

Adams Township, MI

July 15, 1941

Test 1000-G

Standard Grindability Tests on Shale Copper Ore.

Submitted by: Copper Range Co., Painesdale, Mich.  
(Mr. Wm. B. Schacht, Pres.)

This test report describes a complete series of standard ball mill grindability tests made on the copper ore sample marked "White Pine Shale", and mentioned in test 1000-F.

The shale ore as received was crushed in a laboratory gyratory crusher set at  $3/8$ " opening on the close side, and screen analyzed. Half of the gyratory crusher product was split out and crushed in rolls set at  $1/16$ " opening, in closed circuit with a screen, to all passing 6 mesh. The minus 6 mesh roll product was used as feed for the standard ball mill grindability tests at 28, 35, 48, 65, 100, 150 and 200 mesh.

3000  
Fidelity Union Bank  
MADE IN U.S.A.

Adams Township, MI

Test 1000-G

The following screen analyses were obtained:

Mesh	<u>Gyratory Crusher</u>		<u>Roll Product</u>	
	% Wt.	% Cum.	% Wt.	% Cum.
On 1"	0	0		
3/4"	5.74	5.74		
1/2"	21.10	26.84		
3/8"	37.81	64.65		
3 M	20.14	84.79		
4	8.39	93.18		
6	3.04	96.22	0	0
8	1.68	97.90	14.28	14.28
10	0.87	98.77	19.31	33.67
14	0.39	99.16	15.15	48.82
20	0.21	99.37	11.10	59.92
28	0.15	99.52	7.95	67.87
35	0.06	99.58	5.51	73.38
48	0.04	99.62	4.22	77.60
65	0.04	99.66	3.22	80.82
100	0.02	99.68	2.14	82.96
150	0.02	99.70	2.14	85.10
200	0.02	99.72	1.20	86.30
-200	0.28	100.00	13.70	100.00
	<u>100.00</u>		<u>100.00</u>	
m (slope)				0.900
K 9 (microns)				2810
S (Sq.Meters per 100 cc.)				2.23

The plotted screen analyses show that there is no important natural grain size, and that the ore contains 10.0% of excess fines, or clayey slimes.

The specific gravity of the minus 6 mesh ore was determined with a weighing bottle as 2.973. The apparent specific gravity was 1.79 when packed by shaking, equivalent to 112 pounds per cubic foot. This is equivalent to 39.8% void space in the packed ore.

The complete series of closed circuit standard ball mill grindability tests was made on the minus 6 mesh shale ore, with the following summarized results:

Mesh Tested	28	35	48	65	100	150	200
Net Grams/Rev.	3.08	2.66	2.296	1.936	1.560	1.430	1.304
% Circ. Load	252	237	252	254	248	256	263
% -200 Mesh	33.30	38.20	45.39	54.24	70.60	83.66	100.
E (Excess Fines)	24.0	27.0	33.3	31.5	38.0	45.0	50.0
m (slope)	0.970	1.08	1.20	1.05	1.05	1.05	1.05
K	590	425	300	210	150	100	74
S (surface)	5.60	5.58	5.62	8.00	12.24	15.25	18.50
Gross cc./Rev.	1.526	1.220	0.995	0.806	0.633	0.565	0.489
Sq. Meters/ Rev.	.0514	.0409	.0347	.0645	.0634	.0736	.0796

The grindability decreases much more slowly than that of the sandstone as the finer sizes are approached. The plotted slope of the grindability line is 0.447, as compared with 1.223 for the sandstone. The two samples have the same grindability at about 60 mesh, but at finer sizes the shale grinds much easier than the sandstone.

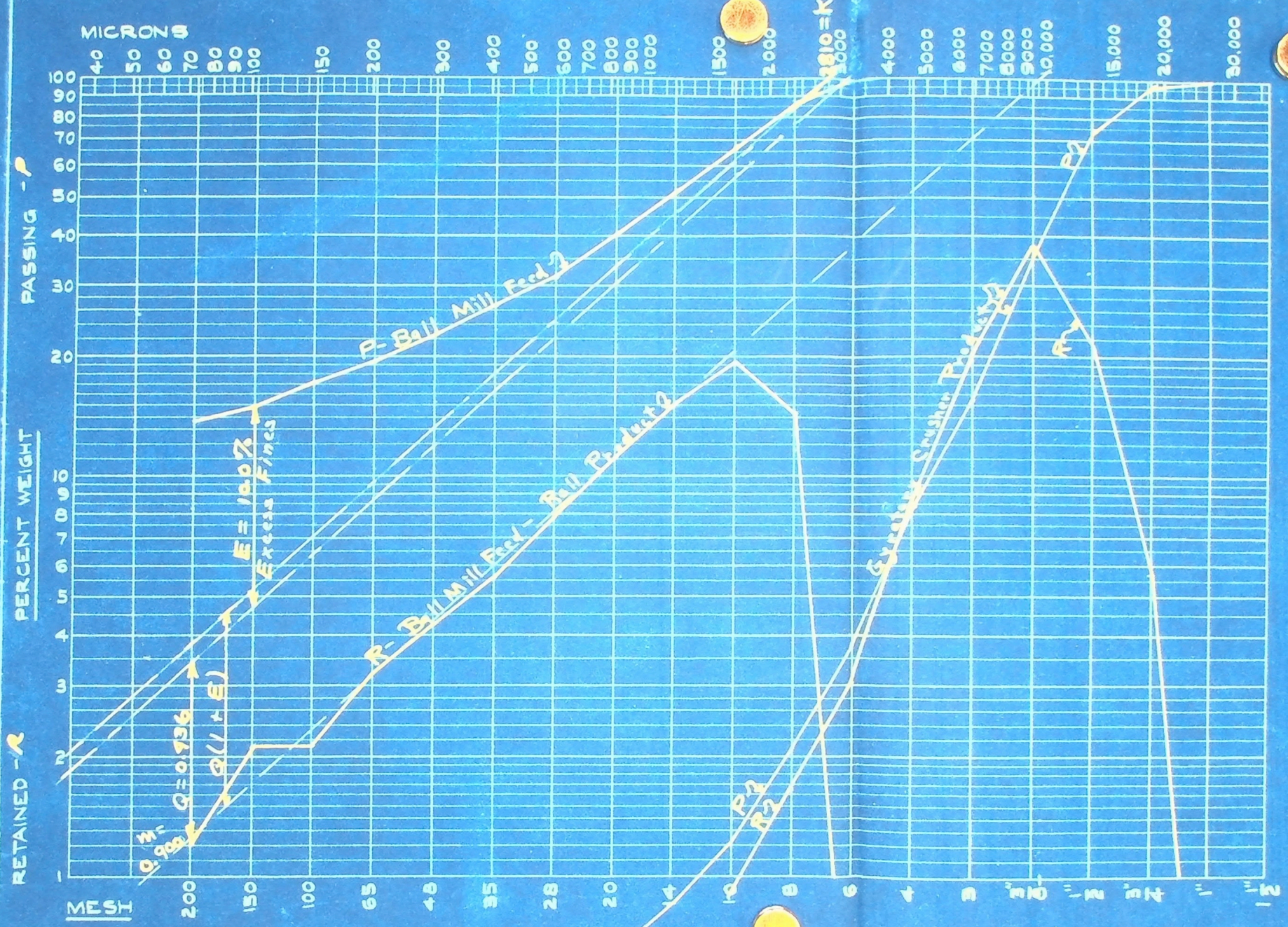
The calculation of surface areas and surface production per revolution was made very uncertain because of the large amount of excess fines, or natural clay, contained in the ore, and the tabulated results should be regarded as only very approximate values.

Details of the tests, including complete screen analyses and plots, are given on the accompanying data sheets.

MINING RESEARCH LABORATORY

Fred C. Bond

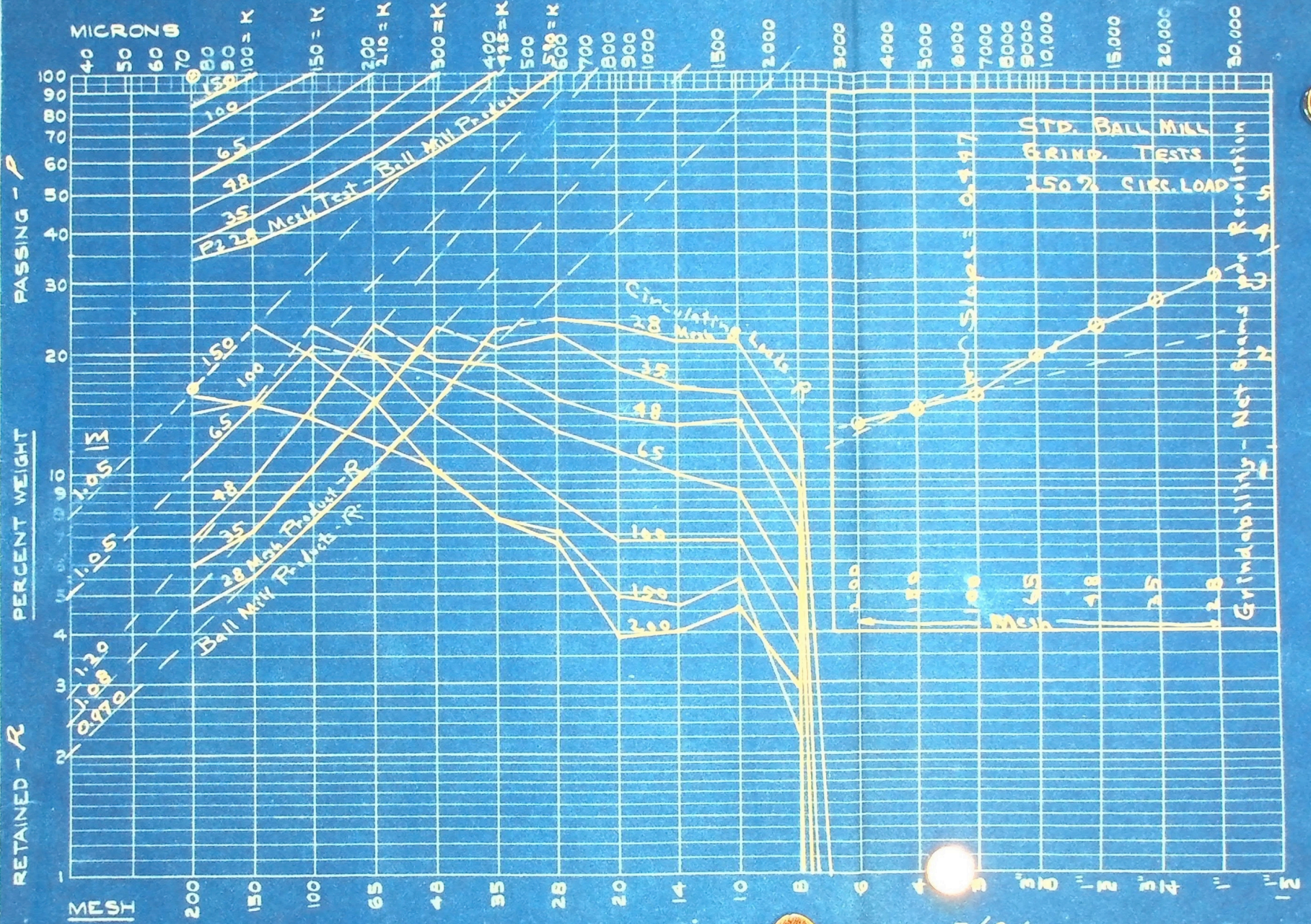
TEST NO 1000 G MATERIAL White Pine Smale SUBMITTED BY COPPER RANGE CO.



ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

DATE 7/1/41 BY M.S.E.  
F.C.B.

TEST NO. 1000G MATERIAL White Pine Shale SUBMITTED BY Copper Range Co.



ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

DATE 7/8/41 BY M.S.E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM E175-0-12-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SHALE

DATE 7/1/41

SUBMITTED BY COPPER RANGE CO.

TEST NO. 1000 G

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 28 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>28</u> MESH	GRAMS IN FEED MINUS <u>28</u> MESH	NET GRAMS MINUS <u>28</u> MESH	NET GRAMS PER REV. MINUS <u>28</u> MESH
1	0	350	350	0	0
2	49	325	112	213	4.35
3	58	309	104	205	3.53
4	74	331	99	232	3.14
5	80	348	106	242	3.02
6	82	364	112	252	3.08

UNIT VOLUME (700 C. C.) 12.53 GRAMS; EQUIVALENT TO 112 LBS. PER CU. FT., BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 3.08 NET GRAMS OF MINUS 28 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 2.52 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

### SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 6 PERIOD

PRODUCT AFTER 6 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 8	0	0	0	0		
8	14.28	14.28	11.77	11.77		
10	19.39	33.67	20.50	32.27		
14	15.15	48.82	20.72	52.99		
20	11.10	59.92	22.84	75.83		
28	7.95	67.87	24.17	100.00	0	0
35	5.51	73.38			23.34	23.34
48	4.22	77.60			15.19	38.53
65	3.22	80.82			10.92	48.95
100	2.14	82.96			7.54	56.49
150	2.14	85.10			5.52	62.01
200	1.20	86.30			4.69	66.70
THROUGH 200	13.70	100.00			33.30	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 6174-B-12-37  
PRINTED IN U. S. A. (2)

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL White Pine Shale DATE 7/1/91  
 SUBMITTED BY Copper Range Co. TEST NO. 10006  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 35 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>35</u> MESH	GRAMS IN FEED MINUS <u>35</u> MESH	NET GRAMS MINUS <u>35</u> MESH	NET GRAMS PER REV. MINUS <u>35</u> MESH
1	93	305	97	208	2.24
2	124	380	81	299	2.41
3	107	384	101	283	2.65
4	96	359	103	256	2.67

UNIT VOLUME (700 C. C.) 1253 GRAMS EQUIVALENT TO 112 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 2.66 NET GRAMS OF MINUS 35 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 237 PERCENT

RATIO OF REDUCTION IN GRINDING

### SCREEN ANALYSES

MESH	MILL FEED		CIRCULATING LOAD AFTER <u>1</u> PERIOD		PRODUCT AFTER <u>1</u> PERIOD	
	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	14.28	14.28	8.74	8.74		
10	19.59	33.67	15.21	23.95		
14	15.15	48.82	16.00	39.95		
20	11.10	59.92	17.96	57.91		
28	7.95	67.87	21.64	79.55		
35	5.51	73.38	20.45	100.00	0	0
48	4.22	77.60			22.95	22.95
65	3.22	80.82			15.78	38.73
100	2.14	82.96			10.06	48.79
150	2.14	85.10			7.18	55.97
200	1.20	86.30			5.83	61.80
THROUGH 200	13.70	100.00			38.20	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 1174-6-12-57  
PRINTED IN U.S.A.

MILWAUKEE, WISCONSIN, U.S.A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE Pine SHALES DATE 7/2/41  
 SUBMITTED BY COPPER RANGE CO. TEST NO. 10006  
 SAMPLE NO. \_\_\_\_\_

### STANDARD GRINDABILITY TEST AT 48 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>48</u> MESH	GRAMS IN FEED MINUS <u>48</u> MESH	NET GRAMS MINUS <u>48</u> MESH	NET GRAMS PER REV. MINUS <u>48</u> MESH
1	141	368	79	289	2.05
2	135	370	82	288	2.14
3	128	373	83	290	2.26
4	121	373	84	289	2.39
5	114	339	84	255	2.24

UNIT VOLUME (700 C. C.) 1253 GRAMS EQUIVALENT TO 112 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 2.296 NET GRAMS OF MINUS 48 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 252 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

### SCREEN ANALYSES

MESH	MILL FEED		CIRCULATING LOAD AFTER <u>5</u> PERIOD		PRODUCT AFTER <u>5</u> PERIOD	
	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	14.28	14.28	7.01	7.01		
10	19.39	33.67	13.35	20.36		
14	15.15	48.82	12.93	33.29		
20	11.10	59.92	13.68	46.97		
28	7.95	67.87	15.26	62.23		
35	5.51	73.38	18.59	80.82		
48	4.22	77.60	19.18	100.00	0	0
55	3.22	80.82			23.46	23.46
100	2.14	82.96			14.66	38.12
150	2.14	85.10			9.60	47.72
200	1.20	86.30			6.89	54.61
THROUGH 200	13.70	100.00			45.39	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.



# ALLIS-CHALMERS MANUFACTURING COMPANY

MILWAUKEE, WISCONSIN, U. S. A.

FORM 217A—5-12-37  
PRINTED IN U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL White Pine Shale

DATE 7/2/41

SUBMITTED BY Copper Range Co.

TEST NO. 10006

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 65 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS 65 MESH	GRAMS IN FEED MINUS 65 MESH	NET GRAMS MINUS 65 MESH	NET GRAMS PER REV. MINUS 65 MESH
1	154	325	66	259	1.68
2	176	371	62	309	1.75
3	164	391	71	320	1.95
4	145	361	75	286	1.97
5	147	347	69	278	1.89

UNIT VOLUME (700 C. C.) 1253 GRAMS EQUIVALENT TO 112 LBS. PER CU. FT., BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 1.936 NET GRAMS OF MINUS 65 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 2.54 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

### SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 5 PERIOD

PRODUCT AFTER 5 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	14.28	14.28	4.93	4.93		
10	19.39	33.67	8.93	13.86		
14	15.13	48.82	9.79	23.65		
20	11.10	59.92	11.19	34.84		
28	7.95	67.87	12.62	47.46		
35	5.51	73.38	15.22	62.68		
48	4.22	77.60	17.89	80.56		
65	3.22	80.82	19.44	100.00	0	0
100	2.14	82.96			20.75	20.75
150	2.14	85.10			14.57	35.32
200	1.20	86.30			10.44	45.76
THROUGH 200	13.70	100.00			54.24	100.00
TOTAL	100.00				100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM E176-5-13-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SHALE DATE 7/8/41  
 SUBMITTED BY COPPER RANGE CO. TEST NO. 1000 G  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 100 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS 100 MESH	GRAMS IN FEED MINUS 0 MESH	NET GRAMS MINUS 100 MESH	NET GRAMS PER REV. MINUS 100 MESH
<u>1</u>	<u>187</u>	<u>327</u>	<u>59</u>	<u>268</u>	<u>1.430</u>
<u>2</u>	<u>212</u>	<u>364</u>	<u>56</u>	<u>308</u>	<u>1.450</u>
<u>3</u>	<u>204</u>	<u>380</u>	<u>62</u>	<u>318</u>	<u>1.560</u>
<u>4</u>	<u>189</u>	<u>360</u>	<u>65</u>	<u>295</u>	<u>1.560</u>

UNIT VOLUME (700 G. G.) 12.53 GRAMS; EQUIVALENT TO 112 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 1.560 NET GRAMS OF MINUS 100 MESH  
 CIRCULATING LOAD (AVERAGE OF LAST 1 PERIODS) 248 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 1 PERIOD

PRODUCT AFTER 1 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>		
8	<u>14.28</u>	<u>14.28</u>	<u>3.60</u>	<u>3.60</u>		
10	<u>19.39</u>	<u>33.67</u>	<u>6.77</u>	<u>10.37</u>		
14	<u>15.15</u>	<u>48.82</u>	<u>6.72</u>	<u>17.09</u>		
20	<u>11.10</u>	<u>59.92</u>	<u>6.72</u>	<u>23.81</u>		
28	<u>7.95</u>	<u>67.87</u>	<u>8.53</u>	<u>32.34</u>		
35	<u>5.51</u>	<u>73.38</u>	<u>11.07</u>	<u>43.41</u>		
48	<u>4.22</u>	<u>77.60</u>	<u>13.92</u>	<u>57.33</u>		
65	<u>3.22</u>	<u>80.82</u>	<u>19.41</u>	<u>76.74</u>		
100	<u>2.14</u>	<u>82.96</u>	<u>23.26</u>	<u>100.00</u>	<u>0</u>	<u>0</u>
150	<u>2.14</u>	<u>85.10</u>			<u>15.27</u>	<u>15.27</u>
200	<u>1.20</u>	<u>86.30</u>			<u>14.13</u>	<u>29.40</u>
THROUGH 200	<u>13.70</u>	<u>100.00</u>			<u>70.60</u>	<u>100.00</u>
TOTAL	<u>100.00</u>		<u>100.00</u>		<u>100.00</u>	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 2574-B-12-57  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SHALE  
SUBMITTED BY COPPER RANGE CO.

DATE 7/9/41  
TEST NO. 1000 G

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 150 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>150</u> MESH	GRAMS IN FEED MINUS <u>150</u> MESH	NET GRAMS MINUS <u>150</u> MESH	NET GRAMS PER REV. MINUS <u>150</u> MESH
1	188	294	54	240	1.280
2	216	373	44	329	1.520
3	226	361	56	305	1.350
4	227	368	54	314	1.380
5	230	362	55	307	1.339
6	218	303	54	249	1.140
7	275	460	15	445	1.610
8	216	362	69	293	1.350
9	216	362	57	305	1.410

UNIT VOLUME (700 C. C.) 13.58 GRAMS; EQUIVALENT TO 11.2 LBS. PER CU. FT., BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 1.420 NET GRAMS OF MINUS 150 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 2563 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 2 PERIOD

PRODUCT AFTER 2 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	14.28	14.28	2.28	2.28		
10	19.59	33.87	5.41	7.69		
14	15.15	49.02	4.66	12.35		
20	11.10	60.12	4.84	17.19		
28	7.95	68.07	7.16	24.35		
35	5.51	73.58	7.65	32.00		
48	4.32	77.90	10.15	42.15		
65	3.22	81.12	15.17	57.32		
100	2.14	83.26	19.48	76.80		
150	2.14	85.40	23.20	100.00	0	0
200	1.20	86.60			16.34	16.34
THROUGH 200	13.70	100.00			83.66	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM E174-4016-09  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SHALE DATE 7/9/41

SUBMITTED BY COPPER RANGE CO. TEST NO. 1000 G

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 200 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS 200 MESH	GRAMS IN FEED MINUS 20 MESH	NET GRAMS MINUS 20 MESH	NET GRAMS PER REV. MINUS 20 MESH
1	347	401	51	350	1.01
2	300	467	55	412	1.37
3	215	369	64	305	1.42
4	226	398	50	348	1.54
5	300	297	50	247	1.236
6	257	393	41	352	1.371

UNIT VOLUME (700 C. C.) 1253 GRAMS EQUIVALENT TO 112 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 1.304 NET GRAMS OF MINUS 200 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 263 PERCENT

RATIO OF REDUCTION IN GRINDING

### SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 6 PERIOD

PRODUCT AFTER 6 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	14.28	14.28	2.94	2.94		
10	19.39	33.67	4.61	7.55		
14	15.15	48.82	4.06	11.61		
20	11.10	59.92	3.88	15.49		
28	7.95	67.87	6.64	22.13		
35	5.51	73.38	7.59	29.72		
48	4.22	77.60	10.08	39.80		
65	3.22	80.82	11.83	51.63		
100	2.14	82.96	13.55	65.18		
150	2.14	85.10	14.80	79.98		
200	1.20	86.30	15.68	95.66		
THROUGH 200	13.70	100.00	4.32	100.00		
TOTAL	100.00		100.00			

TESTED BY M. S. E.

June 23, 1941

Standard Grindability Tests on Sandstone Copper Ore  
Submitted by: Copper Range Co., Painesdale, Mich.  
(Mr. Wm. H. Schacht, Pres.)

Two bags of copper ore containing 100 pounds each were received May 26th. Both had been crushed to pass 2", and contained some fines as received. Bag No. 1 was marked "White Pine Sandstone", and bag No. 2 was marked "White Pine Shale". Both represent ore which is to be treated separately at the Freda mill. A complete series of standard ball mill grindability tests is to be made on each sample.

This test report describes only the results on the White Pine sandstone. The sample of White Pine Shale will be reported in a subsequent test.

It is proposed to grind 45 tons per hour, and to grind the shale finer than the sandstone. It is stated that the sandstone is difficult to grind below its natural grain size.

The sandstone ore as received was crushed in a laboratory gyratory crusher set at 3/8" opening on the close side, and screen analyzed. Half of the gyratory crusher product was split out and crushed in rolls set at 1/16" opening, in closed circuit with a screen, to all passing 6 mesh. The minus 6 mesh roll product was used as feed for the standard ball mill grindability tests at 28, 35, 48, 65, 100, 150 and 200 mesh.

Test 1000-F

-2-

The following screen analyses were obtained:

Mesh	Gyratory Crusher		Roll Product	
	% Wt.	% Cum.	% Wt.	% Cum.
On 1"	0	0		
3/4"	2.78	2.78		
1/2"	9.43	12.21		
3/8"	25.60	37.81		
3M	20.05	57.86		
4	9.99	67.85		
6	5.74	73.59	0	0
8	2.60	76.14	8.00	8.00
10	2.50	78.69	15.50	23.50
14	1.97	80.66	11.60	35.10
20	1.99	82.65	9.90	45.00
28	1.89	84.54	7.40	52.40
35	2.34	86.88	8.10	60.50
48	3.01	89.89	9.40	69.90
65	2.87	92.76	8.40	78.30
100	1.78	94.54	5.70	84.00
150	1.55	96.09	4.30	88.30
200	0.86	96.95	2.70	91.00
-200	<u>3.05</u>	100.00	<u>9.00</u>	100.00
	100.00		100.00	

m (Slope)	-	0.947
K (microns)	-	1010
S (Sq. Meters per 100 cc.)	-	4.99

The screen analyses show that the natural grain size of the sandstone grains is from 48 to 65 mesh, and that they are all finer than 28 mesh, and only a few are retained on 35 mesh.

The specific gravity of the minus 6 mesh ore was determined with a weighing bottle as 2.635. The apparent specific gravity was 1.70 when packed by shaking, equivalent to 106 pounds per cubic foot. This is equivalent to 35.5% void space in the packed ore.

The complete series of closed circuit standard ball mill grindability tests was made on the minus 6 mesh sandstone ore, with the following summarized results:

2196111 011011 2K111  
 8770008

Test 1000-F

-3-

Mesh Tested	28	35	48	65	100	150	200
Net Grams/Rev.	8.63	4.51	3.05	1.623	1.260	0.845	0.733
% Circ. Load	252	250	250	250	250	240	234
% -200 Mesh	13.76	20.40	28.50	42.21	55.60	84.10	100.00
m (Slope)	1.018	0.950	0.967	0.900	0.890	0.910	0.920
K	540	415	295	190	138	89	74
S (Surface)	7.11	10.39	13.10	21.31	27.84	37.29	42.02
Gross cc/Rev.	6.25	2.829	1.655	0.787	.5695	.3631	.3058
Sq. Meters/Rev.	.1325	.1527	.1342	.1284	.1301	.1173	.1132

The slope  $m$  for 200 mesh and 150 mesh were estimated, and are not as accurate as those at coarser meshes, so that the new surface areas produced in square meters per revolution at these sizes may be too low. The average square meters produced per revolution, omitting these two tests, is 0.1356. 52.3 joules of work done per revolution of the mill, divided by 0.1356, gives the surface energy of the sandstone ore as 385 joules per square meter. Test 1000-B gave the surface energy of the mixed sandstone and shale as 329 joules per square meter.

Details of the tests, including complete screen analyses and graphs, are given on the accompanying data sheets.

MINING RESEARCH LABORATORY  
Fred C. Bond

MADE IN U.S.A.

MINING RESEARCH LABORATORY

300043

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 2124-S-1237  
PRINTED IN U.S.A.

MILWAUKEE, WISCONSIN, U.S.A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL White Pine Sandstone

DATE 6/9/41

SUBMITTED BY RANGE COPPER Co.

TEST NO. 1000 F

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 28 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>28</u> MESH	GRAMS IN FEED MINUS <u>28</u> MESH	NET GRAMS MINUS <u>28</u> MESH	NET GRAMS PER REV. MINUS <u>28</u> MESH
1	0	565	565	565	0
2	30	570	269	301	8.60
3	8	391	271	70	8.75
4	20.0	334	163	171	8.55

UNIT VOLUME (700 C. C.) 2190 GRAMS. EQUIVALENT TO 206 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 8.63 NET GRAMS OF MINUS 28 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 252 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

### SCREEN ANALYSES

MESH	MILL FEED		CIRCULATING LOAD AFTER <u>4</u> PERIOD		PRODUCT AFTER <u>4</u> PERIOD	
	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	10.70	10.70		
10	15.50	23.50	20.72	31.42		
14	11.60	35.10	20.30	51.72		
20	8.90	44.00	22.23	73.95		
28	7.90	51.90	26.00	99.95	0	0
38	8.10	60.00			34.42	24.42
48	9.20	69.20			21.30	45.72
68	8.20	77.40			17.56	63.28
100	5.70	83.10			9.84	73.12
150	4.50	87.60			8.59	81.70
200	2.70	90.30			4.51	86.21
THROUGH 200	9.00	100.00			13.76	100.00
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00

TESTED BY M. S. E.



# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 2174-6-12-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SANDSTONE

DATE 6/11/41

SUBMITTED BY COPPER RANGE CO.

TEST NO. 1000 F

SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 35 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>35</u> MESH	GRAMS IN FEED MINUS <u>35</u> MESH	NET GRAMS MINUS <u>35</u> MESH	NET GRAMS PER REV. MINUS <u>35</u> MESH
1	31	349	185	164	5.30
2	38	324	131	186	4.90
3	47	343	128	215	4.56
4	45	336	136	200	4.45

UNIT VOLUME (700 C. C.) 1190 GRAMS: EQUIVALENT TO 106 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 4.51 NET GRAMS OF MINUS 35 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 250 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 1 PERIOD

PRODUCT AFTER 1 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	6.56	6.56		
10	15.50	23.50	14.10	20.66		
14	11.60	35.10	12.21	32.87		
20	9.90	45.00	15.99	48.86		
28	7.40	52.40	23.59	72.45		
35	8.10	60.50	27.55	100.00	0	0
48	9.40	69.90			29.14	29.14
65	8.40	78.30			21.56	50.70
100	5.70	84.00			12.65	63.35
150	4.30	88.30			10.34	73.69
200	2.70	91.00			5.91	79.60
THROUGH 200	9.00	100.00			20.40	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. J. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 5175-5-12-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SANDSTONE  
SUBMITTED BY COPPER RANGE CO.

DATE 6/11/41  
TEST NO. 1000F  
SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 48 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>48</u> MESH	GRAMS IN FEED MINUS <u>48</u> MESH	NET GRAMS MINUS <u>48</u> MESH	NET GRAMS PER REV. MINUS <u>48</u> MESH
1	92	246	105	141	3.36
2	79	320	74	246	3.12
3	78	334	96	238	3.06
4	78	235	100	235	3.00
5	80	350	101	249	3.10

UNIT VOLUME (700 C. C.) 1190 GRAMS; EQUIVALENT TO 106 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 3.05 NET GRAMS OF MINUS 48 MESH

CIRCULATING LOAD (AVERAGE OF LAST 3 PERIODS) 250 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 5 PERIOD

PRODUCT AFTER 5 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	4.72	4.72		
10	15.50	23.50	7.40	12.12		
14	11.60	35.10	5.63	17.75		
20	9.90	45.00	6.42	24.17		
28	7.40	52.40	11.61	35.78		
35	8.10	60.50	24.71	60.49		
48	9.40	69.90	39.51	100.00	0	0
65	8.40	78.30			32.67	32.67
100	5.70	84.00			16.24	48.91
150	4.30	88.30			14.71	63.62
200	2.70	91.00			7.88	71.50
THROUGH 200	9.00	100.00			28.50	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM E174-8-19-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SANDSTONE DATE 6/13/46  
 SUBMITTED BY COPPER RANGE Co. TEST NO. 1000 F  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 65 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS 65 MESH	GRAMS IN FEED MINUS 65 MESH	NET GRAMS MINUS 65 MESH	NET GRAMS PER REV. MINUS 65 MESH
1	34	150	76	74	2.18
2	141	272	33	239	1.70
3	166	325	59	266	1.60
4	168	336	71	265	1.58
5	169	359	73	286	1.69

UNIT VOLUME (700 C. C.) 1190 GRAMS: EQUIVALENT TO 106 LBS. PER CU. FT., BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 3 PERIODS) 1.623 NET GRAMS OF MINUS 65 MESH

CIRCULATING LOAD (AVERAGE OF LAST 3 PERIODS) 2580 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 5 PERIOD

PRODUCT AFTER 5 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	1.47	1.47		
10	15.50	23.50	2.48	3.95		
14	11.60	35.10	1.77	5.72		
20	9.90	45.00	1.63	7.35		
28	7.40	52.40	2.40	9.75		
35	8.10	60.50	7.75	17.50		
48	9.40	69.90	27.30	44.80		
65	8.40	78.30	55.20	100.00	0	0
100	5.70	84.00			20.51	20.51
150	4.30	88.30			24.89	45.40
200	2.70	91.00			12.69	58.09
THROUGH 200	9.00	100.00			42.21	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM B174-9-12-82  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE Pine SANDSTONE DATE 6/13/91  
 SUBMITTED BY COPPER RANGE Co. TEST NO. 1000F  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 100 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS 100 MESH	GRAMS IN FEED MINUS 100 MESH	NET GRAMS MINUS 100 MESH	NET GRAMS PER REV. MINUS 100 MESH
1	283	336	57	279	0.99
2	289	418	54	364	1.26
3	217	340	67	273	1.26

UNIT VOLUME (700 C. C.) 1190 GRAMS; EQUIVALENT TO 10.6 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 1.260 NET GRAMS OF MINUS 100 MESH

CIRCULATING LOAD (AVERAGE OF LAST 1 PERIODS) 250.0 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD AFTER 3 PERIOD

PRODUCT AFTER 3 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	1.45	1.45		
10	15.50	23.50	1.83	3.28		
14	11.60	35.10	1.26	4.54		
20	9.90	45.00	0.91	5.45		
28	7.40	52.40	1.26	6.71		
35	8.10	60.50	3.09	9.80		
48	9.40	69.90	10.20	20.00		
65	8.40	78.30	31.60	51.60		
100	5.70	84.00	18.40	70.00	0	0
150	4.30	88.30			22.26	22.26
200	2.70	91.00			22.10	44.30
THROUGH 200	9.00	100.00			55.60	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM 8174-6-12-37  
PRINTED IN U. S. A.

MILWAUKEE, WISCONSIN, U. S. A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SANDSTONE DATE 6/19/41  
 SUBMITTED BY COPPER RANGE Co. TEST NO. 1000F  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 150 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>150</u> MESH	GRAMS IN FEED MINUS <u>150</u> MESH	NET GRAMS MINUS <u>150</u> MESH	NET GRAMS PER REV. MINUS <u>150</u> MESH
1	376	352	40	312	0.830
2	360	337	41	296	0.820
3	367	362	39	323	0.870

UNIT VOLUME (700 C. C.) 1190 GRAMS; EQUIVALENT TO 106 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 2 PERIODS) 0.845 NET GRAMS OF MINUS 150 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 310 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

### SCREEN ANALYSES

MILL FEED			CIRCULATING LOAD AFTER <u>3</u> PERIOD		PRODUCT AFTER <u>3</u> PERIOD	
MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	0.50	0.50		
10	15.50	23.50	0.56	1.06		
14	11.60	35.10	0.50	1.56		
20	9.90	45.00	0.44	2.00		
28	7.40	52.40	0.44	2.44		
35	8.10	60.50	0.83	3.27		
48	9.40	69.90	2.55	5.82		
65	8.40	78.30	12.79	18.61		
100	5.70	84.00	36.40	55.01		
150	4.30	88.30	44.99	100.00	0	0
200	2.70	91.00			15.90	15.90
THROUGH 200	9.00	100.00			84.10	100.00
TOTAL	100.00		100.00		100.00	

TESTED BY M. S. E.

# ALLIS-CHALMERS MANUFACTURING COMPANY

FORM E174-8-12-37  
PRINTED IN U.S.A.

MILWAUKEE, WISCONSIN, U.S.A.

MINING DIVISION

ORE TESTING LABORATORY

MATERIAL WHITE PINE SANDSTONE DATE 6/19/41  
 SUBMITTED BY COPPER RANGE CO. TEST NO. 1000 F  
 SAMPLE NO. \_\_\_\_\_

## STANDARD GRINDABILITY TEST AT 200 MESH

PERIOD	REVOLUTIONS OF BALL MILL	GRAMS OF PRODUCT MINUS <u>200</u> MESH	GRAMS IN FEED MINUS <u>200</u> MESH	NET GRAMS MINUS <u>200</u> MESH	NET GRAMS PER REV. MINUS <u>200</u> MESH
1	389	262	32	230	0.593
2	534	159	24	135	0.253
3	1290	756	20	736	0.573
4	475	139	68	371	0.780
5	384	319	40	279	0.726
6	130	394	28	366	0.851

UNIT VOLUME (700 C. C.) 1190 GRAMS: EQUIVALENT TO 106 LBS. PER CU. FT. BROKEN

AVERAGE PRODUCTION PER REVOLUTION OF MILL (AVERAGE OF LAST 4 PERIODS) 0.733 NET GRAMS OF MINUS 200 MESH

CIRCULATING LOAD (AVERAGE OF LAST 2 PERIODS) 234 PERCENT

RATIO OF REDUCTION IN GRINDING \_\_\_\_\_

## SCREEN ANALYSES

MILL FEED

CIRCULATING LOAD  
AFTER 6 PERIOD

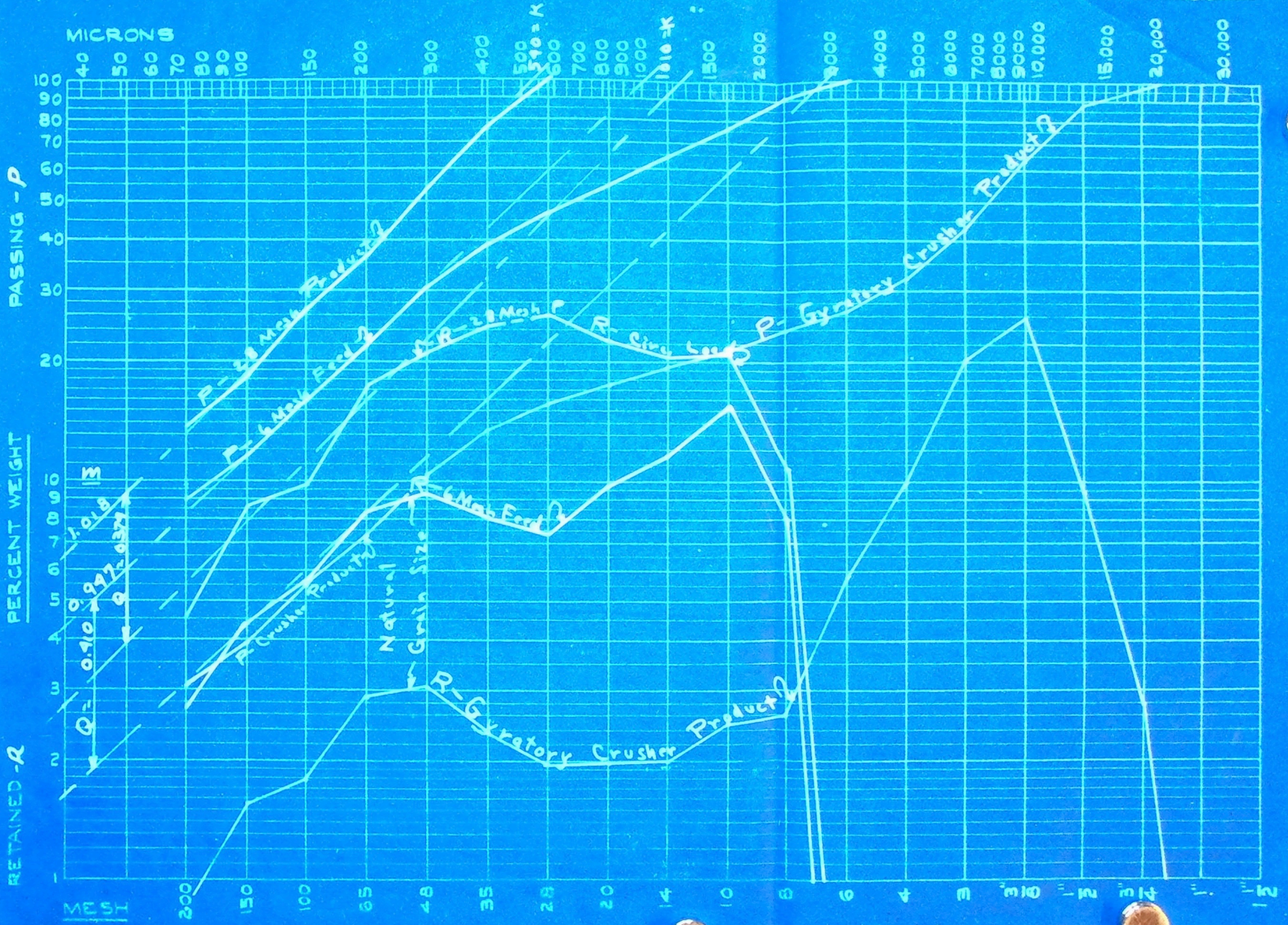
PRODUCT  
AFTER 6 PERIOD

MESH	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE	% WEIGHT	% CUMULATIVE
ON 6	0	0	0	0		
8	8.00	8.00	0.29	0.29		
10	15.50	23.50	0.48	0.77		
14	11.60	35.10	0.38	1.15		
20	9.90	45.00	0.38	1.53		
28	7.40	52.40	0.39	1.92		
35	8.10	60.50	0.48	2.40		
48	9.40	69.90	1.25	3.65		
65	8.40	78.30	5.30	8.95		
100	5.70	84.00	17.14	26.09		
150	4.30	88.30	24.76	50.85		
200	2.70	91.00	49.15	100.00		
THROUGH 200	9.00	100.00				All (-) 200 MESH
TOTAL	100.00		100.00			

TESTED BY M. S. E.

TEST NO. 1000F MATERIAL White Pine Simestone SUBMITTED BY RANGE COOPER CO.

FORM 1948



ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

DATE 6/9/41 BY M.S.E.  
F.C.B.

TEST NO. 1000 F MATERIAL WHITE PINE SANDSTONE SUBMITTED BY COPPER RANGE CO.

-35 MESH

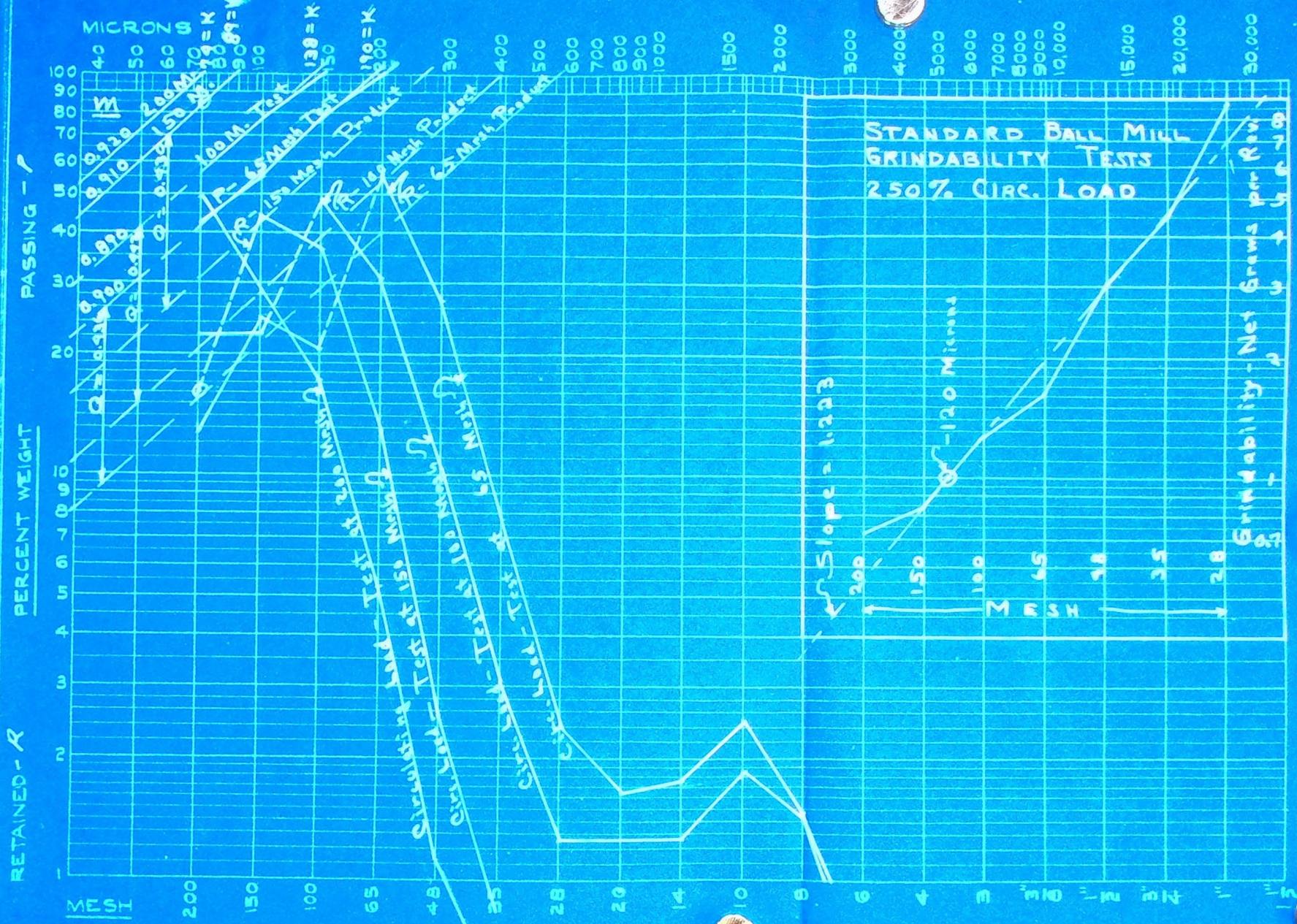


ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

DATE 6/11/41 BY M.S.E.  
F.C. 13.



TEST NO. 1000F MATERIAL WHITE PINE SANDSTONE SUBMITTED BY COPPER RANGE CO.



AUG 11 1941

COPPER RANGE COMPANY

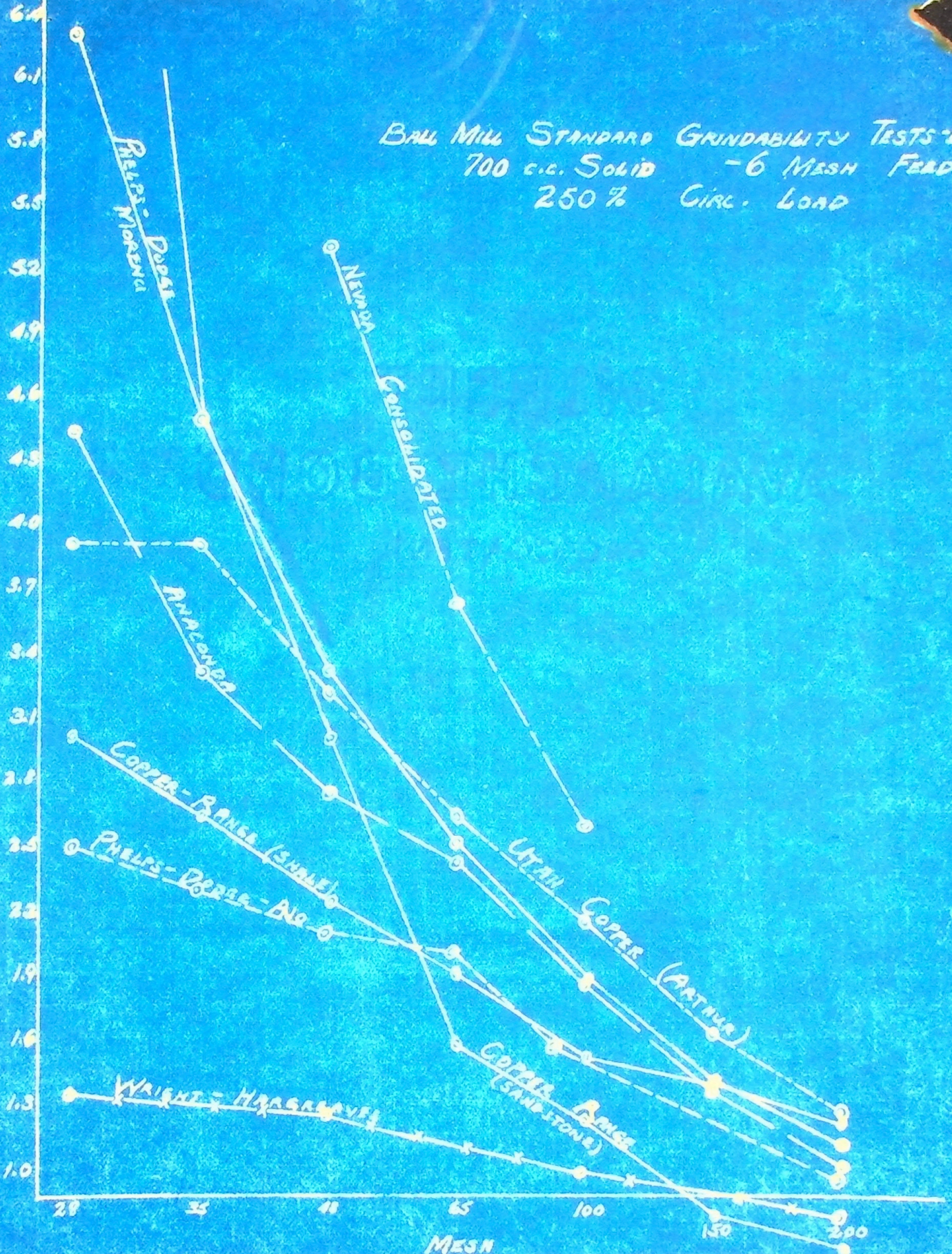
<u>inches</u>	<u>mesh</u>	<u>White Pine</u>		<u>Champion</u>	
		<u>1/2</u>	<u>1/2 Cum.</u>	<u>1/2</u>	<u>% Conv</u>
.263	1/2	6.85		11.8	11.8
.185	4	7.82	14.67	10.8	22.6
.131	6	7.82	22.49	11.0	33.6
.093	8	8.08	30.57	9.5	43.1
.065	10	7.95	38.52	8.2	51.3
.046	14	6.3	44.82	6.3	57.6
.0328	20	6.04	50.86	5.6	63.2
.0232	28	4.8	55.66	4.1	67.3
.0164	35	7.0	62.66	4.1	71.4
.0116	48	8.5	71.16	4.66	76.06
.0082	65	10.7	81.86	5.77	81.83
.0058	100	6.72	88.58	3.34	85.17
.0041	150	1.51	90.09	2.75	87.92
.0029	200	2.74	92.83	2.23	90.15
thru .0029	200	7.27	100.00	7.85	98.5
				Add { 2.00 }	
					100.00

COPPER RANGE CO.  
W. H. SCHACHT, PRESIDENT  
**RECEIVED**  
AUG 15 1941  
Ans'd .....  
Filed .....  
Copies .....

*Return to Customer*

BALL MILL STANDARD GRINDABILITY TESTS - DAY  
 700 c.c. SOLID - 6 MESH FEED  
 250% GIRL. LOAD

Grindability - Net Grams Per Revolution

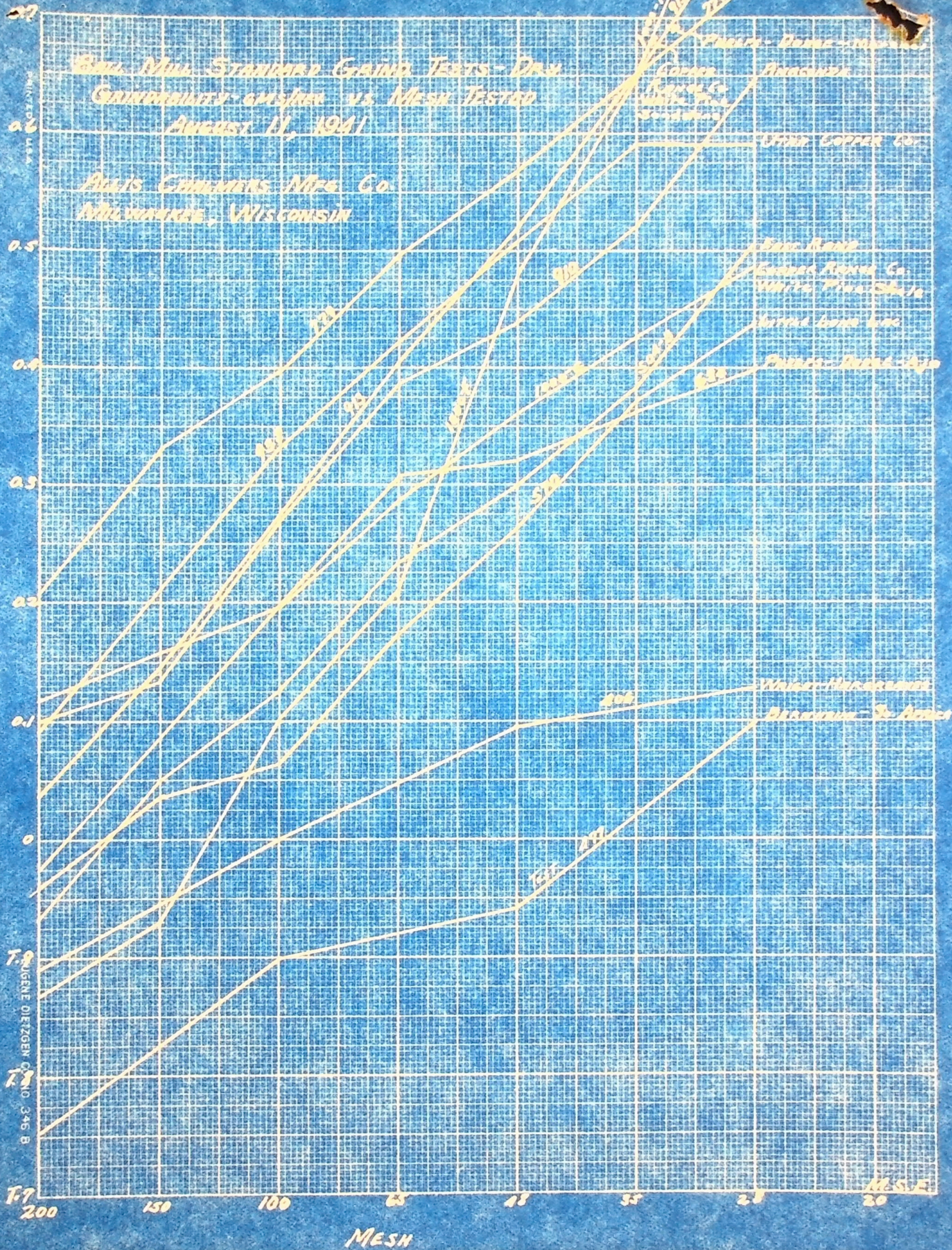


ALLIS-CHALMERS MFG. CO.  
 MILWAUKEE, WIS., U. S. A.  
 MINING DEPT.  
 DRAWN \_\_\_\_\_ DATE 5/14/41

GRINDABILITY  
 CURVES

SCALE \_\_\_\_\_ 1/2"

Loss Coefficient - gms. per sq. foot



Steel Mesh (Standard Growth Tests - Day)  
Loss Coefficient vs. Mesh (ASTM)  
August 11, 1941

Acids (Various)  
Loss Coefficient vs. Mesh

EAST MARTIN

Loss Coefficient vs. Mesh

Loss Coefficient vs. Mesh

Loss Coefficient vs. Mesh

Loss Coefficient vs. Mesh

Loss Coefficient vs. Mesh

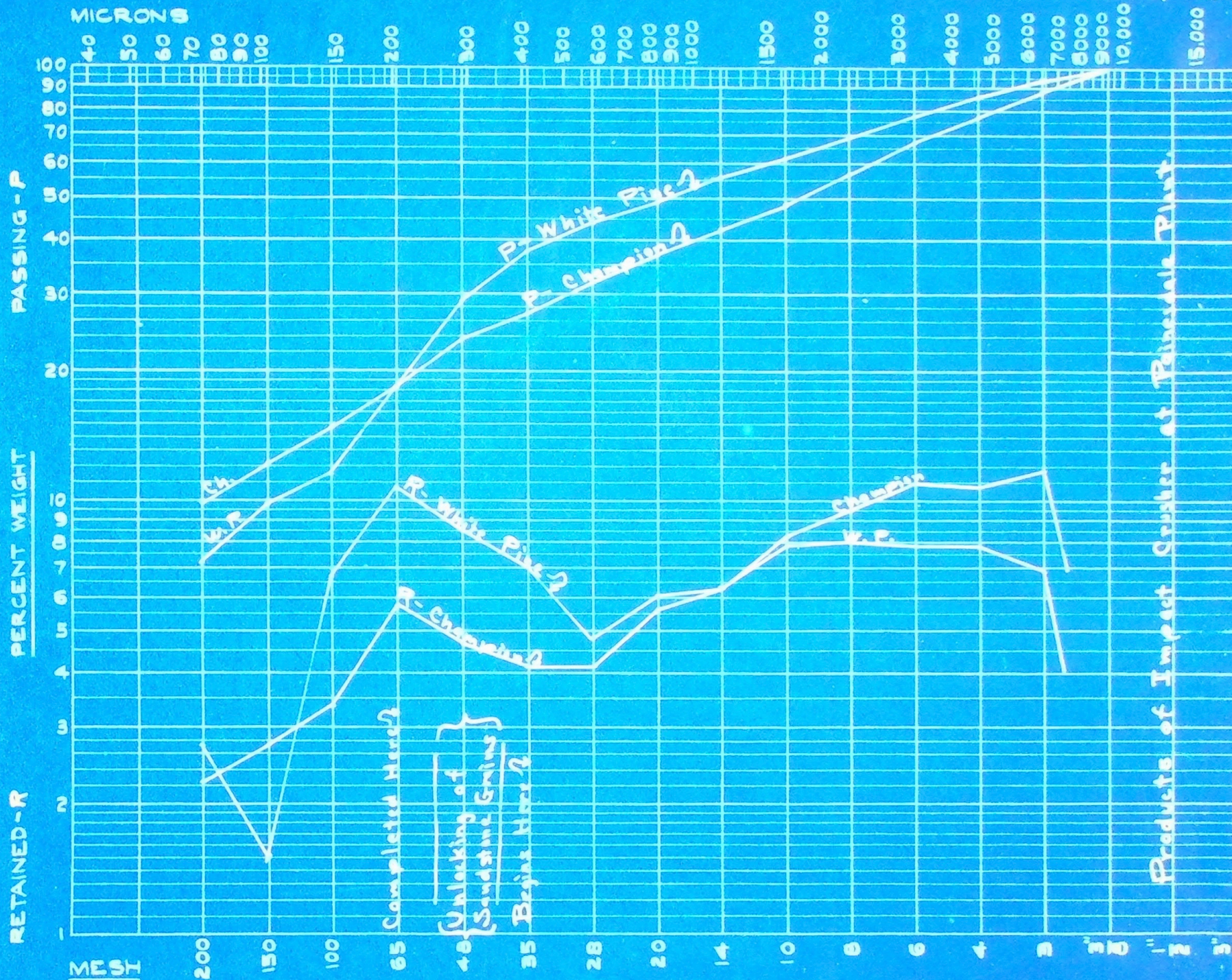
Loss Coefficient vs. Mesh

M.S.E.

TEST NO. 1000

MATERIAL Copper Ore

SUBMITTED BY Copper Range  
Painesdale, Mich



ALLIS-CHALMERS MFG. CO., MILWAUKEE, WIS.

DATE Aug. 11, 1941 BY \_\_\_\_\_