DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

Ottawa, November 16, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2136.

Examination of Four Silica Mill Products to Determine Suitability for Foundry Work.

(Copy No. 3.)

Bureau of Mines
Division of Metallic
Minerals

Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

O T T A W A   November 16, 1946.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2136.

Examination of Four Silica Mill Products to Determine Suitability for Foundry Work.

==========

Introduction:

On May 15, 1946, a request was received from Mr. M. J. S. Bennett, general superintendent, Canada China Clay and Silica, Limited, Kasil, Quebec, to examine four of the company's products to evaluate them for use in foundry work.

The samples, and their use by the foundry industry, were described as follows:

(1) S150 - mould wash flour.
(2) No. 80 - not at present in use.
(3) No. 20M - filler for moulding sand.
(4) 8B/20M - at present being experimented with by one foundry as a moulding sand.

Mr. Bennett also wished to know if any advantage would be gained by separating the coarse and fine materials in the No. 80 product and marketing them separately.

Method of Testing:

Methods and equipment recommended by the American Foundrymen's Association (Foundry Sand Testing Handbook, 1944 edition, A.F.A.) were used in testing the sand. Hot strength tests were made in a high temperature sand dilatometer, using 1-1/8-in.-diameter specimens two inches long. Fineness tests on the silica flours were made by using the Casagrande method (Casagrande, A., "Hydrometer Method for Grain Size Tests," Journal, America Ceramic Society, Vol. 22, No. 9, p. 288 (1939)). This method is also described by Mr. R. C. Hills (Hills, R.C., "A Comparison of Some Wet Methods Used for the Fineness Test of Sands and Clays," Transactions, A.F.A., Vol. 42, p. 101 (1934)) and by Mr. J. M. Dallavalle (Dallavalle, J. M., "Micromeritics the Technology of Fine Particles," Pitman Publishing Co., N.Y., p. 428 (1943)).

Microscopic Examination:

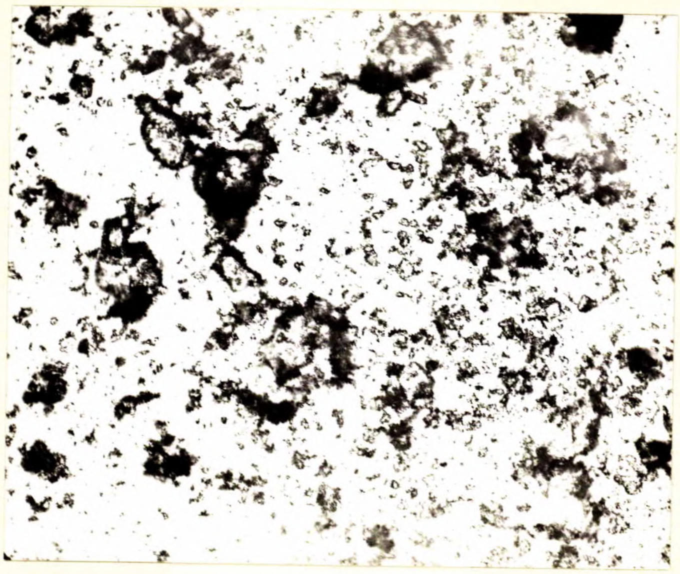
The sands were examined under the microscope. Photomicrographs are shown in Figures 1 to 3. Figure 4 is a photomicrograph of a commercial foundry sand, included for comparative purposes.

Figure 1.

X50. Bright field.
NO. 80 SILICA - Angular grains.

(Microscopic Examination, cont'd) -

Figure 2.



X200. Bright field.

S150 SILICA FLOUR.

-

Figure 3.

X20. Dark field.

NO. 20M SAND - Angular grains.

-

(Microscopic Examination, cont'd) -

Figure 4.

X20. Dark field.

COMMERCIAL CORE SAND - Round to subangular grains.

Fineness Tests:

A screen test was made on the three coarser products, and the following results were obtained:

TABLE I. - Screen Test, Per Cent Retained.

Tyler Screen No.		No. 20M Sand	8B/20M Sand	No. 80 Sand
14	-	Nil	3.0	Nil.
20	-	0.3	4.4	Nil.
28	-	6.4	7.2	0.2
35	-	19.9	14.4	0.1
48	-	24.1	20.4	0.5
65	-	19.7	20.1	8.5
100	-	13.4	14.1	31.2
150	-	7.5	7.5	28.5
200	-	4.3	4.6	18.4
270	-	1.5	1.5	6.0
Pan	-	1.5	1.6	5.4
"A.F.A. Clay"	-	0.6	0.5	0.9
A.F.A. Fineness No.	-	57.7	56.6	110.0

The S150 silica flour was tested with the Casagrande hydrometer method, described above. A test was also

(Fineness Tests, cont'd) -

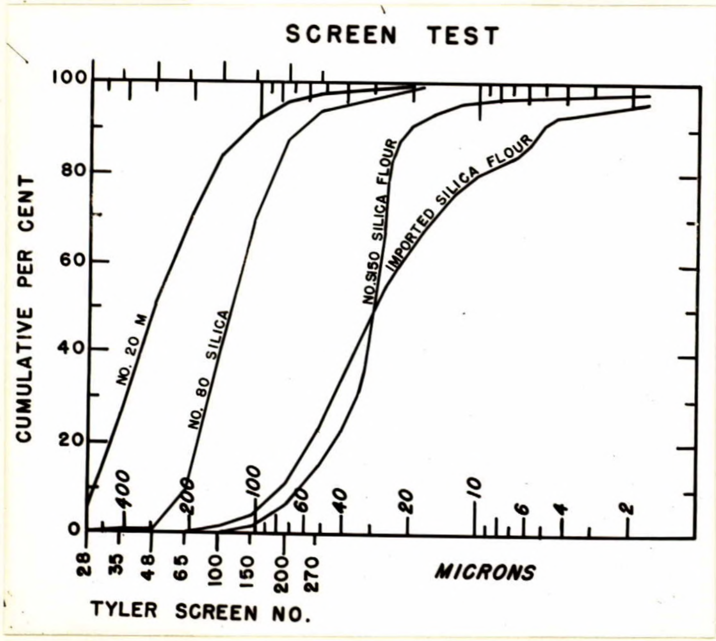
made on an imported silica flour for comparative purposes. The results are tabulated below:

TABLE II. - Fineness Test, Silica Flour.

Tyler Screen No.	Micron Size	Per Cent Cumulative S150 Flour	Per Cent Cumulative Imported Flour
65	210	Nil.	Nil.
100	149	Nil.	1.3
150	105	1.8	3.9
200	74	6.0	10.5
270	53	14.8	23.5
	40	22.8	34.0
	34	31.0	42.0
	30	49.0	49.0
	25	82.0	56.5
	20	90.5	63.2
	10	96.0	80.0
	5	96.6	90.8
	2	98.0	95.5

These results are shown in the form of a cumulative per cent retained curve in Figure 5.

Figure 5.



SCREEN SIZE OF SANDS AND SILICA FLOUR.

MOULDING PROPERTIES:

Moulding Properties of Sand-Bentonite Mixtures:

The moulding properties of the three sand samples (No. 8B/20M, No. 20M, and No. 80 Silica) were tested by mixing them with bentonite in an 18-inch laboratory muller. The following mixture was used:

2,000 grams sand.
100 grams western bentonite.

Moisture to temper.

Mulled 2 minutes dry, 4 minutes wet.

The moulding properties obtained with these mixtures were as follows:

TABLE III.

		No. 8B/20M	No. 20M	No. 80 Silica	No. 80 Silica, Fines Removed
Moisture	-	4.0	3.5	4.4	4.4
Permeability	-	193	250	65	80
Green Compression, p.s.i.	-	6.1	5.0	4.0	4.0
Flowability	-	77	77	79	81
Weight of A.F.A. Specimen, gm.	-	154	150	144	142

Moulding Properties of Sand-Bentonite-Silica Flour Mixtures:

Tests were made on mixtures of A.F.A. test sand, bentonite and moulding sand, to determine how the silica flour additions affected the properties of moulding sand. A control mixture of A.F.A. test sand and bentonite only was made for comparative purposes. The following mixtures were used:

(Continued on next page)

(Moulding Properties, cont'd) -

1. Control Mixture:

2,000 grams A.F.A. test sand.
100 grams western bentonite.

2.4 per cent moisture.

2. Test Mixtures:

1,700 grams A.F.A. test sand.
300 grams silica flour.
100 grams western bentonite.

Moisture to temper.

The mixtures were observed to have the following properties:

TABLE IV.

Property		A.F.A. Test Sand	A.F.A. TEST SAND MIXED WITH No. 80 Silica (unwashed)	No. S150 Silica Flour	Imported Silica Flour
Moisture, per cent	-	2.4	3.6	4.4	4.5
Permeability	-	253	163	102	102
Green Compression, p.s.i.	-	6.0	4.8	7.6	7.3
Flowability	-	83	83	77	78
Weight of A.F.A. Specimen, grams	-	153	160	168	168

Moulding Properties of Sand-Oil Mixtures -

Of the samples submitted, the No. 20M sand had the most favourable screen distribution for use as a core sand. An oil-sand mixture was made up with this sand, and the properties were compared with those of a commercial core sand which is being used with satisfactory results. The commercial sand had the following screen analysis:

(Continued on next page)

(Moulding Properties, cont'd) -

TABLE V.

Tyler Screen No.		Per Cent Retained
28	-	1.0
35	-	24.6
48	-	39.6
65	-	26.3
100	-	7.6
150	-	0.8
200	-	0.1
-200	-	Trace.

A photomicrograph of this sand is shown in Figure 4.

In order to determine whether the different results obtained were caused by the difference in screen distribution, Sample 20M was selectively screened to have the same screen distribution as the commercial sand. The following mixture was used in making these tests:

2,000 grams sand.
20 grams core oil.
20 grams cereal flour.

Moisture to temper.

Baked 2 hours at 400° F.

These mixtures were found to have the following properties:

TABLE VI.

		No. 20M	No. 20M Selectively Screened	Commercial Core Sand
Moisture	-	2.5	2.5	2.2
Green Compression, p.s.i.	-	0.5	0.4	0.9
Flowability	-	88	87	92
Baked Tensile Strength, p.s.i.	-	133	116	224
Weight of A.F.A. Specimen, grams	-	156	154	166

(Continued on next page)

(Moulding Properties, cont'd) -

Moulding Properties of Sand-Silica Flour-Oil Mixtures -

1,700 grams A.F.A. test sand.
300 grams silica flour.
20 grams core oil.
20 grams cereal flour.

Moisture to temper.

The following properties were obtained:

TABLE VII.

Property		A.F.A. TEST SAND MIXED WITH		
		No. 80 Silica (unwashed)	No. S150 Silica Flour	Imported Silica Flour
Moisture, per cent	-	2.5	3.0	3.0
Permeability	-	138	144	138
Green Compression, p.s.i.	-	1.6	2.4	2.2
Flowability	-	87	86	86.5
Baked Tensile Strength, p.s.i.	-	193	173	160
Weight of A.F.A. Specimen, grams	-	163	166	167

HOT STRENGTH TESTS:

Moulding Sand -

The moulding sand mixtures containing bentonite were tested in a dilatometer furnace at 2000° F. The specimens (1-1/8-in. diameter by 2 inches long) were tested at this temperature after they were soaked in the furnace for various lengths of time, up to 12 minutes. The mixtures so tested were:

(1) Sand-Bentonite Mixtures:

Two mixtures:
(a) A.F.A. test sand.
(b) 20M sand.

2,000 grams sand.
100 grams western bentonite.

Moisture to temper.

(Hot Strength Tests, cont'd) -

(2) Sand-Bentonite-Silica Flour Mixtures

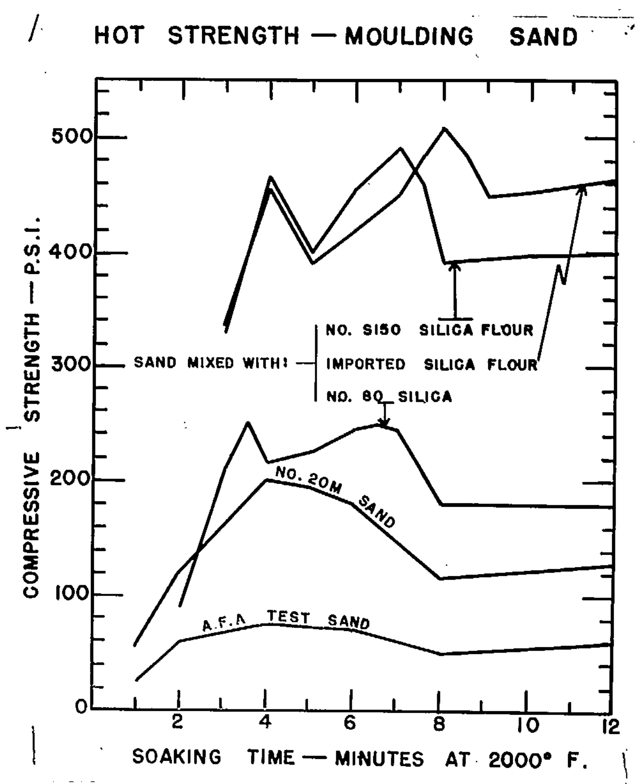
(Three mixtures:
(a) With No. 80 silica.
(b) With S150 silica flour.
(c) With imported silica flour.)

1,700 grams A.F.A. test sand.
300 grams silica flour.
100 grams western bentonite.

Moisture to temper.

The test results obtained using these mixtures are plotted in Figure 6.

Figure 6.



HOT STRENGTH - MOULDING SAND.

Core Sand -

Test specimens of core sand mixtures were soaked in the dilatometer furnace and tested at 2500° F. The specimens were tested in a neutral atmosphere to prevent oxidation of the core oil. The mixtures used in this test were as follows:

(Continued on next page)

(Hot Strength Tests, cont'd) -

(1) A.F.A. Test Sand Mixture:

2,000 grams A.F.A. test sand.
20 grams core oil.
20 grams cereal flour.

Moisture to temper

Baked at 400° F. for 2 hours.

(2) Sand-Silica Flour Mixtures:

(Three mixtures:
(a) No. 80 silica
(b) S150 silica flour.
(c) Imported silica flour.)

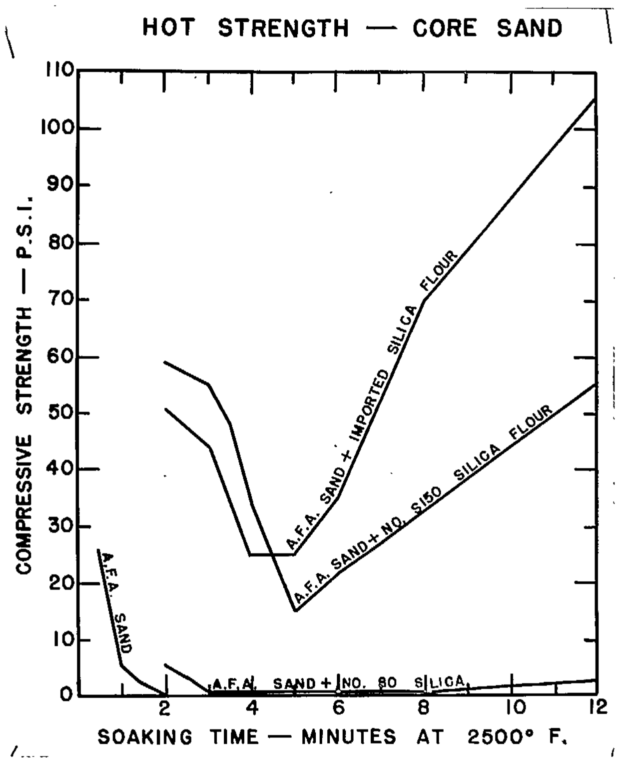
1,700 grams A.F.A. test sand.
300 grams silica flour.
20 grams core oil.
20 grams cereal flour.

Moisture to temper.

Baked at 400° F. for 2 hours.

The results obtained using these mixtures are shown in Figure 7.

Figure 7.



HOT STRENGTH - CORE SAND.

DISCUSSION:

Two of the samples submitted (Nos. 20M and 8B/20M) have potentialities as foundry moulding and core sands. The S150 sample was a foundry silica flour. The other sample (No. 80 Silica) was an intermediate product, that is, the grain size fell between that of a foundry sand and that of a foundry silica flour.

The tests were made for the purpose of determining the following:

I. The suitability of Samples 20M and 8B/20M for use as foundry moulding and core sands.

II. The merits of the S150 silica flour in comparison with other commercial silica flours.

III. Possible uses of the No. 80 silica product, either as a moulding sand or a silica flour.

I. 20M and 8B/20M Sands.

The samples of 20M and 8B/20M sand were so similar in grain size, grain shape, and properties obtained with test mixtures (Tables I and III), that foundries could use them interchangeably and notice little difference in their properties. Many foundrymen would consider the coarse material in the 8B/20M sample objectionable, and hence would prefer the 20M sample. The 8B/20M sample rams into a slightly denser mould, however, and should cause slightly less trouble from metal penetration. Hence, the choice between these two sands would depend upon the personal preferences of the foundryman.

Sands similar to Samples 20M and 8B/20M are used in two ways in foundry work. These are:

(1) Synthetic Moulding Sand -

Pure silica sands to which clay and other binders are added are known as synthetic moulding sands. This type of sand is used in steel foundry work, which requires a

(Discussion, cont'd) -

high permeability, to allow the gases to escape, and a high degree of refractoriness, to withstand the high pouring temperatures. It is also used in some of the larger iron and non-ferrous foundries, where close control of such properties as moisture, green compression, dry compression, and hot strength can be maintained.

The permeability and grain size of Samples 20M and 8B/20M are within the range generally used in steel foundry work. The sand is also refractory enough for steel foundry use. The main disadvantages of the No. 20M sand are the low flowability and the low density of the rammed test specimens. Because of the low flowability, the sand would require excessive ramming to make good moulds. The low density indicates that even if the sand were well-rammed it would still contain a large percentage of voids. The angular grains of this sand (Figure 3), which interlock and prevent the sand from flowing into the voids, are the reason for its low flowability and density. Moulds made with No. 20M sand would be likely to be subject to metal penetration, because of the large percentage of voids. As metal penetration is one of the most troublesome problems encountered by the foundry, this is a serious disadvantage. As sands with a wide screen distribution will ram up to a greater density than those which have most of the grains retained on two or three screens, No. 20M sand should be marketed with a wide screen distribution, such as is possessed by the sample submitted.

Apart from the low flowability and low density of rammed specimens, Nos. 20M and 8B/20M appear to be suitable for use as synthetic moulding sands. The disadvantages mentioned are not so severe that satisfactory moulds

(Discussion, cont'd) -

could not be made, especially on work where metal penetration is not a problem.

(2) Core Sand -

Cores are used to form internal cavities in castings, or to make it possible to draw some portion of the pattern from the sand where the shape does not naturally permit this. Drying oils, which develop their strength on baking, are usually used as the binder in sand cores. Clay-free sands, with an average screen size of about 48 mesh, are usually used in making cores for ferrous and non-ferrous work.

Sands vary widely in the amount of core oil they require to give them sufficient strength to withstand handling and metal washing. As core oil is an expensive item in the foundry, and as the use of excessive amounts result in casting defects, the amount of core oil required by a sand is an important measure of its merit.

The low tensile strength obtained with the No. 20M sand (see Table VI) would discourage its use in foundry cores, as excessive amounts of oil would be required. If the sand is selectively screened to the same screen distribution as that possessed by most commercial core sands (about 80 per cent retained on 3 adjacent screens), even larger amounts of core oil would be required, as shown in Table VI. As in the case of the moulding sand, the low flowability and low density of the 20M sand are further disadvantages, as cores would have a tendency to be subject to metal penetration.

These disadvantages of the 20M and 8B/20M sand samples which were submitted are so great that it is not likely that these sands will find a wide use in core work.

(Continued on next page)

(Discussion, cont'd) -

II. S150 Silica Flour.

The grain size test of this material (Figure 1) showed that about 50 per cent by weight was between 25 and 35 microns in size. This material is much more closely sized than the sample of imported silica flour which was tested. The effect of this close sizing on the quality of mould and core washes made from these silica flours has not yet been studied.

Foundries use considerable amounts of silica flour in moulding and core sand mixtures, to inhibit metal penetration, and also to increase the hot strength of the sand. The test batches of core and moulding sands (Tables IV and VII) indicate that the two samples of silica flour tested have about the same effect on the properties of the sand. The hot strength of the moulding sand mixture containing S150 sand is slightly less than that of the one containing imparted silica flour, however. The S150 sample appears to be a good material for use as a hot strength binder for moulding and core sands, and for increasing the density of sand moulds and cores.

III. No. 80 Silica.

The moulding sand tests made on this sand (see Table III) indicate that it would make a good base for synthetic sand, where a fine sand is required. The permeability may be increased by removing the fines. The low density of this sand is not such a disadvantage as it is in the case of the 20M sand, as the size of the voids would be smaller. The sand would also be subject to less severe conditions, as it would be used in making light castings, which are not so subject to metal penetration as are large ones.

(Continued on next page)

(Discussion, cont'd) -

When used as an addition to coarser moulding sand, No. 80 increases the hot strength, but to a lesser extent than does silica flour (Figure 6). It also increases the density of the sand, but is less effective than silica flour in this respect (Table IV). The No. 80 silica product does not impart appreciable strength to core sand at 2500° F. (Figure 7).

It is thus evident that No. 80 silica may be used to increase the hot strength of moulding sand mixtures, or to increase the density of moulding and core sand mixtures, but is less effective than silica flour in these respects. It is much less effective than silica flour in increasing the hot strength of core sands.

CONCLUSIONS:

1. Samples 20M and 8B/20M as submitted may be used as bases for synthetic moulding sands. The low flowability and low mould density possessed by these sands would be likely to be a source of trouble, however, in causing metal penetration.

2. The 20M and 8B/20M sands should not be sold with a narrower screen distribution than is possessed by the samples submitted. Sands with a narrow screen distribution have a lower density, and hence are more subject to metal penetration, than those with a wide screen distribution.

3. Because of their high core oil consumption, low mould density, and low flowability, Samples Nos. 20M and 8B/20M are not suitable for core work.

4. No. S150 silica flour is a good material for imparting hot strength to moulding and core sands, and to

(Conclusions, cont'd) -

increase the density of rammed cores and moulds.

5. No. 80 silica might find use as a synthetic moulding sand where a fine sand is required. It might also be used as an addition to coarser moulding sands, to raise the hot strength and increase the density.

6. The No. 80 silica sample as received was well sized, but the permeability may be increased by removing the fines. The fines thus removed could be used as an addition to moulding sands, as outlined above. The quantity of fines removed from the No. 80 silica would be quite small, however, and for this reason the separation may not be commercially justified.

000000000000
00000000
00

AEM:LB.