theory of grinding, i.e. Bond's new theory of comminution, possibly the only thing needed now to get at the general efficiency of one's grinding system, compared to others, is a standardized screening technique at the Mines Branch. This would place us all on one basis of sizing".

The mining industry, which was canvassed through the branches of the Canadian Institute of Mining and Metallurgy from coast to coast, unanimously approved the establishment of a national set of

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master screens in Ottawa. Accordingly, a proposal was prepared[2] and submitted to the mill operators at the Ninth Business Conference, Metallurgy Division, C.I.M., in Edmonton in April, 1953. The proposal suggested that the Lake Shore[3] method of standardizing the testing sieves be used at the Mines Branch. The Conference approved the proposal and formally requested the Mines Branch to proceed with the establishment of a national set of master screens.

Three screens, each of the following Tyler mesh, were purchased: 48, 65, 100, 150, 200, 270, and 325. However, before proceeding with the standardization of these screens, a study of wet screen analysis was made.

II. SUMMARY AND CONCLUSIONS FROM THE STUDY OF LAKE SHORE METHOD OF WET SCREEN ANALYSIS PRIOR TO STANDARDIZATION

(This study was carried out by John McIntosh, B.Sc., Queen's, as student assistant in the summer of 1953.)

In this study, all procedures were patterned after those used at LakeShore Mines[3], and all screen analyses were carried out with screens in daily use in Mineral Dressing laboratories. The purpose of this study was to determine factors which affect the accuracy of screening.

Using three different ores, namely, a copper ore, a pyritic ore and a low-grade chromite ore, and 28-, 35-, 48-, 65-, 100-, 150- and 200-mesh screens, it was found that:

(1) When washing with a gentle stream of water on the 200-mesh screen, the duration of the washing operation is an important factor. The operator, before the drying for rotapping, must be fairly sure that the finer particles adhering to coarser ones have been well separated. This is indicated when only clear water is passing through the sieve.

(2) When good care is taken in mixing (rolling not less than 100 times) and cutting out 200-gram samples, the discrepancies in the screen analysis are low, as shown by Table I.

Nine tests were made and the above three are first of the series. Thus, the sampling procedure proved to be adequate.

(3) When the same sample is used in several screen analyses, combining all fractions before each subsequent screening, attrition on the coarser fractions was indicated by the increase in the minus 200-mesh fraction and corresponding decrease in plus 28-mesh fraction for the pyritic ore ground coarse.

TABLE I

Time of first rotap: 15 min.

" " second " : 15 "

Copper Ore

Tyler Mesh	Test #1	Test #2	Test #3
+28	9.4	9.6	9.1
-28 +35	15.0	15.1	14.4
-35 +48	9.8	9.9	10.5
-48 +65	10.2	10.3	10.3
-65 +100	8.9	8.9	9.1
-100+150	6.8	6.4	6.6
-150+200	5.3	5.1	5.3
-200	33.9	33.9	34.4
	99.3	99.2	99.7

(4) For the same pyritic ore, ground all to minus 48 mesh, when time of rotapping was increased, the increased minus 200-mesh fraction was almost accounted for in the decrease in the minus 150- plus 200-mesh fraction. With the increased length of sieving time this seemed to indicate that this variation might have been due to two other causes besides attrition: (a) a certain percentage of oversize sieve apertures which allowed a larger percentage of the coarser particles to pass as sieving continued, and (b) by more borderline particles finding openings through which to pass. This effect would not be noticeable for the coarse sieves owing to their sturdier construction.

(5) Both types of sieving loss occurred in the results of tests on chromite ore.

(6) When following Lake Shore procedure, the final additional minute on the Rotap showed in all cases that the end point was reached, the amount of increase in the minus mesh fraction, determining the measure of grind, being only a fraction of one per cent.

III. STANDARDIZATION OF TESTING SIEVES

All the experimental work in carrying out the setting of master sieves will be herein described as standardization of testing sieves. The finest screen in each case was denoted as the master screen, followed by sub-master 1 and 2 in order of decreasing fineness. For identification, these sieves were stamped respectively with numbers 1, 2 and 3.

For standardizing screens of the industry, only No. 2 and No. 3 screens will be used. No. 1 screen, i.e., the master screen, will be used only for standardizing new sub-master screens when the present ones are discarded owing to wear or blockage of apertures.

In standardizing the Mines Branch screens, extreme care was taken not to distort in any way the weaving of the sieves. In other words, brushing or washers were not used, nor compressed air for blowing of the screens.

1. Standardization of 48-mesh Sieves.

The screens to be standardized were marked Set #1, #2, and #3, and similar tests were carried out with each screen.

a. Samples of three gold ores from Porcupine and Red Lake were crushed to all minus 14 mesh and then ground to a variable percentage of minus 48 mesh for each ore. The samples were rolled at least 100 times.

b. A 100-gram sample was taken and pulped in a clean granite-ware pail and the sands were allowed to settle. The slime and fines were decanted and washed through a 200-mesh screen. The remainder in the pail was then washed into the screen.

c. The material on the screen was washed thoroughly until only clear water passed through it. The fraction retained on the screen was transferred to a clean granite-ware dish, dried, rewashed and dried.

d. The plus 200-mesh material was screened on a 28-, 35- and the standard 48-mesh screens, Set 1, for 25 minutes on the Rotap.

e. Each plus fraction was then washed on the 48-mesh screen. The fractions were then dried, returned to their respective screens and given another 5 minutes on the Rotap.

The above procedure was applied using each of the three ores and repeated for Sets 2 and 3.

The results from this series of screen tests are tabulated as follows:

TABLE II

Series 1

Set #1	Ore "A"	Ore "B"	Ore "C"
Mesh	%	%	%
+28	16.5	14.2	5.9
+35	13.2	12.9	15.5
+48	11.9	10.4	14.8
-48	58.4	62.5	63.8
Total	100.0	100.0	100.0

Set #2	Ore "A"	Ore "B"	Ore "C"
+28	16.3	13.9	5.8
+35	13.0	12.8	15.8
+48	11.9	10.1	14.3
-48	58.8	63.2	64.1
Total	100.0	100.0	100.0

Set #3	%	%	%
+28	16.4	14.0	6.0
+35	13.0	12.8	15.2
+48	11.8	10.5	14.5
-48	58.8	62.7	64.3
Total	100.0	100.0	100.0

A second series of tests was run on the 48-mesh standard screen Set 1 using the same procedure as in Series 1.

The minus 200-mesh material which was washed through the screen was filtered and dried. The plus fractions from Set 1 screen were combined with the minus 200-mesh material and used for the standardization of Set 2. The combined fractions from Set 2 screen were used for the standardization of Set 3 screen by the same method.

The results of this series of tests are as follows:

TABLE III

Series 2

Set #1	Ore "A"	Ore "B"	Ore "C"
Mesh	%	%	%
+28	16.3	14.0	6.1
+35	12.9	12.7	15.6
+48	12.1	10.7	15.0
-48	58.7	62.6	63.3
Total	100.0	100.0	100.0

Set #2	%	%	%
+28	16.5	14.0	6.0
+35	12.9	12.8	15.7
+48	11.8	10.6	14.9
-48	58.8	62.6	63.4
Total	100.0	100.0	100.0

Set #3	%	%	%
+28	16.7	14.1	6.2
+35	13.0	12.7	15.8
+48	11.9	10.5	14.7
-48	58.4	62.7	63.3
Total	100.0	100.0	100.0

In all cases the 'end point' was reached, the difference in total weights after 25 minute rotapping and the additional 5 minute rotapping being always well under 1%.

The highest loss in total weight after completion of filtering and screening was 0.7%. Using the standard procedure adapted by the mining industry, this loss was added to the finest fraction, namely, to the % minus 48 mesh. Table IV summarizes the results obtained.

TABLE IV

Screen Set #1

% Minus 48 Mesh

Ore	A	B	C
Series 1	58.4	62.5	63.8
" 2	58.7	62.6	63.3
Average	58.55	62.55	63.55

Screen Set #2

% Minus 48 Mesh

Series 1	58.8	63.2	64.1
" 2	58.8	62.6	63.4
Average	58.8	62.9	63.75

Screen Set #3

% Minus 48 Mesh

Series 1	58.8	62.7	64.3
" 2	58.4	62.7	63.3
Average	58.6	62.7	63.8

The final results are shown in Table V.

TABLE V

Screen	Average Percentage of Samples Retained			% Coarseness		
	A	B	C	A	B	C
Set #1	41.45	37.45	36.45	Taken as reference		
" #2	41.2	37.1	36.25	0.25	0.35	0.20
" #3	41.4	37.3	36.2	0.05	0.15	0.25

Screen	Average Percentage Retained on 48 mesh	% Coarseness
Set #1	38.45	Taken as Master
" #2	38.18	0.27
" #3	38.30	0.15

These results show that there is very little to choose among the three screens. However, screen #1 was stamped as the master screen, 1; screen #3 as the first sub-master, 2; and screen #2 as the second sub-master, 3.

2. Standardization of 65-mesh Sieves.

a. Samples of the same ores, A, B and C, were crushed to all minus 28 mesh and ground to a variable percentage of minus 65 mesh for each ore. The samples were rolled thoroughly at least 100 times and screening was carried out using each of the three ores with Sets #1, #2, and #3.

b. A 100-gram sample was taken and washed in the same manner as for the standardization of the 48-mesh screen.

c. The plus 200-mesh material after drying was screened on a 35-, 48- and the standard 65-mesh screens for 25 minutes on the Rotap.

d. Each plus fraction was washed on the standard 65-mesh screen, and dried. The fractions were then returned to their respective screens and given 5 minutes on the Rotap.

TABLE VI

Series 1

Set #1	Ore		
	"A"	"B"	"C"
Mesh	%	%	%
+35	11.8	10.8	2.8
+48	15.6	11.4	5.0
+65	11.4	6.1	4.7
-65	61.2	71.7	87.5
	100.0	100.0	100.0

Set #2			
Mesh	%	%	%
+35	12.0	10.6	2.8
+48	15.2	11.7	5.1
+65	11.8	5.8	4.7
-65	61.0	71.9	87.4
	100.0	100.0	100.0

Set #3			
Mesh	%	%	%
+35	12.0	10.6	2.8
+48	15.2	11.7	5.1
+65	11.8	5.8	4.7
-65	61.0	71.9	87.4
	100.0	100.0	100.0

The tests carried out in Series 1 were repeated and the results are shown in Table VII.

TABLE VII

Series 2

Set #1	Ore		
	"A"	"B"	"C"
Mesh	%	%	%
+35	11.8	10.3	2.8
+48	15.4	11.6	5.2
+65	11.6	6.1	4.7
-65	61.2	72.0	87.3
	100.0	100.0	100.0
Set #2			
Mesh	%	%	%
+35	11.9	10.3	2.9
+48	15.3	11.7	5.2
+65	11.8	6.1	4.8
-65	61.0	71.9	87.1
	100.0	100.0	100.0
Set #3			
Mesh	%	%	%
+35	11.7	10.3	2.6
+48	15.5	11.6	5.2
+65	11.7	6.4	5.0
-65	61.1	71.7	87.2
	100.0	100.0	100.0

Table VIII summarizes the results obtained.

TABLE VIII

Screen Set #1

Ore	"A"	"B"	"C"
	% Minus 65 Mesh		
Series 1	61.2	71.70	87.5
" 2	61.2	72.00	87.3
Average	61.2	71.85	87.4

Screen Set #2

Ore	"A"	"B"	"C"
	% Minus 65 Mesh		
Series 1	61.0	71.90	87.40
" 2	61.0	71.90	87.10
Average	61.0	71.90	87.25

Screen Set #3

Ore	"A"	"B"	"C"
	% Minus 65 Mesh		
Series 1	61.0	71.90	87.4
" 2	61.1	71.70	87.2
Average	61.05	71.80	87.3

The final results are shown in Table IX.

TABLE IX

Screen	Average Percentage of Samples Retained			% Coarseness		
	A	B	C	A	B	C
Set #1	38.8	28.15	12.6	0.1	0.1	0.3
" #2	39.0	28.10	12.75	-0.1	0.15	0.15
" #3	38.95	28.20	12.7	Taken as reference		

TABLE IX (cont'd.)

Averages

	Percentage retained on 65 mesh	% Coarseness
Set #1	26.52	0.06
" #2	26.62	0.00
" #3	26.62	Taken as master

Again, as in case of 48-mesh screens, there is very little to choose among the three 65-mesh screens. However, Set #3 was stamped as the master screen, 1; Set #2 as the first sub-master, 2; and Set #1 as the second sub-master, 3.

Since the percentages of coarseness for screening the three different ores at different grinds were practically the same, it was considered safe to average those percentages of coarseness for obtaining an average figure for the coarseness of each screen.

3. Standardization of 100-mesh Sieves.

From the previous study on wet screen analysis, it was found that the results obtained with 100-gram samples were just as reliable as with 200-gram samples. The only difference was that after the final additional minute on the Rotap to determine if the 'end point' had been reached, it was found that the amount of minus 100-mesh for both 100- and 200-gram samples was increased by the same amount, namely 0.1 gram, or 0.1% for the 100-gram sample and 0.05% for the 200-gram sample. Hence, it was decided that for standardizing 100-mesh screens, 100-gram samples would be adequate.

a. Samples of the same ores, A, B and C, were ground all to minus 35 mesh and reground to various percentages of minus 100 mesh for each ore. The samples were rolled 100 times.

b. A 100-gram sample of each ore was taken in turn and washed by the same method as for the standardization of the 48-mesh screen in steps b and c, except that the sample had three washings on the 200-mesh screen instead of two.

c. The plus 200-mesh material, after drying, was screened on a 48-, 65- and the standard 100-mesh screen for 15 minutes on the Rotap.

d. Each plus fraction was washed on the standard 100-mesh screen and dried. The fractions were returned to their respective screens and given 20 minutes on the Rotap.

A second series of tests was run to confirm the results obtained from the first series of screen tests.

TABLE X

Series 1

Set #1	Ore		
	A	B	C
Mesh	%	%	%
+48	15.0	5.1	3.4
+65	10.3	10.3	6.3
+100	7.8	9.1	6.2
-100	66.9	75.5	84.1
	100.0	100.0	100.0
Set #2	%	%	%
+48	15.0	4.9	3.4
+65	10.4	10.6	6.3
+100	7.7	9.1	6.1
-100	66.9	75.4	84.2
	100.0	100.0	100.0
Set #3	%	%	%
+48	14.8	5.1	3.4
+65	10.5	10.4	6.4
+100	7.5	9.1	5.9
-100	67.2	75.4	84.3
	100.0	100.0	100.0

TABLE XI

Series 2

Set #1	Ore		
	A	B	C
Mesh	%	%	%
+48	14.8	5.9	3.4
+65	10.3	11.4	6.2
+100	7.8	10.1	6.3
-100	67.1	72.6	84.1
	100.0	100.0	100.0

Set #2	%	%	%
+48	14.6	5.7	3.4
+65	10.4	11.5	6.4
+100	7.8	10.1	6.1
-100	67.2	72.7	84.1
	100.0	100.0	100.0

Set #3	%	%	%
+48	14.6	6.0	3.4
+65	10.6	11.0	6.5
+100	7.6	10.2	6.0
-100	67.2	72.8	84.1
	100.0	100.0	100.0

Note: Not sufficient B ore was ground to last both series. Hence, for Series 2, another batch was prepared. This accounts for the difference in the screening of Sample B in Series 1 and 2.

The results from screen tests for the two series are summarized in Table XII.

TABLE XII

Set #1	Ore % Minus 100 Mesh A	B	C
Series 1	66.9	75.50	84.1
" 2	67.1	72.60	84.1
Average	67.0	74.05	84.1
Set #2			
Series 1	66.90	75.40	84.20
" 2	67.20	72.70	84.10
Average	67.05	74.05	84.15
Set #3			
Series 1	67.2	75.4	84.3
" 2	67.2	72.8	84.1
Average	67.2	74.1	84.2

The final results are shown in Table XIII.

TABLE XIII

	Average Percentage of Sample Retained			% Coarseness		
Screen	A	B	C	A	B	C
Set #1	33.00	25.95	15.90	Taken as reference		
" #2	32.95	25.95	15.85	0.05	0.00	0.05
" #3	32.80	25.90	15.80	0.20	0.05	0.10

TABLE XIII (cont'd.)

Averages

	Percentage retained on 100-mesh	% Coarseness
Set #1	24.95	Retained as master
" #2	24.92	0.03
" #3	24.83	0.12

The difference among the screens is negligible. Set #1 was stamped as the master screen, 1; Set #2 as the first sub-master, 2; and Set #3 as the second sub-master, 3.

4. Standardization of 150-mesh Sieves.

a. Samples of gold ores, A, B, C and, in addition, of a chromite ore D, were ground all to minus 48 mesh. They were reground to variable percentages of minus 150 mesh for each ore. The samples were rolled at least 100 times.

b. A 200-gram sample of each ore was taken in turn and washed on a 200-mesh screen in the same manner as for the 100-mesh screen.

c. The plus 200-mesh material after drying was screened on a 65-, 100- and the standard 150-mesh screen for 15 minutes on the Rotap.

d. Each plus fraction was washed on the standard 150-mesh screen and dried. The fractions were returned to their respective screens and given 25 minutes on the Rotap.

The same procedure was repeated for the standardization of Set #2 and Set #3.

A second series of tests was run using the same procedure as above except that Step d, washing of the plus 200 fractions on the standard 150-mesh screen, was eliminated. For these tests, the time on the Rotap was increased from 15 to 40 minutes in Step c.

Results of Screen Tests

TABLE XIV

Series 1

Set #1	Ore			
	A	B	C	D
Mesh	%	%	%	%
+65	18.65	13.35	6.70	2.40
+100	7.05	8.10	4.50	3.20
+150	8.95	6.80	6.90	3.50
-150	65.35	71.75	81.90	90.90
Total	100.00	100.00	100.00	100.00
Set #2	%	%	%	%
+65	18.50	13.25	6.70	2.35
+100	7.10	8.20	4.55	3.20
+150	8.80	6.75	6.70	3.60
-150	65.60	71.80	82.05	90.85
Total	100.00	100.00	100.00	100.00
Set #3	%	%	%	%
+65	18.70	13.20	6.60	2.25
+100	7.05	8.15	4.65	3.40
+150	8.90	6.80	6.75	3.60
-150	65.35	71.85	82.00	90.75
Total	100.00	100.00	100.00	100.00

TABLE XV

Series 2

Set #1	Ore			
	A	B	C	D
Mesh	%	%	%	%
+65	18.80	13.30	6.65	2.50
+100	7.10	8.10	4.60	3.25
+150	9.15	6.75	6.85	3.70
-150	64.95	71.85	81.90	90.55
Total	100.00	100.00	100.00	100.00
Set #2	%	%	%	%
+65	18.90	13.30	6.70	2.50
+100	6.90	8.25	4.60	3.20
+150	8.90	6.70	6.95	3.80
-150	65.30	71.75	81.75	90.50
Total	100.00	100.00	100.00	100.00
Set #3	%	%	%	%
+65	18.80	13.45	6.65	2.35
+100	7.20	8.05	4.60	3.40
+150	8.70	6.65	6.80	3.75
-150	65.30	71.85	81.95	90.50
Total	100.00	100.00	100.00	100.00

Table XVI summarizes the results of the two series.

TABLE XVI

Set #1	Ore A	B	C	D
Mesh	% Minus 150 Mesh			
Series 1	65.35	71.75	81.90	90.90
" 2	64.95	71.85	81.90	90.55
Average	65.15	71.80	81.90	90.72
Set #2	% Minus 150 Mesh			
Series 1	65.60	71.80	82.05	90.85
" 2	65.30	71.75	81.75	90.50
Average	65.45	71.77	81.90	90.67
Set #3	% Minus 150 Mesh			
Series 1	65.35	71.85	82.00	90.75
" 2	65.30	71.85	81.95	90.50
Average	65.32	71.85	81.97	90.62

The final results are shown in Table XVII.

TABLE XVII

Series 1

Screen	Percentage of Sample Retained				% Coarseness			
	A	B	C	D	A	B	C	D
Set #1	34.65	28.25	18.10	9.10	Taken as Reference			
" #2	34.40	28.20	17.95	9.15	0.25	0.05	0.15	-0.05
" #3	34.65	28.25	18.00	9.25	0.00	0.00	0.10	-0.15

TABLE XVII (cont'd.)

Series 2

Screen	Percentage of Sample Retained				% Coarseness			
	A	B	C	D	A	B	C	D
Set #1	35.05	28.15	18.10	9.45	Taken as Reference.			
" #2	34.70	28.25	18.25	9.50	0.35	-0.10	-0.15	-0.05
" #3	34.70	28.15	18.05	9.50	0.35	0.00	0.05	-0.05

Since the variation in results from both series appear to be negligible, it was considered that it would be safe to average all the results. Table XVIII shows the final averages.

TABLE XVIII

Screen	Percentage retained on 150-mesh	% Coarseness
Set #1	22.61	Taken as Master
" #2	22.55	0.06
" #3	22.56	0.05

Actually, the difference among the three screens is negligible. Set #1 was stamped as the master screen, 1; Set #3 as the first sub-master, 2; and Set #2 as the second sub-master, 3.

Conclusions Drawn from the Standardization Tests on 48-, 65-, 100-, and 150-mesh Sieves.

In studying the results obtained on three sets of sieves of each mesh, it would appear that in most of the tests the percentages passing the finest sieves in Series 1 and Series 2 show higher discrepancies in sampling or sieving errors than do the percentages passing in comparing the three sets of sieves.

However, since the tests showed that for all practical purposes the three sieves of each mesh were the same, it was decided that no useful purpose would be served by running many repeats on the same sample to determine the differences in sieving accuracy for different sieves.

5. Standardization of 200-mesh Sieves.

a. Samples of the same ores used for the standardization of the 150-mesh screens were ground all to minus 65 mesh. The samples were reground to variable percentages of minus 200 mesh for each ore. The samples were rolled at least 100 times.

b. A 200-gram sample of each ore was taken in turn and washed on a 200-mesh screen to be standardized and dried according to the procedure as used for the 150-mesh screen. The sample was washed, dried, rewashed and redried twice, making three washings altogether.

c. The plus 200-mesh fraction was screened on a 100-, 150- and the standard 200-mesh screen for 15 minutes on the Rotap.

d. The plus 200-mesh fractions were washed separately on the 200-mesh screen and dried.

e. The fractions were then returned to their respective screens and given 20 minutes on the Rotap.

f. Each fraction was washed again on the 200-mesh screen, dried and given a final 5 minutes on the Rotap.

Results of Screen Tests

TABLE XIX

Set #1	Ore			
	A	B	C	D
Mesh	Percent			
+100	9.70	4.45	4.22	0.75
+150	11.80	4.00	3.55	0.35
+200	11.00	10.95	5.80	4.90
-200	67.50	80.60	86.43	94.00
Totals	100.00	100.00	100.0	100.00

TABLE XIX (cont'd)

Set #2	Percent			
+100	9.70	4.45	4.25	0.75
+150	12.15	5.85	3.60	0.95
+200	10.70	9.20	5.90	4.90
-200	67.45	80.50	86.25	93.40
Totals	100.00	100.00	100.00	100.00

Set #3	Percent			
+100	9.85	4.55	4.20	0.70
+150	12.05	5.85	3.20	1.00
+200	10.85	9.65	6.45	4.95
-200	67.25	79.95	86.15	93.35
Totals	100.00	100.00	100.00	100.00

Alternate Method

Another method of screen tests was used to confirm the results obtained by the Lake Shore method. A 200-gram sample of ore C was taken and washed on a 200-mesh screen by exactly the same procedure as the Lake Shore method, including the wash of each plus 200-mesh fraction on the 200-mesh screen.

The sample was given the same screening time on the Ro-tap, i.e. 15, 20 and 5 minutes, consecutively.

After weighing the fractions from Set 1 screen test, they were combined and used for screening with Set 2. Likewise the fractions from Set 2 were combined and used for screening with Set 3.

Three series of tests were run on the same plus 200-mesh fractions in the following order: first, Sets 1, 2, 3; second, Sets 2, 3, 1; and third, Sets 3, 1, 2. Table XX shows the test results by this method.

Table XX

Results of Tests - Alternate Method

Series 1

Ore C	Set 1	Set 2	Set 3
Mesh		Per cent	
+ 100	4.30	4.20	4.20
+ 150	4.35	4.60	4.75
+ 200	4.85	4.85	4.70
- 200	86.50	86.35	86.35
Totals	100.00	100.00	100.00

Series 2

Ore C	Set 2	Set 3	Set 1
Mesh		Per cent	
+ 100	4.30	4.30	4.15
+ 150	4.75	4.55	4.55
+ 200	4.65	4.95	4.75
- 200	86.30	86.20	86.55
Total	100.00	100.00	100.00

Series 3

Ore C	Set 3	Set 1	Set 2
Mesh		Per cent	
+ 100	4.35	4.20	4.25
+ 150	4.65	4.50	5.15
+ 200	4.70	4.80	4.10
- 200	86.30	86.50	86.50
Total	100.00	100.00	100.00

Table XXI

Summary. Lake Shore Method

	"A"	"B"	"C"	"D"
	% minus 200 mesh			
Set I	67.50	80.60	86.42	94.00
Set 2	67.45	80,50	86.25	93.40
Set 3	67.25	79,95	86.15	93.35

Alternate Method

Ore "C" Standard Screen

	Set 1	Set 2	Set 3
	% minus 200 Mesh		
Series I	86.50	86.35	86.35
" 2	86.55	86.30	86.20
" 3	86.50	86.50	86.30
Average -	86.52	86.38	86.28

The final results are shown in Tables XXII and XXIII.

TABLE XXII

Screen	Percentage of Sample Retained				% Coarseness			
	A	B	C	D	A	B	C	D
Set #1	32.50	19.40	13.58	6.00	0.25	0.65	0.27	0.35
" 2	32.55	19.50	13.75	6.60	0.20	0.50	0.10	0.05
" 3	32.75	20.05	13.85	6.65	Taken as reference			

Average

	Percentage retained on 200 mesh	% Coarseness
Set #1	17.87	0.45
" 2	17.95	0.37
" 3	18.32	Taken as master

TABLE XXIII

Alternate Method

Ore C

Screen	Percentage retained on 200 mesh	% Coarseness
Set #1	13.48	0.24
" #2	13.62	0.10
" #3	13.72	Taken as master

Set #3 was stamped as the master screen, 1; Set #2 as the first sub-master, 2; and Set #1 as the second sub-master, 3.

6. Standardization of 270-mesh Sieves.

a. Samples of the same ores were ground all to minus 100 mesh. They were reground to variable percentages of minus 270 mesh for each ore. The samples were rolled at least 100 times.

b. A 200-gram sample of each ore was taken in turn and washed on a 325-mesh screen and dried by the same procedure as used for the 200-mesh screen.

Each of the four samples had three washings on the screen.

c. The plus 325-mesh fractions were screened on a 150-, 200- and the standard 270-mesh screen for 15 minutes on the Rotap.

d. Each fraction was then washed separately on the standard 270-mesh screen and dried.

e. The fractions were now returned to their respective screens and given 25 minutes on the Rotap.

f. The fractions were washed on the 270-mesh screen, dried, and given a final 5 minutes on the Rotap.

TABLE XXIV

Results of Screen Tests

Set 1

Ore

Mesh	A	B	C	D
	Per cent			
+150	5.65	6.70	1.40	0.35
+200	15.95	11.10	0.45	0.65
+270	13.90	6.40	9.25	5.75
-270	64.50	75.80	88.90	93.25
	100.00	100.00	100.00	100.00

Set 2

Mesh	A	B	C	D
+150	5.50	8.35	1.85	0.40
+200	16.30	10.20	1.95	0.55
+270	12.45	5.25	6.30	5.00
-270	65.75	76.20	89.90	94.05
	100.00	100.00	100.00	100.00

Set 3

Mesh	A	B	C	D
+150	4.95	7.80	2.50	0.20
+200	17.00	11.55	0.20	1.45
+270	13.35	5.80	8.55	5.05
-270	64.70	74.85	88.75	93.30
	100.00	100.00	100.00	100.00

The samples were re-rolled 100 times and a second series of screen tests was made, following the same procedure.

TABLE XXV

Set 1

Sample

Mesh	A	B	C	D
	Per cent			
+150	4.60	8.70	2.75	0.80
+200	19.35	8.80	3.70	3.45
+270	10.25	6.70	5.40	2.45
-270	65.80	75.80	88.15	93.30
Total	100.00	100.00	100.00	100.00

Set 2

+150	4.75	8.80	2.75	0.45
+200	18.55	9.40	4.35	2.55
+270	10.70	5.90	4.15	3.25
-270	66.00	75.90	88.75	93.75
Total	100.00	100.00	100.00	100.00

Set 3

+150	4.00	7.20	1.40	0.65
+200	19.40	8.20	4.75	2.40
+270	11.45	9.60	5.75	3.80
-270	65.15	75.00	88.10	93.15
Total	100.00	100.00	100.00	100.00

Table XXVI summarizes the results obtained.

TABLE XXVI

Ore

Set 1	A	B	C	D
	% Minus 270 Mesh			
Series 1	64.50	75.80	88.90	93.25
" 2	65.80	75.80	88.15	93.30
Average	65.15	75.80	88.52	93.27
Set 2	% Minus 270 Mesh			
Series 1	65.75	76.20	89.90	94.05
" 2	66.00	75.90	88.75	93.75
Average	65.87	76.05	89.32	93.90
Set 3	% Minus 270 Mesh			
Series 1	64.70	74.85	88.75	93.30
" 2	65.15	75.00	88.10	93.15
Average	64.92	74.92	88.42	93.22

The final results are shown in Table XXVII.

TABLE XXVII

	Average Percentage of Sample Retained				% Coarseness			
Screen	A	B	C	D	A	B	C	D
Set #1	34.85	24.20	11.48	6.83	0.23	0.88	0.10	0.05
" 2	34.13	23.95	10.68	6.10	0.95	1.13	0.90	0.68
" 3	35.08	25.08	11.58	6.78	Taken as reference			

TABLE XXVII (cont'd)

Screen	Average Percentage retained on 270 mesh	% Coarseness
Set #1	19.34	0.29
" 2	18.72	0.91
" 3	19.63	Taken as master

Set #3 was stamped as the master screen, 1; Set #1 as the first sub-master, 2; and Set #2 as the second sub-master, 3.

7. Standardization of 325-mesh Sieves.

a. Samples of ores A, B, C and D were ground all to minus 150 mesh.

Part of these samples were reground to various percentages of minus 325 mesh for each ore. The samples were rolled at least 100 times.

b. A 200-gram sample of each ore was taken in turn and washed on a 325-mesh screen by the same procedure as was used for the 270-mesh screen.

Each sample had three washings altogether on the 325-mesh screen.

c. The plus 325-mesh fraction was dried and screened on a 200-, 250-, and the standard 325-mesh screen for 15 minutes on the Rotap.

d. Each fraction was then washed separately on the standard 325-mesh screen and dried.

e. The fractions were returned to their respective screens and given 30 minutes on the Rotap.

f. Each fraction was washed again on the 325-mesh screen, dried, and given a final 5 minutes on the Rotap.

Results of Screen Tests

Table XXVIII

Series 1 — Set 1

Mesh	Ore A	Ore B	Ore C	Ore D
	Per cent			
+200	0.10	5.90	22.40	13.95
+250	0.55	2.95	4.60	5.05
+325	9.10	10.35	10.20	28.20
-325	90.25	80.80	62.80	52.80
Total	100.00	100.00	100.00	100.00

Set 2

Mesh	A	B	C	D
+200	0.10	7.10	23.50	15.55
+250	0.50	1.30	3.15	5.05
+325	8.95	10.20	10.45	26.05
-325	90.45	81.40	62.90	53.35
Total	100.00	100.00	100.00	100.00

Set 3

Mesh	A	B	C	D
+200	0.10	7.55	23.80	13.15
+250	0.35	1.65	2.85	4.30
+325	8.30	9.40	10.20	28.45
-325	91.25	81.40	63.15	54.10
Total	100.00	100.00	100.00	100.00

The four samples were re-rolled and a second series of screen tests performed using the same procedure as for Series 1.

TABLE XXIX

Series 2 Set 1

Ore

Mesh	A	B	C	D
	Per cent			
+200	0.50	7.40	23.75	11.30
+250	0.30	1.75	3.35	6.50
+325	8.70	9.95	10.05	29.55
-325	90.50	80.90	62.85	52.65
Total	100.00	100.00	100.00	100.00

Set 2

	Per cent			
+200	0.35	7.25	23.50	15.55
+250	0.20	1.00	3.15	5.05
+325	8.95	10.50	10.45	26.05
-325	90.50	81.25	62.90	53.35
Total	100.00	100.00	100.00	100.00

Set 3

	Per cent			
+200	0.10	6.95	23.80	9.95
+250	0.55	1.80	2.85	8.65
+325	8.40	9.50	10.20	27.75
-325	90.95	81.75	63.15	53.65
Total	100.00	100.00	100.00	100.00

Table XXX summarizes the results obtained.

TABLE XXX

Ore

Set 1	A	B	C	D
	Per cent minus 325 Mesh			
Series 1	90.25	80.80	62.80	52.80
" 2	90.50	80.90	62.85	52.65
Average	90.37	80.85	62.82	52.72

Set 2	Per cent minus 325 Mesh			
Series 1	90.45	81.40	62.90	53.35
" 2	90.50	81.25	62.90	53.35
Average	90.47	81.32	62.90	53.35

Set 3	Per cent minus 325 Mesh			
Series 1	91.25	81.40	63.15	54.10
" 2	90.95	81.75	63.15	53.65
Average	91.10	81.57	63.15	53.87

The final results are shown in Table XXXI.

TABLE XXXI

	Average Percentage of Sample Retained				% Coarseness			
Screen	A	B	C	D	A	B	C	D
Set #1	9.63	19.15	37.18	47.28	Taken as reference			
" 2	9.53	18.68	37.10	46.65	0.10	0.47	0.08	0.63
" 3	8.90	18.43	36.85		0.73	0.72	0.33	1.15

Average

Screen	Percentage retained on 325 mesh	% Coarseness
Set #1	28.31	Taken as master
" 2	27.99	0.32
" 3	27.58	0.73

Set #1 was stamped as the master screen, 1; Set #2 as the first sub-master, 2; and Set #3 as the second sub-master, 3.

IV. CONFIRMATORY TEST

The results obtained in the above standardization tests were somewhat surprising since it was expected that, if not the coarser sieves, at least the finer ones would show larger divergencies in their coarseness than those actually found from the tests. Since three different ores were used for coarser sieves and four ores for finer ones, the results were self-checking and established accurately the comparative coarseness of each screen.

However, it was decided to carry out a final confirmatory test. Accordingly, another engineer, with hardly any experience in actual screening and who knew nothing of the previous results, was asked to carry out a test using the 325-mesh sieves stamped 1 and 3.

For this purpose the chromite ore (D) was ground to approximately 90% minus 325 mesh and two 200-gram samples cut. Taking Sieve 1, the screening was carried out using the Lake Shore procedure with the exception that Step c (page 29) was omitted. The plus 325-mesh fractions were weighed after 30 and 5 minutes rotapping. Next, the three plus fractions were combined and rotapped for 15 minutes on standardized screen 3. The time of rotapping was cut down to 15 minutes since the chromite ore had shown some signs of attrition. This test was repeated with the second sample. Table XXXII shows the results.

TABLE XXXII

Mesh	Screen 1			Screen 3	
	30 min.	5 min.	Increase in % minus 325 mesh	15 min.	Increase in % minus 325 mesh
+200	0.06	0.02			
+250	0.77	0.77			
+325	10.85	10.75			
	11.68	11.54	0.14	10.52	1.02
+200	0.05	0.03			
+250	0.81	0.82			
+325	12.30	12.14			
	13.16	12.99	0.17	11.28	1.71

These results show:

(1) When the results on ore D from standardization tests (Table XXXI) are compared to those in Table XXXII, checks obtained are very close, percentages of coarseness being 1.15, 1.02 and 1.71 respectively;

(2) Cutting out of 200-gram samples for screening must be done with extreme care. Accordingly, the sampler must be well trained in the art of sampling.

V. SUMMARY AND CONCLUSIONS

The purpose of the above standardization of testing sieves was to determine the finest sieve in the series of three. This was done by using the Lake Shore method. Times of rotapping were as follows:

Sieve	Weight of Sample, gm.	1st Interval, min.	2nd Interval, min.	3rd Interval, min.	Total time, min.
48 mesh	100	25	5	--	30
65 "	100	25	5	--	30
100 "	100	15	20	--	35
150 "	200	15	25	--	40
200 "	200	15	20	5	40
270 "	200	15	25	5	45
325 "	200	15	30	5	50

In all cases it was found that after the final rotapping the additional weight in the final minus fraction very seldom exceeded 0.3 per cent, thus establishing the "end point". Hence, it is proposed that the above times of rotapping be standard for all types of ore; in other words, when a sieve is standardized for any given ore, that these time intervals for rotapping be used in the initial standardization. After that, an attempt will be made to cut down the time intervals untill a safe minimum is reached, i.e. untill the results are not changed by more than 1/2 per cent. The final procedure will be reported to the mill operator who has requested standardization of his sieve or sieves.

In some of the tests, the minus product from washing of plus fractions on the standard sieve was collected, dried and weighed. This indicates a possibility that with certain ores, which are not sticky, washing of the plus fractions might be safely eliminated. However, a limit must be set.

The washing of plus fractions might actually be a safety measure in order to be certain that all the fine particles adhering to coarser ones had been separated. Hence, the first washing separation is one of the most important steps and subsequent washings of plus fractions cannot be eliminated, unless the operator is certain that his first washing was a thorough job.

Much care must be taken in decanting off the excess water in the pan after each washing so as not to lose any of the finer plus fraction particles. The water should be invariably decanted on to the sieve.

It is considered now that Master Sieves have been established at the Mines Branch. A mill operator wishing to obtain a master correction factor for a sieve is invited to send the sieve to the Mines Branch together with the pertinent mill product, and sieving tests will be carried out in parallel with the standard sieves. In all cases, tests will be run to modify the Lake Shore method with a view to cutting to a minimum the time of sieving, without affecting the accuracy of the results, and a master correction factor will be given.

If an ore happens to be soft and thus subject to attrition during rotapping, an attempt will also be made to determine the amount of attrition, in order, if possible, to give an attrition correction factor.

VI. SUGGESTIONS TO MILL OPERATORS

a. Mill operators who wish to have sieves standardized, i. e. given a master correction factor, should send them, appropriately packed, to:

Chief,
Division of Mineral Dressing and Process Metallurgy,
Mines Branch,
552 Booth Street,
Ottawa, Canada.

This shipment should be accompanied by a letter requesting the standardization.

b. A representative sample of the dry mill product, for instance of the tailing, should be sent with the sieve. The amount of the sample should be 2, 000 grams.

c. On receipt of the sieves and the sample, tests will be made not only to determine the master correction factor, but also to determine the minimum time for arriving at the "end-point". When tests are completed, the sieves will be shipped back together with sieving instructions and the master correction factor determined by the tests.

d. Standardized sieves should not be used for daily mill tests, but should preferably be reserved for use as standards against which the sieves in daily use can be checked.

VII. REFERENCES

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