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REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1935.

Report on Properties of Mould and Core Sand
Used at Hull Iron and Steel Foundries
Limited, Hull, Quebec.

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(Copy No. 14.)

Division of Metallic Minerals
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Physical Metallurgy Research Laboratories

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

O T T A W A September 15, 1945.

REPORT

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ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1935.

Report on Properties of Mould and Core Sand Used at Hull Iron and Steel Foundries Limited, Hull, Quebec.

Origin of Request:

Early in August, 1945, Mr. H. I. Anderson, work manager of the Hull Iron and Steel Foundries Limited, Hull, Quebec, requested the assistance of the Bureau of Mines in connection with the sand control program of his company.

Accordingly, samples of each of the sand mixtures used in the HISCO foundries were tested in these Laboratories, at convenient intervals, over a period of one month. This report contains the results of these tests, the mixtures used, and some comments based on the tests.

COMMENTS:

Moisture -

1. Most steel foundries run from 3 to 4 per cent moisture content. This is approximately what prevails at HISCO.

2. The sand mixed at HISCO appears to indicate a satisfactory degree of manual skill so far as moisture control is concerned. Number 3, for example, was held within a 0.3 per cent range over a period of two weeks.

3. Control of moisture within ±0.2 or ±0.3 per cent should be possible in normal operations.

Permeability -

1. The average steel foundry uses sand between 100 and 200 permeability.

2. Correlation of sand tests with casting tests at HISCO have shown that lower permeability results in less scrap. A recent example of this was the mixture used on ball sockets in which No. 100 sand was used to lower the permeability and an improvement in casting finish resulted.

Improved results at lower permeability are probably due to the increased hot strength of the sand as well as to the finer surface of the sand.

Green Bond -

1. The average steel foundry runs from 5½ to 7 pounds green bond.

2. Mould sands at HISCO run from 7 to 11 pounds green bond.

3. Defects attributable to high green bond are blows, rough surface, and difficult shake-out.

4. Defects attributable to low green strength are pin holes, dirt, veining, and sticky sand.

5. More careful weighing of the ingredients might make it possible to reduce the spread of green bond results

(Comments, cont'd) -

in moulding sand at HISCO.

6. Mixture No. 5 shows a run of 6.7 to 10.4 pounds green bond.

7. For any given mixture the green bond should be held within plus or minus 1 pound per square inch.

Green Deformation -

1. Deformation is the distance the sand sample is compressed before it breaks.

2. A certain amount of strain on the sand is imposed in making and handling moulds.

3. The average steel noulding sand will have 0.025 inch deformation.

4. The average HISCO sand has a deformation of 0.016 to 0.017 inch.

5. Low deformation is listed as one cause for dirty castings.

6. Deformation can be increased by the addition of cereal flour.

Toughness -

The toughness of the sand is the green bond multiplied by the green deformation.

1. The average steel foundry sand has a toughness of about 140. HISCO sands run in the neighbourhood of 140, with a considerable number of results below 120.

2. Mixture No. 9 requires low toughness in order to operate in the core blower.

3. Mixtures Nos. 1, 2, 3, 5 and 8 are practically identical as far as toughness is concerned.

Flowability -

The flowability in the sand is the amount that it is compressed on the fifth ram of the standard ramming device.

(Comments, cont'd) -

A flowability value of 90 means that the fifth ram compresses the specimen 0.010 inch. A flowability rating of 70 means that the fifth ram compresses the specimen 0.030 inch.

1. The average steel foundry sand for moulds has a flowability rating of 75 to 80. HISCO sands fall within this range.

2. Moulders and core makers get used to a certain flowability in the sand. A change in this property causes difficulty in moulding.

Core sands tend to have higher flowability values than moulding sands.

The control of sands for core blowing is mainly concerned with its flowability and toughness.

3. Mixtures Nos. 4, 5, 7 and 8 have a low flowability.

4. Mixtures Nos. 1, 2, 3, 6 and 10 have medium flowability while Mixtures Nos. 9 and 11 have high flowability values.

Mould Hardness -

The mould hardness readings of standard specimens give some idea of how hard they will ram with a given amount of work.

1. Note that Mixtures Nos. 1, 2, 3, 4, 5, 6 and 7 have, in general, the same ramming qualities.

2. The higher values for No. 4 mixture are due to the addition of cereal flour.

3. The low value of the Mixture No. 5 is probably due to the excess moisture in that particular mixture.

4. The low values for Mixture No. 8 are attributable to the absence of bentonite and the use of organic binders.

(Comments, cont'd) -

Dry Shear -

1. The dry strength of sand is taken after the moisture has all been driven out by baking at 215° F.

2. Low dry strength will contribute to the occurrence of cuts, dirt and veining.

3. High dry strength will contribute to hot casting cracks.

4. The dry shear of twenty-four typical steel moulding sands ran from 15 to 60 p.s.i. with an average value of about 37 p.s.i. In view of this, it is obvious that HISCO sands are considerably below average in dry shear.

5. Low dry shear values are connected with the occurrence of dirt defects and, since HISCO sands are below average in dry shear strength, it is considered advisable that dry shear values should be increased.

6. The variations in dry shear strength in Mixture No. 5 are no doubt attributable to the extreme variations in moisture content observed in this mixture, and the high dry shear values obtained on Mixture No. 8 are due to the use of Copacite and Rex.

Hot Strength -

In carrying out the hot-strength tests, the sand specimen is heated to 2500° F. and its compressive strength is then measured.

1. Low hot strength will contribute to cuts, rough surfaces, and penetration of the sand by the steel.

2. High hot strength will contribute to hot casting cracks.

3. Since the defects observed in HISCO castings tend to be cuts, dirt, etc., it is probable that a slight increase in hot strength would be advantageous.

(Comments, cont'd) -

4. Mixtures Nos. 4, 9, 11 and 12 have low hot strength.

5. Mixtures Nos. 1, 3, 5 and 7 have medium hot strength.

6. Mixture No. 2 has a high hot strength, which was attributed to the addition of No. 100 sand.

7. The addition of silica flour to Mixtures Nos. 10 and 11 produces a quite high hot strength. Note that Mixture No. 11 has a hot strength of from 70 to 82 p.s.i., which is desirable in this case.

These high values are obtained by the addition of silica flour, and it is suggested that Mixture No. 11 be reclassified as Mixture No. 11a, b, c, etc., in order that definite mixtures will be prepared rather than the system of adding the varying amounts to the mixture.

Hot Deformation -

When the sample is heated to 2500° F. and its compressive strength is measured, a dial indicator is used at the same time to register the amount of plastic flow before the sample breaks.

1. With most of the HISCO sands this deformation falls between 0.040 and 0.060 inch.

2. The core sand mixtures Nos. 9, 10 and 11 have lower clay content and thus lower deformation values.

3. It is interesting to note that in the case of Mixture No. 11 the addition of silica flour raises the deformation considerably.

4. Low hot deformation will contribute to the appearance of cuts and dirt. Such being the case, the mixtures at HISCO which would show the most dirt would be Mixtures Nos. 3, 4, 5 and 6.

(Comments, cont'd) -

Retained Strength -

In the retained strength test the sample is heated to 1000° F. for 12 minutes, after which it is removed from the furnace and allowed to c ool. The compressive strength when cooled is called the retained strength.

Retained strength is important because it indicates the difficulty which may be encountered in the shake-out.

1. Note that Mixtures Nos. 10, 11 and 12 have values covering a wide range. This is no doubt due to varying amounts of silica flour. It is therefore proposed that this mixture be subdivided, and named 11a, 11b, etc., to avoid confusion of mixtures in this test.

Mould and Core Gas -

In this test a sample of 5 grams, after having been dried, is placed in the furnace at 2500° F. The amount of gas generated in 30 seconds is recorded, also that in 60 seconds. Obviously, the core mixtures Nos. 9, 10, 11 and 12 will generate the greatest amount of gas in this test. The amount of gas generated indicates the amount of organic material as well as the amount of baking.

A mixture containing only new sand will generate the least amount of gas.

It should be remembered that with green sand there is a tremendous volume of steam generated and also that the gas from the dry sand represents only a small part of the gas evolved.

The absence of organic material in some of the moulding sand means that the gas produced will be oxidizing in nature, and this oxidizing mould atmosphere will contribute to pin-holes, metal penetration, and veining.

Since there is a considerable amount of pin-hole trouble at HISCO, it is recommended that some organic material

(Comments, cont'd) -

be introduced into the moulding sands there.

Core Hardness and Tensile Strength -

1. Core Mixture No. 11 has a satisfactory control of tensile strength.

2. Core Mixtures Nos. 9, 10 and 12, however, do not appear to be under control. This may be due to the fact that several mixtures are lumped under the designation of each number.

Tensile strength is the most expensive property to obtain in core sands. Thus, improved control over this property is desirable, both from the view-point of economy and from the view-point of getting good castings.

It is strongly recommended that HISCO secure a test core oven in order to control core mixtures and core baking procedures.

SUMMARY:

The green properties of HISCO sands have been developed to suit the arrangements in moulding. A change in green properties would disturb the moulding and core-making and, therefore, it is desirable that green properties be maintained as they are at present, but within narrower limits.

According to HISCO, the main cause of defects at this time are pin holes and dirt. An examination of the properties of the sand mixtures would indicate that the pin hole and dirt condition might be improved by making the following changes in properties:

1. Increase green deformation.
2. Increase dry strength.
3. Increase hot strength.
4. Add organic mixtures to the sand in order to produce a reducing mould atmosphere.

(Summary, cont'd) -

To accomplish these objects, it is recommended that the following changes in the sand mixture be tried out:

1. Addition of 0.5 per cent cereal flour, or less.
2. Addition of 5 to 7½ per cent silica flour.
3. Adjust the bentonite to maintain the green properties, with the exception of deformation, within the present range.

It is further recommended that HISCO set up a method of testing core mixtures, that is, install a test core baking oven.

Some confusion exists with the mixture "oil sand for core room", and varying amounts of silica flour are added for different sized castings. Therefore, it is recommended that several separate mixtures be worked out and recorded separately under a name or number.

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(Pages 10 to 22, following, contain)
(tabulations of test results and data.)

TABLE I. - MOLDING SAND PROPERTIES - - HULL IRON AND STEEL FOUNDRIES

No.	Mix	Moist.	Green Bond	Green Def.	Green Perm	Tough.	Flowa-bility	Baked Perm	Hardness Mold	Hardness Core	Bake Tens-ile	Dry Shear	Hot Str. 2500	Hot Def. 2500	Ret'd Str. 1000°F	Shock Test	Gas cc. 5 gm 30 s	Gas cc. 5 gm 60 s	100 lb. Collapsi-bility	Date Aug.
1	New	3.2	9.0	16	163	139.5	77.5		85			22.5	13	60	41	OK	20	30		7
	Green	3.9	8.5	17	156	144	78		82			23	17	50	65	OK				14
	C.F.	3.4	11.7	9.5	178	112	78		89			16.5			30					20
2	New	3.4	8.1	14	90	113	78		83			22.5	22	57	79	OK	15	22		7
	Green	3.7	9.2	15.5	93	143	78		84			19.0	19	50	50	OK	15	29		15
	Drag B.S.																			
3	Machine	3.7	8.5	13.5	138	115	79.5		85			34	12	47	21	OK	29	45		8
	Moulding	3.8	10.7	13.5	105	144	78		85			12	15	45	23	OK	55	74		17
	Green	4.0	8.1	17.5	88	142	78		83			33	11	70	48	OK	23	34		20
4	Old Green	3.2	10.7	13	134	162	77		84			20.5	13	40	31	Slight Cracks	30	37		13
	Snaps	3.6	10.3	16	126	165	72		89			18	7	40	19	OK	28	48		9
	Changed	3.2	9.7	18.5	122	179	75		82			22.5	12	55	24	OK	36	50		14
		3.6	10.5	13.5	128	142	75		84			20.5	10	53	32	OK	37	51		21
		3.2	8.1	27	178	219	69.5		94			27	8	63	25	OK	44	58		22
5	Old	3.9	9.1	16	134	145.5	75		85			19.5	14	48	35	OK	27	40		7
	Green	4.8	6.7	17	112	114	78.5		77			51.0	19	40	82	OK	22	35		16
	C.F.	4.3	8.3	16	138	133	77		84			34	16	58	87	OK	21	35		23
		3.0	10.4	14.5	138	150	75		85.5			26	11	60	34	OK				28
6	Heap	4.2	5.1	16	119	82	76		84			36	16	47	42	OK	22	34		8
	Sand	2.6	7.5	11	122	79	80		86			16	12	37	24	Spoiled	15	28		17
		3.1	7.3	14	138	102	78.5		84.5			23	12	43	40	OK	16	28		23

(Continued on next page)

TABLE I (Cont'd) - MOULDING SAND PROPERTIES + - H. I. S. (cont'd).

No.	Mix	Moist.	Green Bond	Green Def.	Green Perm	Tough.	Flowa-bility	Hardness Mold	Hardness Core	Dry Shear	Hot Str. 2500	Hot Def. 2500	Ret'd Str. 1000°F	Shock Test	Gas cc 5gm 30 s	Gas cc 5gm 60 s	Date August.
7	Dry Sand	4.5	8.0	17	132	136	76	83		33	12	54	46	OK	32	50	8
		3.7	9.9	15	128	143	72	84		30	11	58	47	OK	28	37	20
		4.0	8.7	21	142	183	72	84		32.5	11	52	58	OK			24
8	Regular Core	5.2	5.0	21	93	105	77	72		57.5	14	53	78	OK	40	60	9
		5.3	7.0	17	102	123	77	74		44	16	50	82	Cracked	30	44	16
		4.2	8.2	20	134	164	72.5	82		45	7	60	37	OK	45	60	

(Continued on next page)

TABLE I (Cont'd) - MOLDING SAND PROPERTIES - HULL IRON & STEEL FOUNDRIES (cont'd) (3)

No.	Mix	Moist.	Green Bond	Green Def.	Green Perm.	Tough.	Flowability	Baked Perm	Hard. Core	Baked Tens.	Hot Str. 2500	Hot Def. 2500	Ret'd Str. 1000°F	Shock Test	Gas cc 5 gm 30 s	Gas cc 5 gm 60 s	100 lb Collapsibility	Baking time	Date Aug.
9	Blower Core Sand	1.9	2.1	21.5	119	45.2	89	151	65	128	8	28	3	OK	69	79	16 sec.	1½	9
		1.9	2.6	12.0	119	31.2	85.5	138	73	179	7	34	3	Cracked	79	91	15 sec.	2	16
		2.2	2.8	12.5	148	35	85.5	193	63	152	5	30	40	Cracked	85	97	16 sec.		22
10	Oil Sand C.F.	6.2	8.2	26.0	102	203	77	167	45	58	23	60	9	OK	60	75		2	10
		6.7	8.5	20.0	90	170	78	156	63	114	46	35	97	OK	64	80	25 sec.	2	14
		6.0	7.2	19.5	108	140	79	167	62	115.5			42	OK			20 sec.	2½	21
11	Oil Sand for Core room (100# Si. flour)	2.7	3.0	25	122	75	88				10	28	11	OK	78	95	10 sec.		10
		4.0	3.2	18	112	58	86	193	77	154	11	33	26	Cracks	88	102	20	2	13
		2.4	3.5	18.5	146	65	87	205	65	147	7	43	48	OK	82	95		2	23
		5.1	5.2	20.5	90	113	80.5	134	63	146	34	55	145	OK				2½	24
12	Special Oil Sand for Core Room	3.5	5.8	16	102	90	82	185	15	29.5	13	40	14	OK	90	109	20 lb. 15 sec.		10
	Changed Mixture	6.0	5.9	20	90	118	82	151	43	151	7	45	87	OK	110	128		1½	20

TABLE II. - HULL IRON AND STEEL SAND MIXTURES.

No.	Mixture	Date 1945	#60 Sand	#100 Sand	Old Sand	Bento-nite	Rex	Casco	Copacite	Oil	Akro	Type of Work	Remarks
1	New Green C.F.	Aug. 6	700			8 gal.						Facing heavy casting	
2	New Green Drag Roll	Aug.6 Aug.13	350	350		8 gal.							
3	Machine Moulding Cope ball socket	" 6 " 13 " 20	250		700 1000	1½ gal. 1 gal.						Facing	
4	Old Green -Snaps	" 6 " 13 " 22			1000 1000 1000	1 gal. 1 gal. 1 gal.		 1 2				Small	To increase dry strength
5	Old Green	" 6 "13			1000	1 gal						Backing heavy castings	
6	Heap Sand	" 6			1000							Backing misc.	

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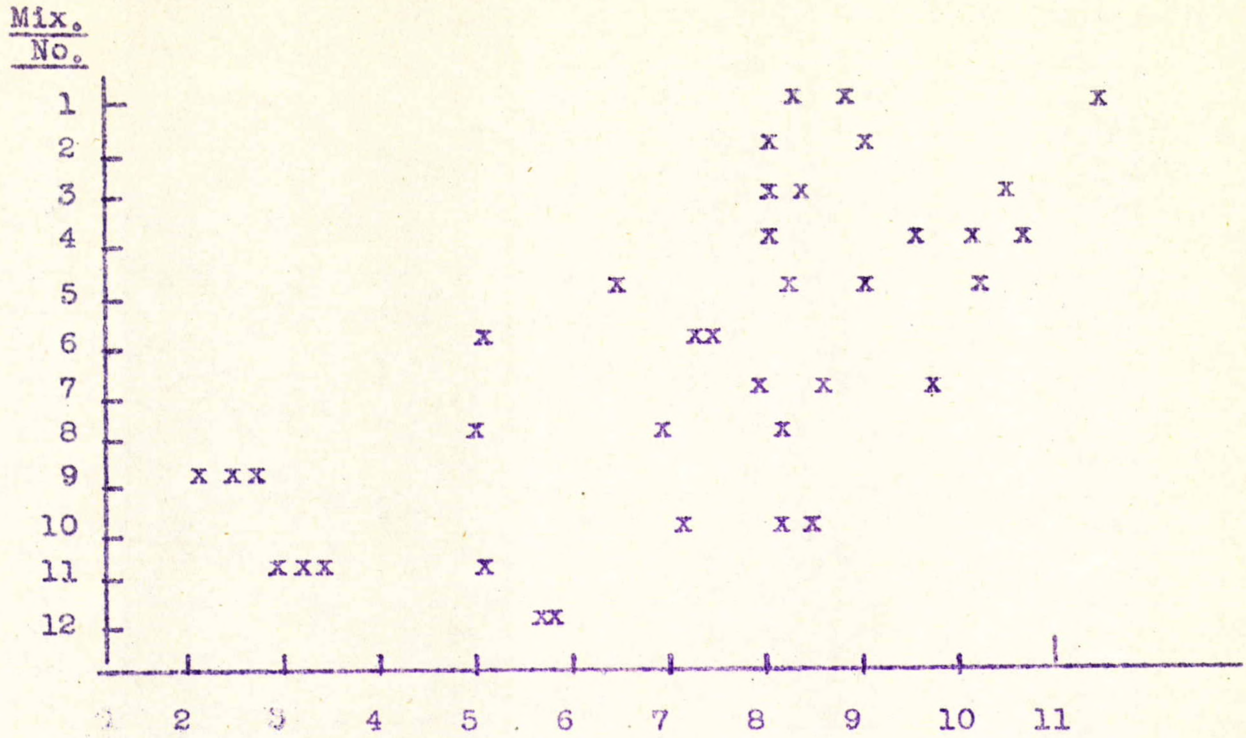
TABLE II (Cont'd) - HULL IRON AND STEEL SAND MIXTURES.

No.	Mixture	Date 1945	#60 Sand	Old Sand	Silica flour	Bentonite	Rex	Casco	Copacite	Oil	Akro	Type of Work	Remarks
7	Dry Sand	Aug.6 " 13		1000		0-1 gal			2 gal.			Backing heavy casting	
8	Regular Core	" 6		1000			0-1		2			Cores & dried molds	
9	Blower Core Sand	" 6	1000			½ gal		3 gal.		2½ gl		Mix cores	
10	Oil Sand Centre Floor	" 6 "13	700		50-200 depending upon size	4 gal.		1½ gal.		1½-2		Facing heavy castings	
11	Oil Sand Core room	" 6 " 13	700		50-100 lb. for heavier sections	1 gal. ¾ gal.		2		1½		Facing large cores. Small cores on bench.	
12	Special Oil Sand	" 6 "13 "17 "20	700		 100 100	3 gal. 1 gal.		2 cans		2½ 2 pt	6	Collapsible cores	

TABLE IV. - GREEN BOND, P.S.I.

Hisco Sands



GREEN BOND, P.S.I.

TABLE V.

GREEN DEFORMATION MISCO SANDS

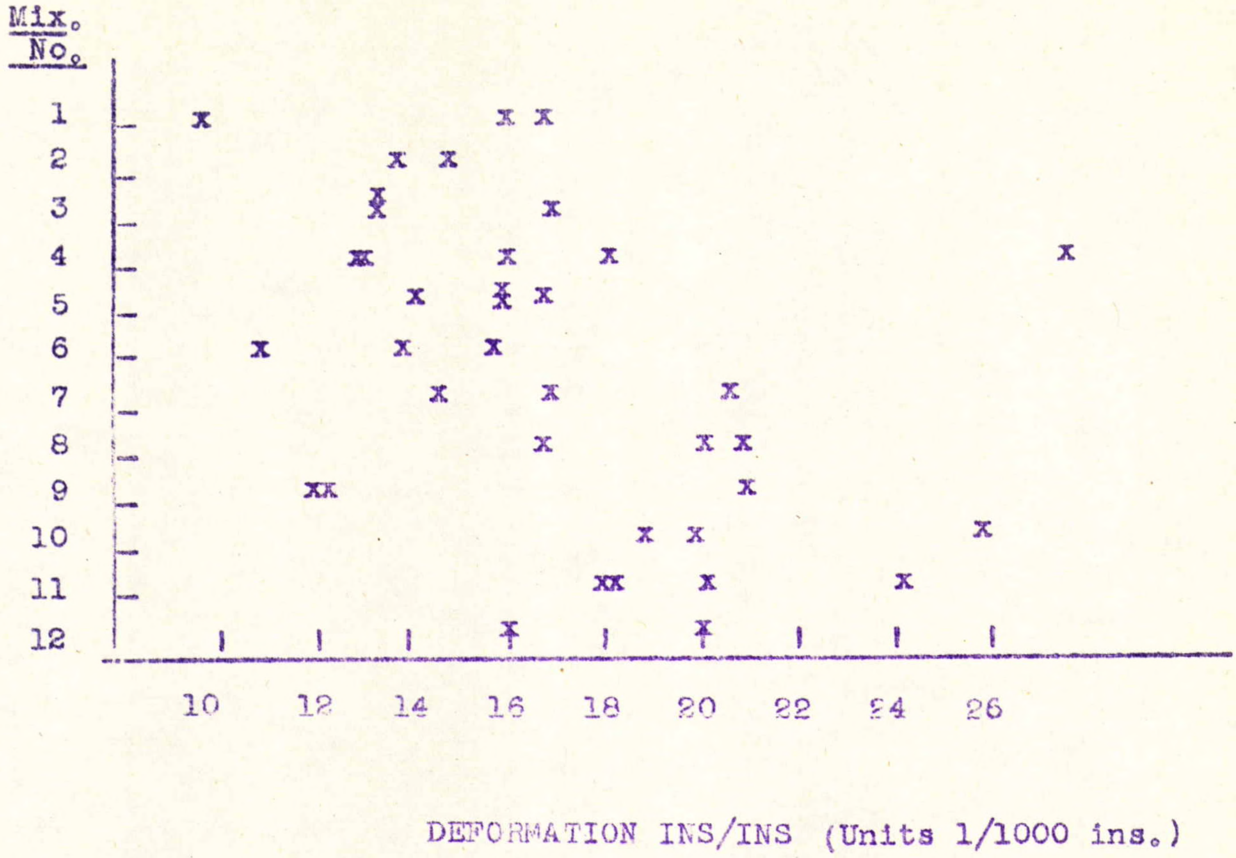


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TABLE VI. - TOUGHNESS HISCO SANDS

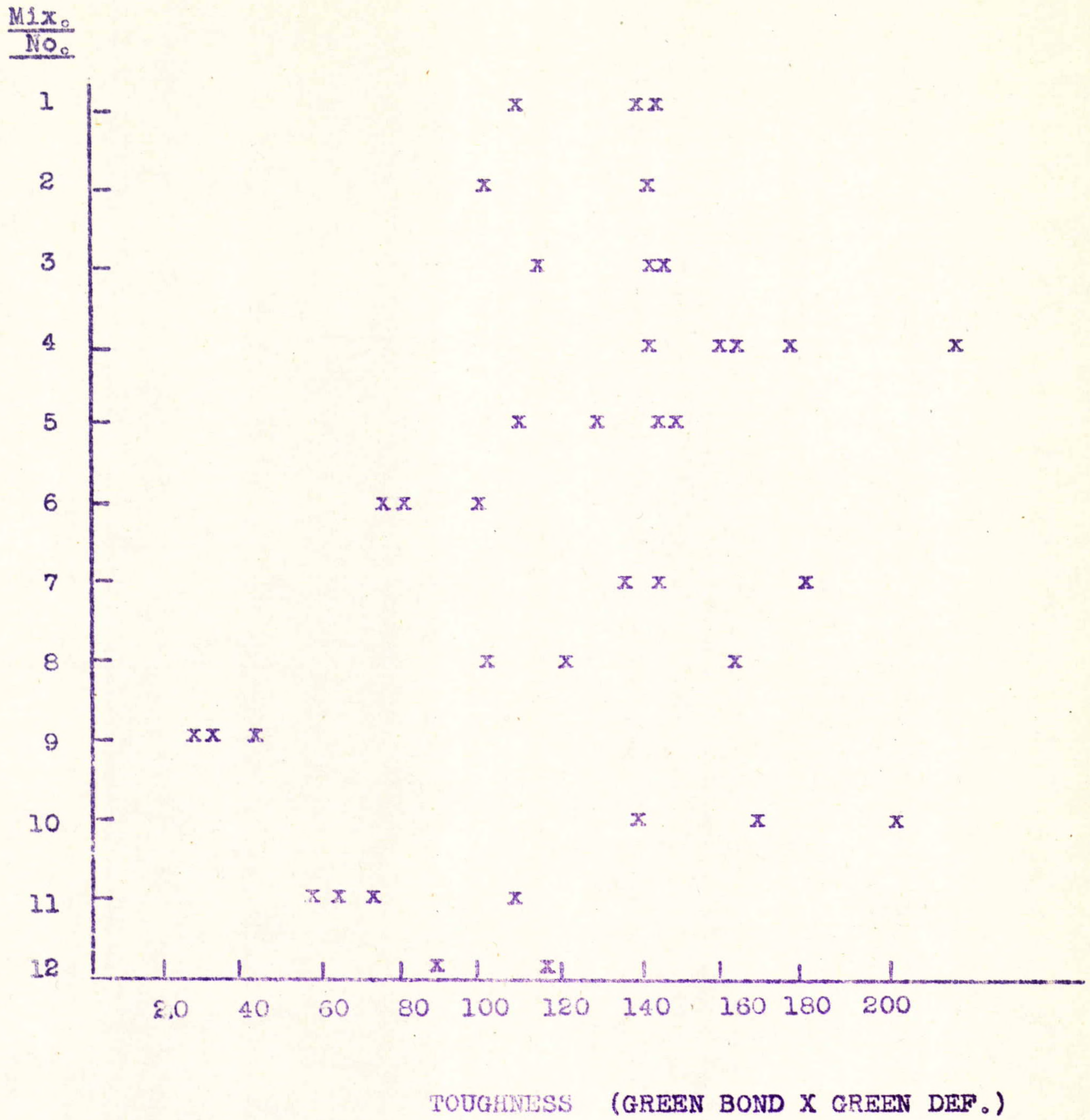

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TABLE VII. - FLOWABILITY HISCO

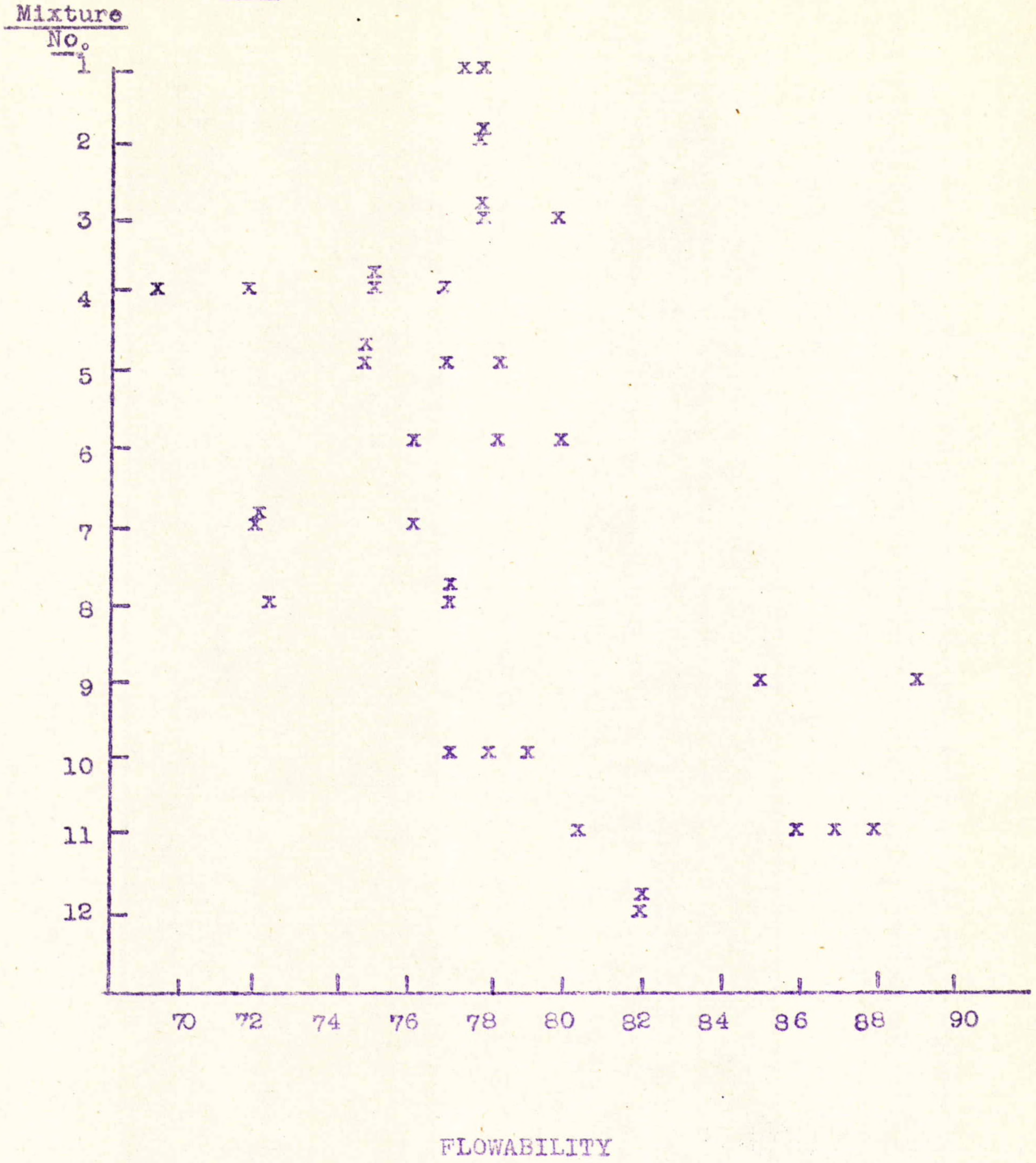

TABLE VIII. MOLD HARDNESS HISCO SANDS

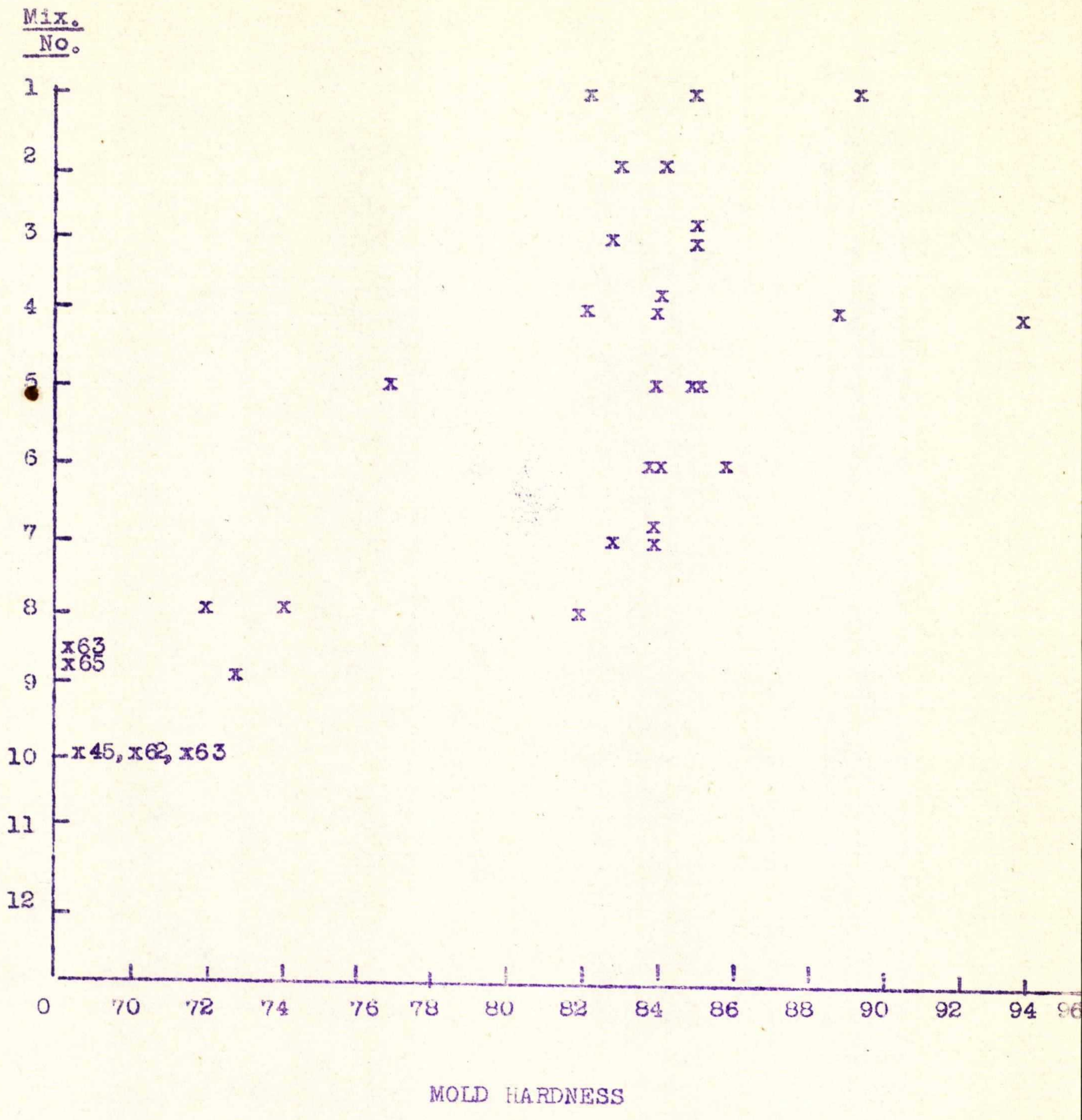

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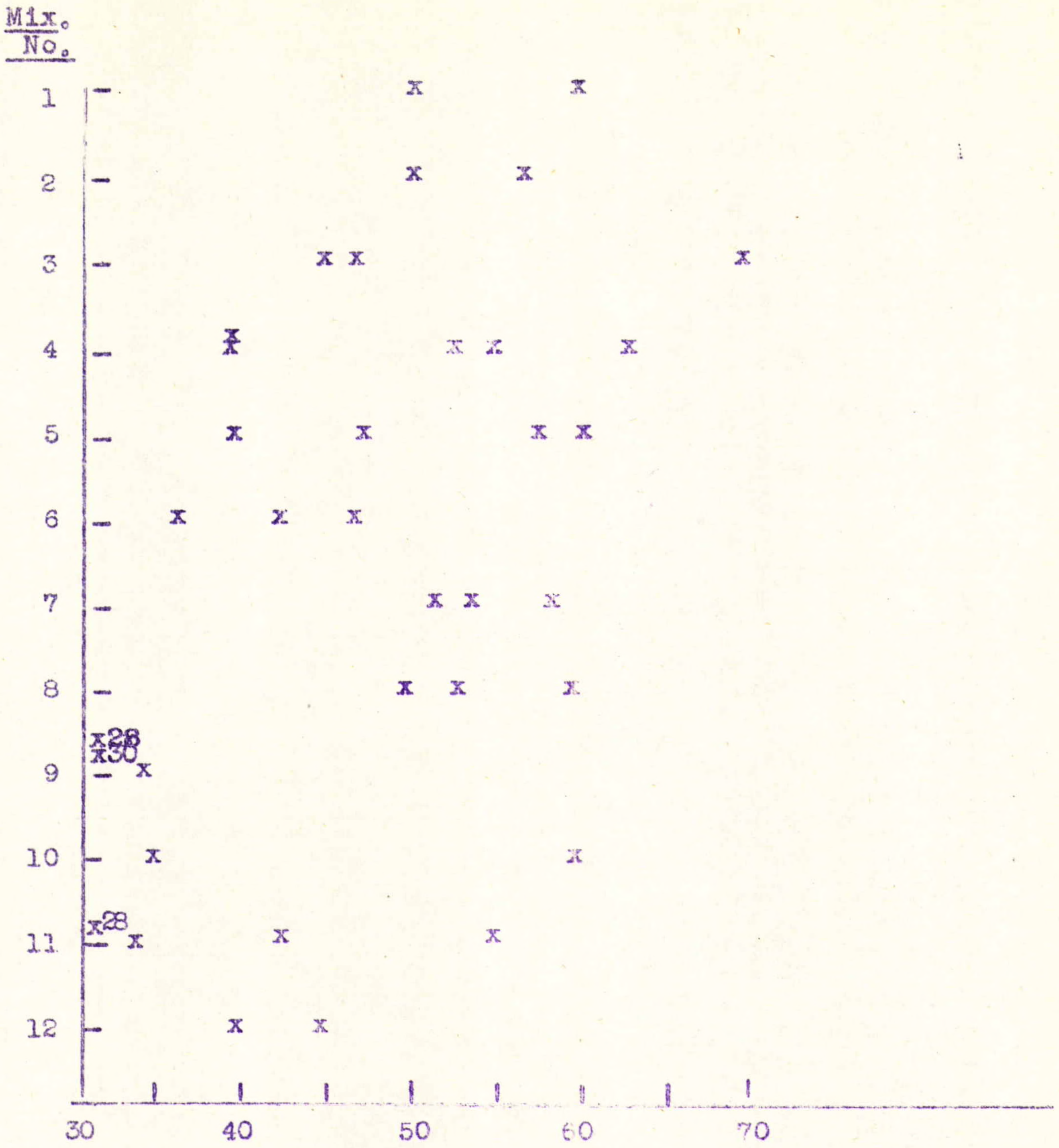
TABLE IX.
HOT DEFORMATION.



HOT DEFORMATION (Units of 1/1000 ins. per ins.)

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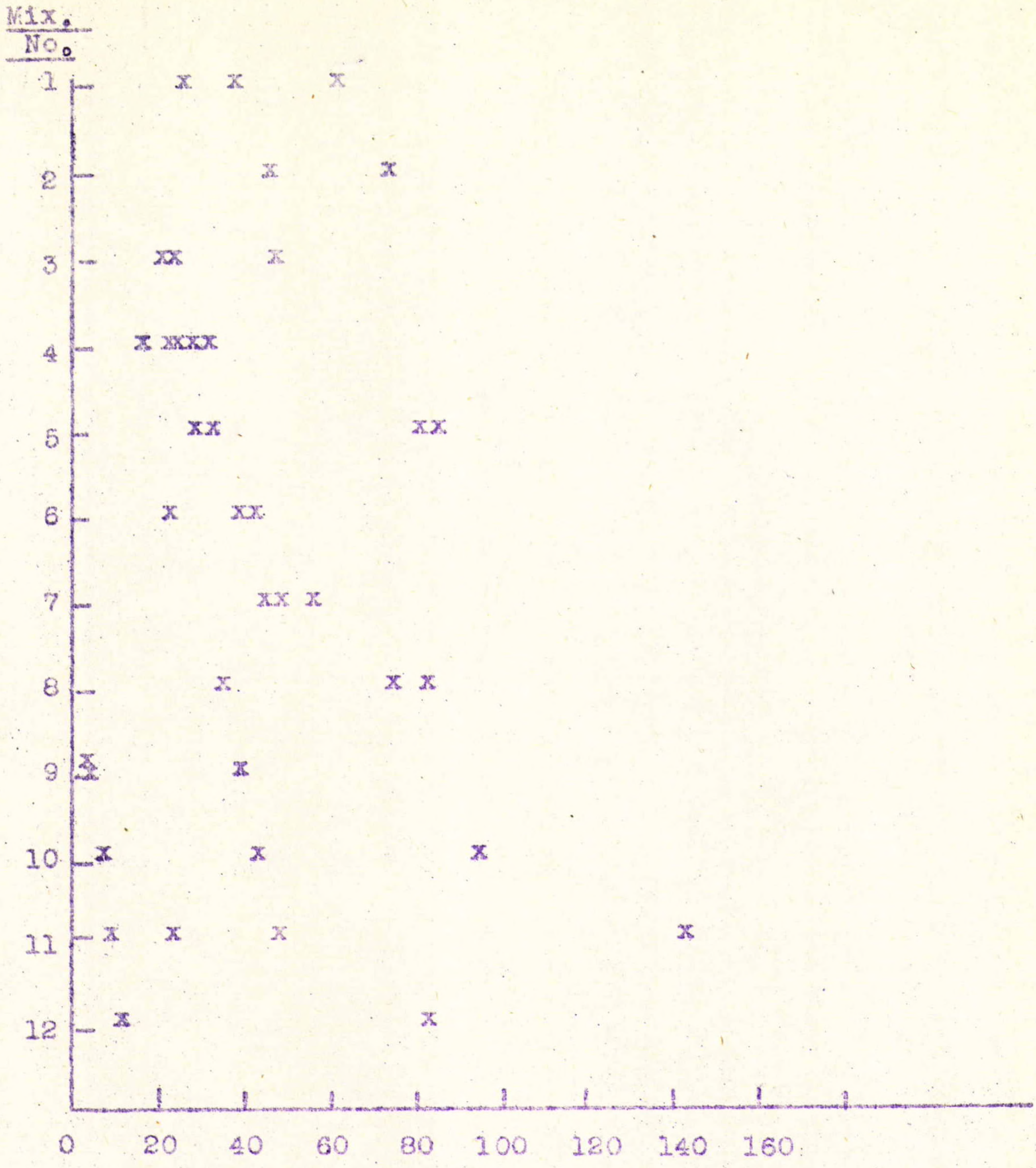
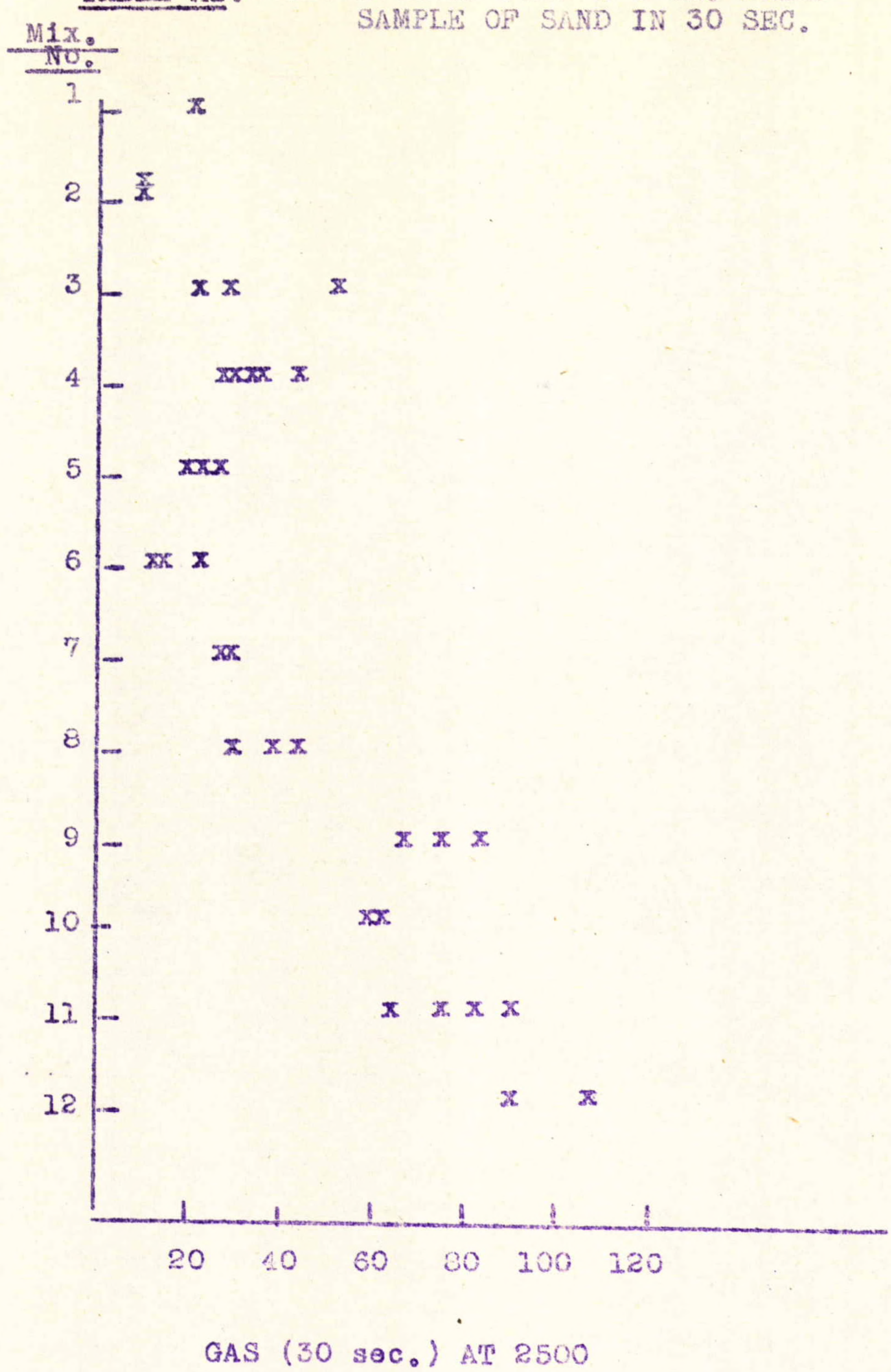
TABLE X.

RETAINED STRENGTH AFTER HEATING TO 1000°F.



RETAINED STRENGTH P.S.I.

TABLE XI. - GAS EVOLVED FROM A 5 GM. DRIED SAMPLE OF SAND IN 30 SEC.



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