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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

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Ottawa, November 13, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2135.

Foundry Potentialities of Five Quebec Natural Sand Samples and One Granite Dust Sample.

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(Copy No. 4.)

Bureau of Mines
Division of Metallic Minerals

Physical Metallurgy
Research Laboratories

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Introduction:

On September 20, 1946, Mr. L. H. Cole, Engineer, Industrial Minerals Section, Division of Mineral Resources, Bureau of Mines, Ottawa, submitted five samples of natural moulding sands from the province of Quebec, for examination to determine if they were suitable for use as foundry moulding sands. Mr. Cole also submitted a sample of granite cuttings, to determine if it would make a suitable parting powder for foundry moulds.

The description of the samples submitted was as follows:

"No. 37-19. Sample of deposit in dust collecting system at Brodies Limited dressing shed at Iberville, Que. This sample should be . . . . . tested to see whether it is suitable as a silica wash for dusting moulds in foundry work.

"No. 38-19. Moulding sand sample taken from side of old sand or gravel pit 2 miles south of Farnham, Que. This sample was taken with a 6-inch auger bit over a depth of 18 inches.

(Continued on next page)

(Introduction, cont'd) -

"No. 39-19. Moulding sand taken from a pit on the farm of Mr. Lavallee, R. R. 1, St. Hyacinthe - about 2 miles north of St. Hyacinthe on the west bank of the Yamaska River. This sample was a channel sample across the bit about 4 feet thick showing in the side of the pit.

"No. 43-19. Moulding sand sample taken from the sand pit on north side of No. 2 Highway about ½ mile west of the branch with No. 43 Highway to L'Assomption, and about 1½ miles west of St. Sulpice. This sample was a channel from the bed of sand showing in the side and bottom of the pit and represents about 5 feet.

"No. 44-19. Moulding sand sample taken from property of Scotstown Granite Co., near Grenville, Que. This sample was obtained by a 6-inch auger hole drilled northwest of the boiler plant of this granite quarry and represents the top 18 inches of the moulding sand after removal of about 9 inches of top soil.

"No. 45-19. Moulding sand sample taken as 44-19 above, but representing 10 inches of sand underlying No. 44-19."

Method of Testing:

Procedures and equipment recommended by the American Foundrymen's Association (Foundry Sand Testing Handbook, 1944 edition, A.F.A.) were used in testing the sand.

Test specimens 1-1/8 inches in diameter by two inches long were used in testing the properties of the sands at elevated temperatures.

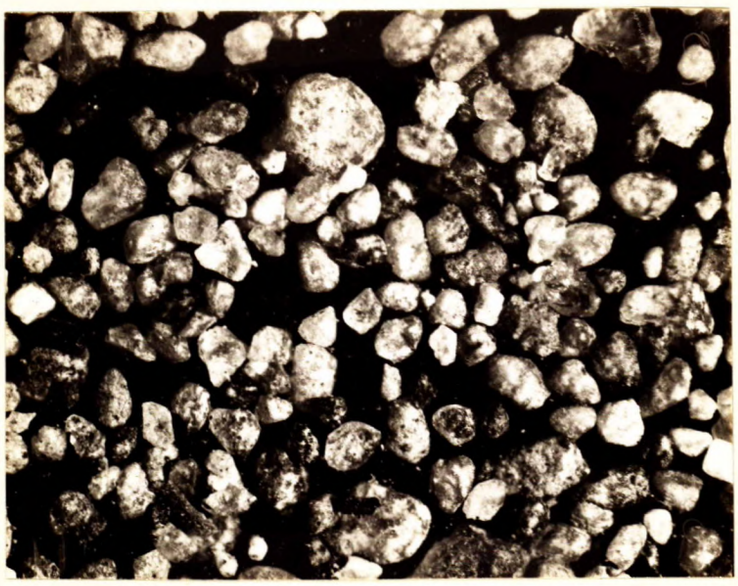
Microscopic Examination:

Sample No. 38-19 was the only one which had a screen analysis which indicated that it might prove suitable as a core sand. This sample was examined under the microscope. A photomicrograph is shown in Figure 1.

(Figure 1 follows, on Page 3.)

(Microscopic Examination, cont'd) -

Figure 1.



X25.

Grains round to subangular, very rough.

Screen Test:

Before making the screen tests the material coarser than 12 mesh was screened out and discarded.

TABLE I. - Screen Tests.

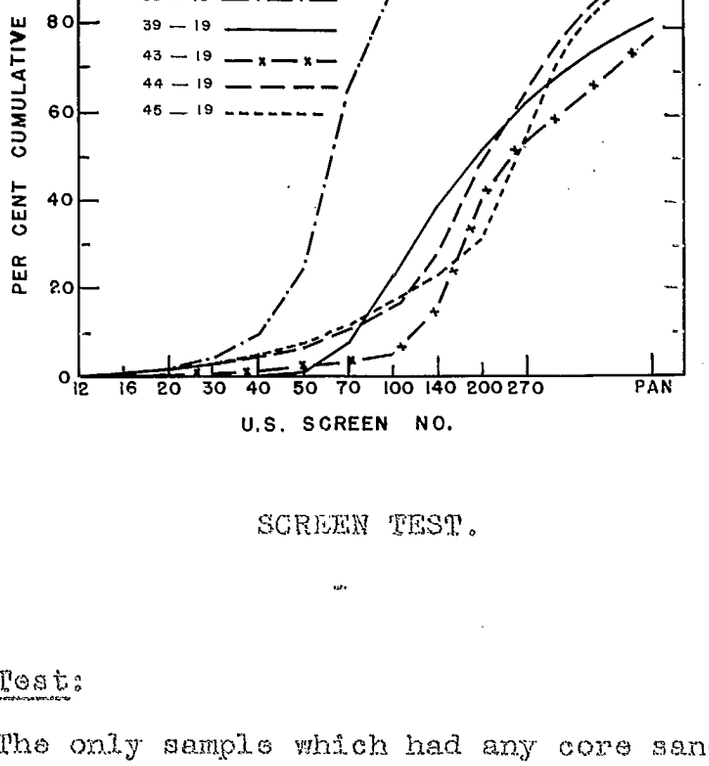
Screen No.	PER CENT RETAINED					
	Sample No. 37-19	Sample No. 38-19	Sample No. 39-19	Sample No. 43-19	Sample No. 44-19	Sample No. 45-19
16	0.8	0.9	Nil.	0.3	0.3	0.8
20	1.2	0.9	Nil.	0.2	1.2	1.0
30	2.4	2.4	0.1	0.4	1.5	1.5
40	3.4	5.5	0.3	0.6	1.5	1.7
50	6.0	14.8	1.0	0.9	2.2	2.5
70	10.2	40.5	6.1	1.0	4.0	4.2
100	12.9	22.7	15.2	2.4	6.0	5.2
140	12.9	4.0	15.6	9.6	11.1	7.4
200	12.0	1.3	15.4	25.4	21.1	16.8
270	6.0	0.4	9.0	13.6	16.1	13.5
Pan	15.2	1.5	19.0	24.3	28.5	36.5
"A.F.A." Clay	16.4	4.8	18.2	20.9	6.5	8.9
A.F.A. Fineness No.		58.4	154.5	187.4	177.9	192.0

The results are shown in the form of a cumulative per cent retained curve in Figure 2.

(Figure 2 follows, on Page 4.)

(Screen Test, cont'd) -

Figure 2.



SCREEN TEST.

Core Sand Test:

The only sample which had any core sand potentialities was No. 38-19. All the other specimens were too fine to permit them to be used as core sands, even if the considerable amount of clay were to be washed out.

Sands vary widely in the amount of core oil they require to give them sufficient strength to be used in foundry cores. As core oil is an expensive item, and excess amounts will produce defective castings, the core oil requirement of a sand is very important to the foundryman. In testing this factor, the following mixture was used:

2,000 gm. washed sand.
20 gm. cereal flour.
20 gm. core oil.
2.7 per cent moisture by weight.

Baked 2 hours at 400° F.

The results of this test were as follows:

(Continued on next page)

(Core Sand Test, cont'd) -

	38-19 (washed)	Normal Range of Value for Commercial Core Sands.
Tensile strength, p.s.i. -	8	180-250

It will be noted that these results were obtained with washed sand. If the sand had not been washed the results would have been lower, as clay absorbs the oil and destroys its effectiveness.

Moulding Properties:

Four of the sands (Samples Nos. 39-19, 43-19, 44-19, and 45-19) had characteristics similar to those of natural bonded moulding sands used in iron and non-ferrous foundry work. The moulding properties of these sands were tested at different moisture contents, to determine their working characteristics. The properties specifically so tested were: permeability, green compression, dry compression, and toughness (green compression multiplied by deformation of the A.F.A. test specimen in thousandths of an inch). The moulding properties of the sands tempered with the optimum moisture content are shown in Table II. The curves of the moulding properties at different moisture contents are shown in Figures 3, 4, and 5.

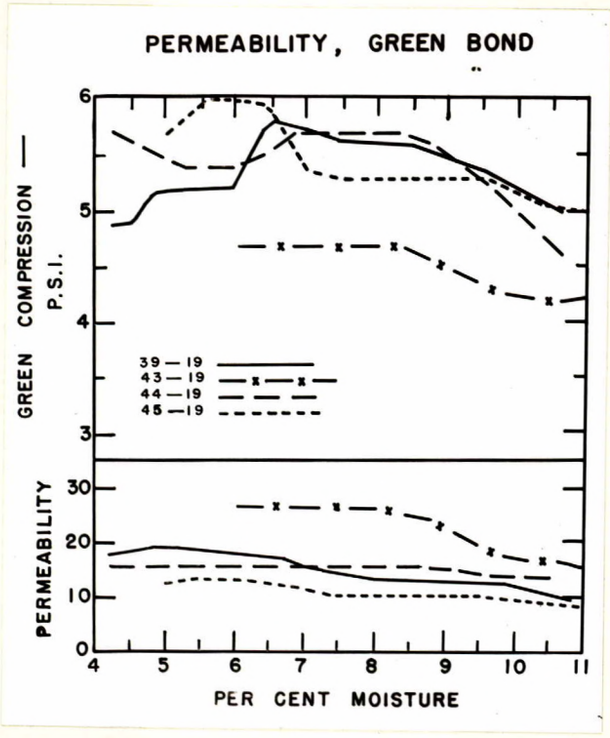
TABLE II.

	Sample No. 39-19	Sample No. 43-19	Sample No. 44-19	Sample No. 45-19
Per Cent Moisture -	8.5	9.5	8.0	9.4
Permeability -	12.5	20.7	16.0	10.0
Green Compression, p.s.i. -	5.6	4.7	5.7	5.3
Dry Compression, p.s.i. -	88	148	14	45
Toughness -	117	90.5	99.5	112

(Figures 3, 4 and 5 follow,)
(on Pages 6 and 7. Text is)
(resumed on Page 7.)

(Moulding Properties, cont'd) -

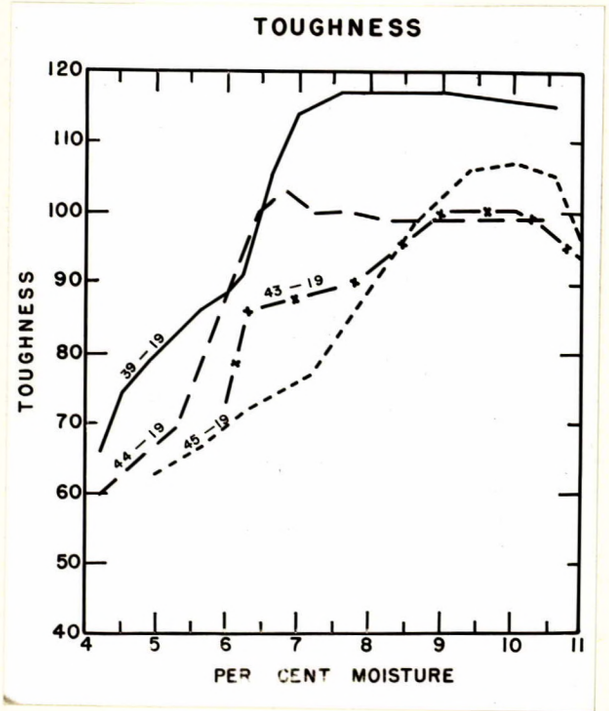
Figure 3.



PERMEABILITY AND GREEN BOND.

-

Figure 4.

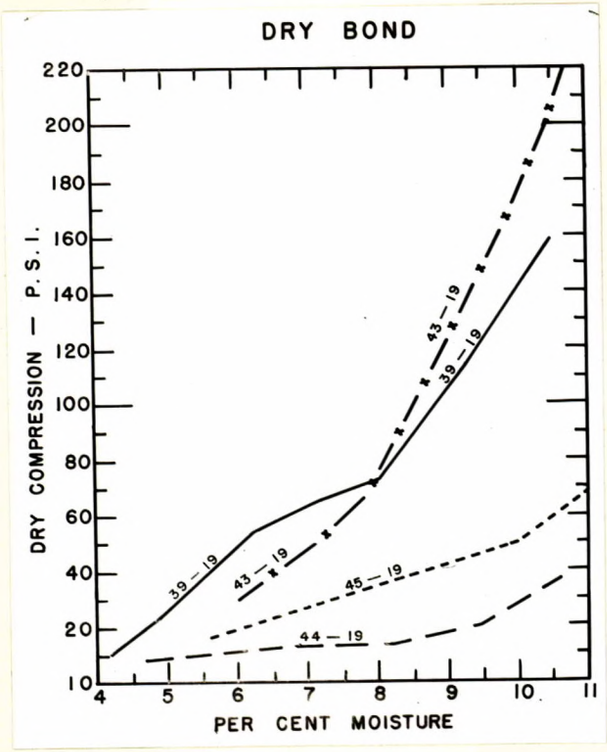


TOUGHNESS.

-

(Moulding Properties, cont'd) -

Figure 5.



DRY BOND.

Durability:

When moulding sands are heated by molten metal, chemically combined water is driven off from the clay. This loss of water causes the bonding properties of the clay to deteriorate, until the sand becomes "burnt out". The ability of a clay to withstand heating is known as durability, and may be measured by heating the sand to different temperatures, and then re-tempering and testing it. Durability tests were made by heating the sand to 400, 600, 800, 1000, 1200 and 1400 degrees Fahrenheit, and then testing the moulding properties. The results of these tests are shown below in Tables III and IV, and are also given in graphical form in Figures 6 and 7.

(Continued on next page)

(Durability, cont'd) -

TABLE III. - Durability of Green Bond.

Baking Temp., °F.	Sample No. 39-19	Sample No. 43-19	Sample No. 44-19	Sample No. 45-19
	- (Green Compression, p.s.i.) -			
Unbaked -	5.4	4.3	5.4	5.3
400 -	4.9	4.3	5.0	5.0
600 -	4.9	4.1	4.0	4.7
800 -	4.9	3.6	3.5	3.9
1000 -	4.4	2.9	3.2	3.6
1200 -	4.3	2.6	2.9	3.3
1400 -	4.3	2.5	2.5	3.3

TABLE IV. - Durability of Dry Bond.

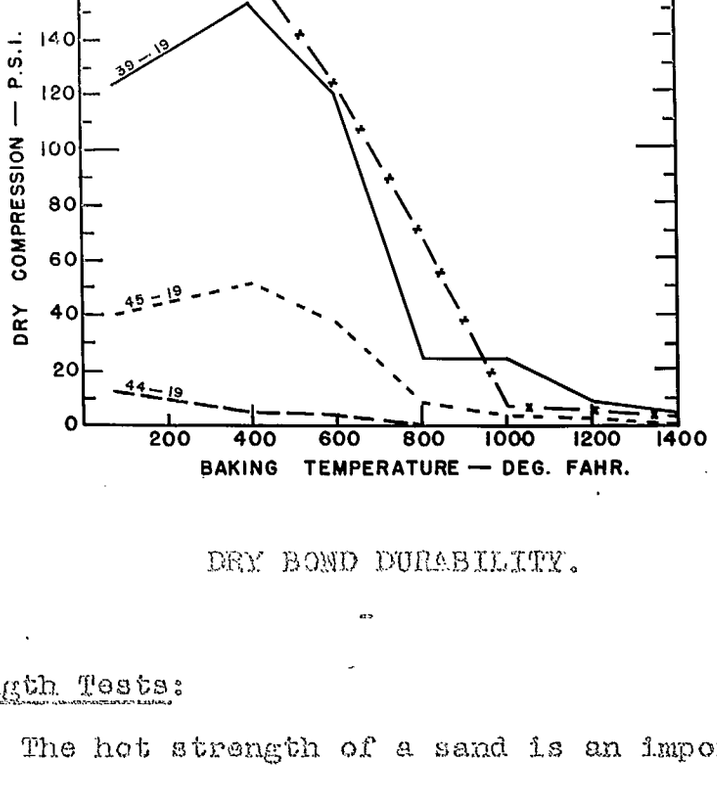
Baking Temp., °F.	Sample No. 39-19	Sample No. 43-19	Sample No. 44-19	Sample No. 45-19
	- (Dry Compression, p.s.i.) -			
Unbaked -	123	158	12.5	40
400	153	168	5.0	51
600	120	124	3.7	37
800	24	68	Nil.	9
1000	24	7.0	Nil.	4
1200	8.5	5.5	Nil.	3
1400	4.5	4.0	Nil.	Nil.

Figure 6.

GREEN BOND DURABILITY.

(Durability, cont'd) -

Figure 7.



DRY BOND DURABILITY.

Hot Strength Tests:

The hot strength of a sand is an important factor in foundry work. If the hot strength is too low the metal will cut and wash the sand. If the sand sinters at too low a temperature the metal will "burn-in" or penetrate the sand, or the sand will deform under the weight of metal, and castings will "swell".

The specimens used in the hot strength test were cylinder 1-1/8 inches in diameter by 2 inches long. They were soaked in a dilatometer furnace at the given temperatures for 12 minutes before they were broken. The results are tabulated below in Table V, and shown graphically in Figure 8.

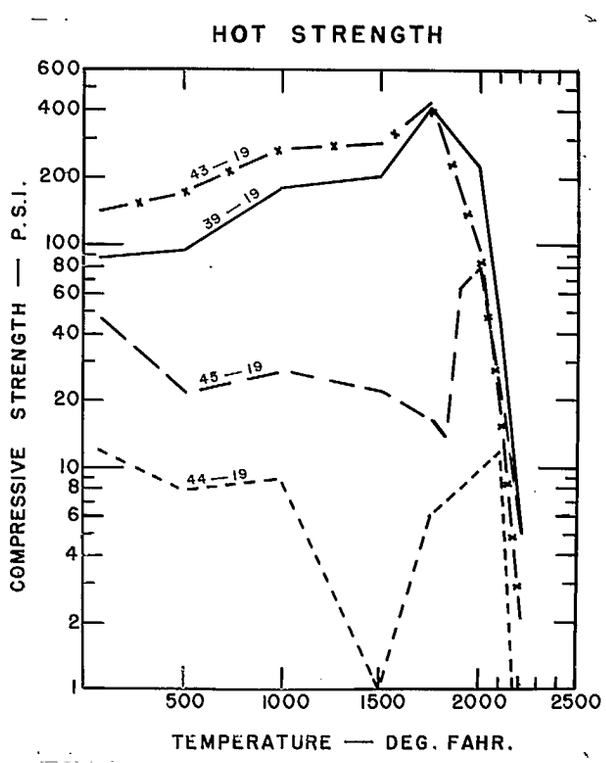
(Continued on next page)

(Hot Strength Tests, cont'd) -

TABLE V. - Hot Compressive Strength.

Temp., °F.	Sample No. 39-19	Sample No. 43-19	Sample No. 44-19	Sample No. 45-19
	- (Compressive Strength, p.s.i.) -			
Room	88	142	12	47
500	95	170	8	22
1000	170	270	9	27
1500	200	285	1	28
1750	405	425	6	16
1825				14
1900				64
2000	225	95	11	80
2100	45	18	12	24
2200	6 (sintered)	2 (sintered)	Nil.	6 (sintered)

Figure 8.



HOT STRENGTH.

Test for Mould Parting:

Sample No. 37-19 was tested as a mould parting powder, by dusting it on a pattern instead of a commercial product. The pattern dusted with this powder withdrew from the sand satisfactorily.

DISCUSSION:

(1) Sample No. 37-17

This sample appeared to have some merit as a parting powder, in that it facilitated withdrawal of the pattern from the sand. However, its potentialities as a commercial parting powder are limited because:

(a) It contains silica dust, which is injurious to health. Industrial health laws of many states and provinces of the U. S. A. and Canada prohibit the use of this type of material as mould parting powders, because of the health hazard involved. Commercial parting powders are available which meet the specifications required by the health laws of these states and provinces, in that their use does not expose the workmen to the risk of being disabled by silicosis.

(b) The fusion point of the 37-19 sample is so low that it could not be used in moulds for iron and steel foundry work.

(2) Sample No. 38-19

This sample has none of the characteristics of a natural bonded moulding sand. The grain size and screen distribution of this sand are similar to those of commercial core sands used in foundry work. However, the amount of core oil required to give this sand sufficient strength for foundry work is much too great to make its use as a core

(Discussion, cont'd) -

sand practical. Probably the rough condition of the sand grains (see Figure 1) explains the unusually high core oil requirements of this sand.

(3) Samples Nos. 39-19, 43-19, 44-19, and 45-19

These samples had many of the desirable characteristics of a natural bonded moulding sand. The screen size is not suitable for core sand work, however. As moulding sands they have the following characteristics:

Sand No. 39-19 -

I. Advantages:

(a) The permeability and dry bond are within the range usually considered most desirable. (Figures 3 and 5)

(b) The green bond and toughness are slightly below the most desirable range, but are still high enough to permit satisfactory results. (Figures 3 and 4)

(c) The durability of the green bond is quite good. (Figure 6)

(d) The permeability and toughness are fairly constant over a wide moisture range, making for good workability of the sand.

II. Disadvantages:

(a) The dry bond increases quite rapidly with increased moisture content (see Figure 5). This would make control of the dry bond difficult. The sand would be likely to wash if the moisture content were too low, or casting cracks might be caused by excess moisture.

(b) The dry bond durability is fairly poor (see Figure 7). This would be likely to make the used sand low in dry strength, and hence likely to wash.

(Continued on next page)

(Discussion, cont'd) -

(c) The sand is not refractory enough for iron foundry use, as it sinters below 2200° F. (Figure 8)

Sand No. 43-19 -

I. Advantages:

(a) This sand has a good permeability. (Figure 3)

(b) The green bond durability is good. (Figure 6)

II. Disadvantages:

(a) The green bond and toughness are too low for satisfactory work. (Figures 3 and 4)

(b) The dry bond is too high, and the dry bond increases rapidly with increased moisture content (Figure 5). This would make it difficult to control the dry strength, and to prevent casting cracks.

(c) The dry bond durability is quite low (Figure 7). This would further increase the difficulty of controlling sand conditions.

(d) The sand is not refractory enough for iron foundry use. (Figure 7)

Sand No. 44-19 -

I. Advantages:

(a) Fairly good permeability and green bond, which are constant over a wide moisture range. (Figure 3)

(b) The green bond durability is good.

II. Disadvantages:

(a) The toughness and dry bond of this sand are too low (Figures 4 and 5). It would be difficult to prevent sand from dropping in the moulds, and from washing under the metal stream.

(b) The dry bond durability is poor. (Figure 7)

(c) The hot strength is low in the range of

(Discussion, cont'd) -

1500° F., and the sand sinters below 2200° F. This sand is not refractory enough for iron foundry work, and the hot strength in the range of 1500° F. is too low to prevent washing in non-ferrous work.

Sand No. 45-19 -

I. Advantages:

(a) Permeability and green bond are fairly good, and are maintained over a wide moisture range. (Figure 3)

(b) The dry bond is satisfactory, and does not increase too rapidly with increased moisture content. (Figure 5)

(c) The green bond durability is good. (Figure 6)

II. Disadvantages:

(a) The toughness is somewhat low for most satisfactory results, and is at a maximum at a fairly narrow moisture range (Figure 4). This would make the sand difficult to work.

(b) The dry bond durability is low (Figure 7). The used sand would be likely to wash.

(c) The sand is not refractory enough for iron foundry work. (Figure 8)

CONCLUSIONS:

1. Sample No. 37-19 might prove suitable as a parting powder, but the health hazard involved because of the silica flour, and also the low fusion point, would limit its usefulness.

2. Sample No. 38-19 is not suited for foundry work, either as a core sand or as a moulding sand. The screen distribution and low clay content make it unsuitable

(Conclusions, cont'd) -

as a natural moulding sand. The high core oil consumption makes it impractical as a core sand.

3. None of the other sands has potentialities as a core sand.

4. Of the four sands which have potentialities as natural bonded moulding sands, none is refractory enough for iron foundry work.

5. The low values obtained for dry bond, dry bond durability, and hot strength at 1500° F. for Sample No. 44-19 indicate that it would not make a suitable foundry sand. This sand would also impair the value of Sample No. 45-19 (found in the same bed) if they were mixed together.

6. Samples Nos. 39-19, 43-19 and 45-19 have some merit for non-ferrous foundry work, with limitations as outlined above.

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