FINAL REPORT

FOR

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

MOA NO. 14-09-0070-1260

MAGNETIC BELT COBBING TECHNOLOGY FOR UPGRADING COARSE TACONITE ORE

U.S. BUREAU OF MINES

TWIN CITIES RESEARCH CENTER

MINNEAPOLIS, MINNESOTA 55417

IN COOPERATION WITH

INLAND STEEL MINING COMPANY

MINORCA MINE

VIRGINIA, MINNESOTA 55792

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FINAL REPORT

on

MAGNETIC BELT COBBING TECHNOLOGY FOR UPGRADING COARSE TACONITE ORE

to

MINNESOTA DEPARTMENT OF NATURAL RESOURCES

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by

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Section I

SUMMARY

A magnetic belt cobbing test program was conducted at Inland Steel Mining Company's Minorca mine, Virginia, Minnesota, during the summer of 1986. Cooperators in the program included the State of Minnesota, Department of Natural Resources-Minerals, the Inland Steel Mining Company, and the U.S. Bureau of Mines, Twin Cities Research Center.

A small production scale (permanent magnet) dry belt cobber with ancillary materials handling equipment was erected at Inland Steel Mining Company's Minorca mine. Sixty-seven field tests were conducted on three ore types, ranging from 10 to 24 pct magnetic iron and at two different ore sizes, namely the secondary crusher discharge (3 x 0 inches) and tertiary crusher discharge (1 x 0 inches). Samples of feed, concentrate, and reject from each test run were collected and transported to the Twin Cities Research Center for laboratory studies. It was determined that only the 12 best field tests would be analyzed in detail.

Table 1 summarizes the test parameters considered during the testing phase of the cobbing research program.

TABLE 1. - Parameters associated with field cobbing tests

Parameter	Value
Belt magnetic field strength, fixed....	980 gauss
Belt speed............................	100-400 FPM
Belt splitter position................	50-100 pct
Belt loading..........................	1-4 inches
Ore types.............................	3-(10-24 pct MagFe)
Ore size..............................	2-(3 x 0 inches; 1 x 0 inch)
Field test weight.....................	10-30 ton/run

The parameters for the 12 tests analyzed included a single belt speed of 197 feet/minute, two feed sizes (tertiary feed - 1 x 0 inches, and secondary crusher feed - 3 x 0 inches), a belt bed depth of 2 inches for tertiary feed stock and 3.5 inches for secondary crusher feed stock, cobber splitter positions of 50 pct and 100 pct, magnetic iron contents ranging from 10 to 21 pct, and a single magnetic field strength of 980 gauss, as measured at a distance of 2 inches from the face of the permanent magnet.

The most favorable test results for the three taconite types are summarized in table 2. Field cobbing of the test materials produced an enriched iron ore concentrate and a low-grade reject material. Successful ore separation and enrichment occurred with both tertiary and secondary crusher feed stocks. Certain material types currently considered to be uneconomic, were upgraded using the dry magnetic cobbing process to produce a millable ore concentrate. Best magnetic iron recoveries after cobbing ranged from approximately 78 to 95 pct for the tertiary feed and 50 to 95 pct for the secondary crusher feed. The tests indicate that the lean-grade ore types (LC2 and LC5) lend themselves to dry magnetic cobbing, producing an enriched concentrate with noticeable upgrading. Additionally, the coarser size of those lean ore types produced the higher grade magnetic iron. The higher-grade LC4, ore type, (current plant feed) compared less favorably.

Bond grindability work indices were determined for the 12 selected cobbing field tests. Work index values obtained from the taconite products ranged from 11 KWh/ton for the cobber concentrates to 15 KWh/ton for the reject material. These data suggest that crushing and grinding energy consumption costs could be reduced by rejecting the low-grade

TABLE 2. --Dry cobbing test results[1]

Ore type	Cobber feed,		Cobber concentrate			Cobber tails		
	Mag Fe, pct	Wi, kWh/ton	Mag Fe, pct	Mag Fe rec., pct	Wi, kWh/ton	Mag Fe, pct	Wt. rejected, pct	Wi, kWh/ton
Fine (1 in x 0 in):								
LC4................	21.3	12.19	23.4	94.4	11.50	10.0	12.4	13.10
LC2................	13.5	12.44	16.2	95.4	12.03	4.5	14.4	13.28
LC5................	12.9	11.63	14.5	78.4	12.55	3.6	52.8	13.33
Coarse (3 in x 0 in):								
LC4................	19.1	12.15	22.1	95.2	11.32	7.0	13.6	14.03
LC2................	17.1	13.15	21.8	92.7	12.27	5.0	25.6	14.89
LC5................	10.9	11.26	22.0	89.8	11.98	3.8	39.1	13.22

[1]Data calculated from analysis on compostie samples (see table 6).

(lean) material at the coarsest size possible. These savings, however, would be offset to the extent of extra costs incurred in mining an additional amount of crude ore to balance out lost iron units in the reject material.

None of the analyzed tests, under the conditions tested, yielded a product with a magnetic iron content and a weight recovery which would be acceptable feed to the current Minorca mill flowscheme. Major modification to the mill flowsheet would be necessary in order to accept the dry cobbed concentrate. Addtional testing under more optimum operating conditions is warranted to prove out the validity of incorporating dry cobbing technology into mining of lean-grade taconite ore.

Section II

INTRODUCTION

The Bureau of Mines (BOM), the Inland Steel Mining Company (ISMC), and the Minnesota Department of Natural Resources (MDNR) cooperated in a research project to investigate dry magnetic belt cobbing technology as a method for upgrading coarse taconite ore. The goal of this cooperative research effort was to improve the economics of taconite mining and processing through removal of the leaner grade and/or contaminated ore fraction at the coarsest size possible early in the processing flowsheet and provide an increased mill feed grade.

The cobbing test program was conducted at ISMC's Minorca mine, Virginia, Minnesota, during the summer of 1986. All tests were conducted at the same field strength (approximately 980 gauss) using a permanent magnetic head pulley. The specific objectives of the project were to:

1. Determine the amount of material (percent) that could be rejected prior to grinding and the quality of the products (magnetic iron content, grindability, etc.).
2. Determine the size at which iron range taconite could be dry cobbed effectively.
3. Determine whether different geological horizons in the mine would react differently, and if so, to quantify the differences.

A fourth objective was to duplicate the above tests at different magnetic field strengths, through the use of an electromagnetic head pulley, however, sufficient project funds were not available to purchase the electromagnetic head pulley at this time.

The cobbing project consisted of the four main tasks listed below.

- Assembling the cobbing unit at the test site.
- Running the ore types over the cobber and optimizing the unit.
- Conducting laboratory studies on various feed, concentrate and tailing samples from the testing indicated above.
- Reporting test results by the BOM and ISMC to the MDNR.

ISMC provided the necessary equipment, materials, and personnel to erect and operate the cobbing facility at their Minorca mine. Tonnage quantities of taconite ore from three Minorca pit locations (magnetic iron content ranging from 10 to 24 pct), at two different sizes, one representative of the secondary crusher discharge and one representative of the tertiary crusher discharge (rod mill feed) were evaluated in the program. ISMC was responsible for weighing the cobber field products and providing representative samples to the BOM for the laboratory studies. The Bureau's laboratory investigation included (1) chemical and sizing analyses, (2) bond grindability (work index) determination, and (3) grinding/liberation and magnetic iron recovery on selected cobber feed, concentrate, and reject products. The task schedule and cooperator's contributions for the cobber program are shown in figure 1.

The research, if successful, would make available to the taconite industry a relatively coarse size separation technique which should not only provide savings in grinding energy and media consumption, but also extend existing mine reserves and reduce fine tailing disposal and related environmental problems. A system of coarse ore separation, i.e., 4 to 6 inches at the mines face, via in-pit crushing, sorting, and

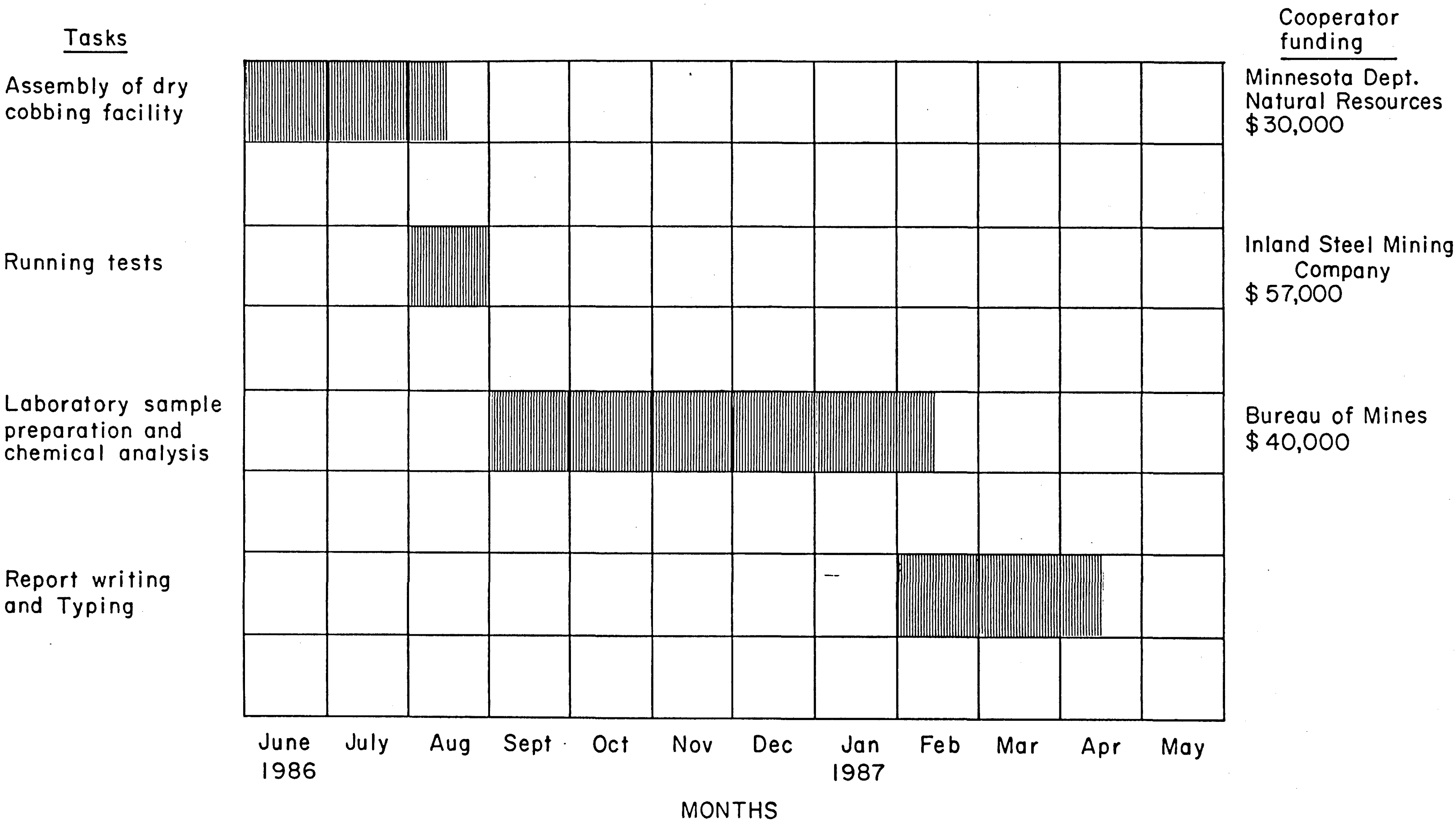

FIGURE 1. - Task schedule and cost sharing of dry cobbing program

conveying could provide additional savings in crushing, haulage, and ore blending costs by removing the leaner-grade portion of the run-of-mine ore before reaching the mill.

Section III

TEST PROGRAM

Test Site and Equipment

The location of the dry cobber test facility is shown in figure 2. Associated equipment and buildings are labeled. The dry cobbing unit was set up at the south end of the fine ore pile. Power for the unit was run via an underground cable from the primary crusher.

The equipment used in the dry cobbing project is described below.

1. Dry cobber:
   a. Forty-eight-inch-wide feed conveyor complete with 15 hp drive motor, idlers, and bearings.
   b. Thirty-six-inch-diameter by 48-inch "Dings" DFC permanent magnetic pulley with approximate field strength of 900 gauss.
   c. Two thirty-inch-wide transfer conveyors complete with 5 hp motors, idlers, and bearings.
   d. Feed hopper, chutes, and auxiliary equipment for the operating unit.
2. Ancillary equipment consisting of various sized loaders at Minorca to feed the cobber and handle the products.

During the period May 15-July 15, ISMC personnel reassembled the dry cobbing unit with minimal alterations to the original equipment design previously used by the Jackson County Iron Company (JCIC), original owners of the unit. The ore types to be used for testing were stockpiled during this time period as they became available. A view of the dry cobbing facility and ore stockpiles at the Minorca mine is shown in figure 3.

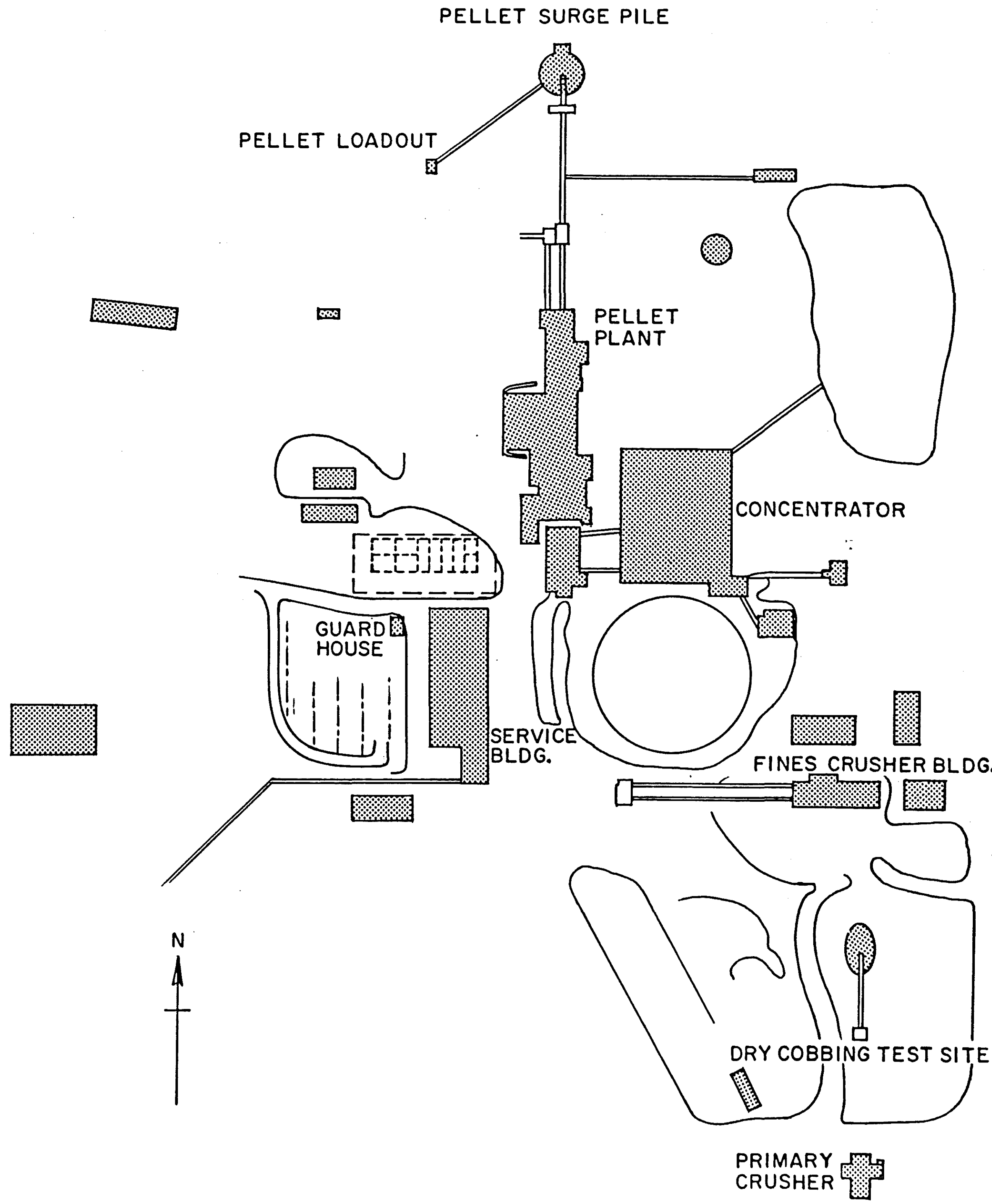

FIGURE 2. - Map of the Minorca plant showing location of dry cobbing test site

FIGURE 3. - Aerial photograph of dry cobbing test facility (Minorca mine, Virginia, Minnesota)

Test Material

Three Inland Steel ore types were tested to discern the dry magnetic cobbing recovery of the magnetic iron ore. Material from other mining taconite operations was not evaluated in the program at this time, consequently, no comparable data are presented for the various range taconite ore types.

The three ore types were sampled, collected, and stockpiled (each at two different feed sizes) for field testing. The ore types included the lower cherty two (LC-2) horizon of the Biwabik Iron Formation, a combination of the lower cherty three and lower cherty four (LC-3/4) horizons of the Biwabik Iron Formation, and the lower cherty five (LC-5) horizon. Feed size consisted of (1) a secondary crusher discharge designated as a coarse ore with a size consist of 3 inch x 0 inch with the majority of the material +1 inch in size, and (2) a tertiary crusher discharge designated as a fine ore (rod mill feed) with a size consist of 1 inch x 0 inch with the majority of the material -1/2 inch.

The top of the LC-2 horizon defines the current pit bottom at the Minorca mine. This is a silicate-rich horizon that varies in magnetic iron between 0-16 pct. The top 15 to 20 feet are classified as lean taconite containing 10-16 pct magnetic iron. The silicates are found in distinct bands and contained little or no disseminated magnetite.

The LC-3 and LC-4 were blended together as one homogenous sample. This is the current Inland Steel feed to the concentrator. Most other taconite companies mine these two in conjunction with each other. These tests should be relevant to other companies as well.

The LC-5 horizon forms an oxidized cap over the underlying material of the Biwabik Iron Formation in the Minorca pit. Some of this material is classified as lean taconite and appears to be a good candidate for upgrading by dry cobbing. Average analysis of the three test samples are summarized in table 3.

Minorca crushed approximately 1,000 tons of each ore type to provide samples of two size consists. The samples were stockpiled near the cobber site on the south end of the fine ore stockpile (see figure 4). The LC-3/4 tertiary crusher discharge sample was taken off Minorca's existing ore stockpile. Prior to crushing the LC-2 and LC-5 ore types, the primary crusher surge pile was drawn down. Several truckloads of material from the pit supplied the 1,000-ton samples needed.

Test Parameters

Test parameters included the feed rate, belt bed depth, cobber discharge splitter position, magnetic iron content, feed size consist, and magnetic field strength. These parameters were varied where equipment design permitted.

Belt Speed

Only two conveyor belt speeds, i.e., 197 feet per minute and 320 feet per minute were available for setting the cobber feed rate. All tests were conducted at these two belt speeds.

Bed Depth

The belt bed depth was limited to a maximum of 4 inches and a minimum of 1 inch. A sliding plate at the hopper discharge and a "v" plow (see figure 5) were set to the desired thickness. Attempts were made to run feed material at different bed depths (1-4 inches). Most tests failed due to the hopper frame construction design constraints of the cobbing

FIGURE 4. - Dry cobber test facility with coarse ore at left foreground and fine ore at right foreground

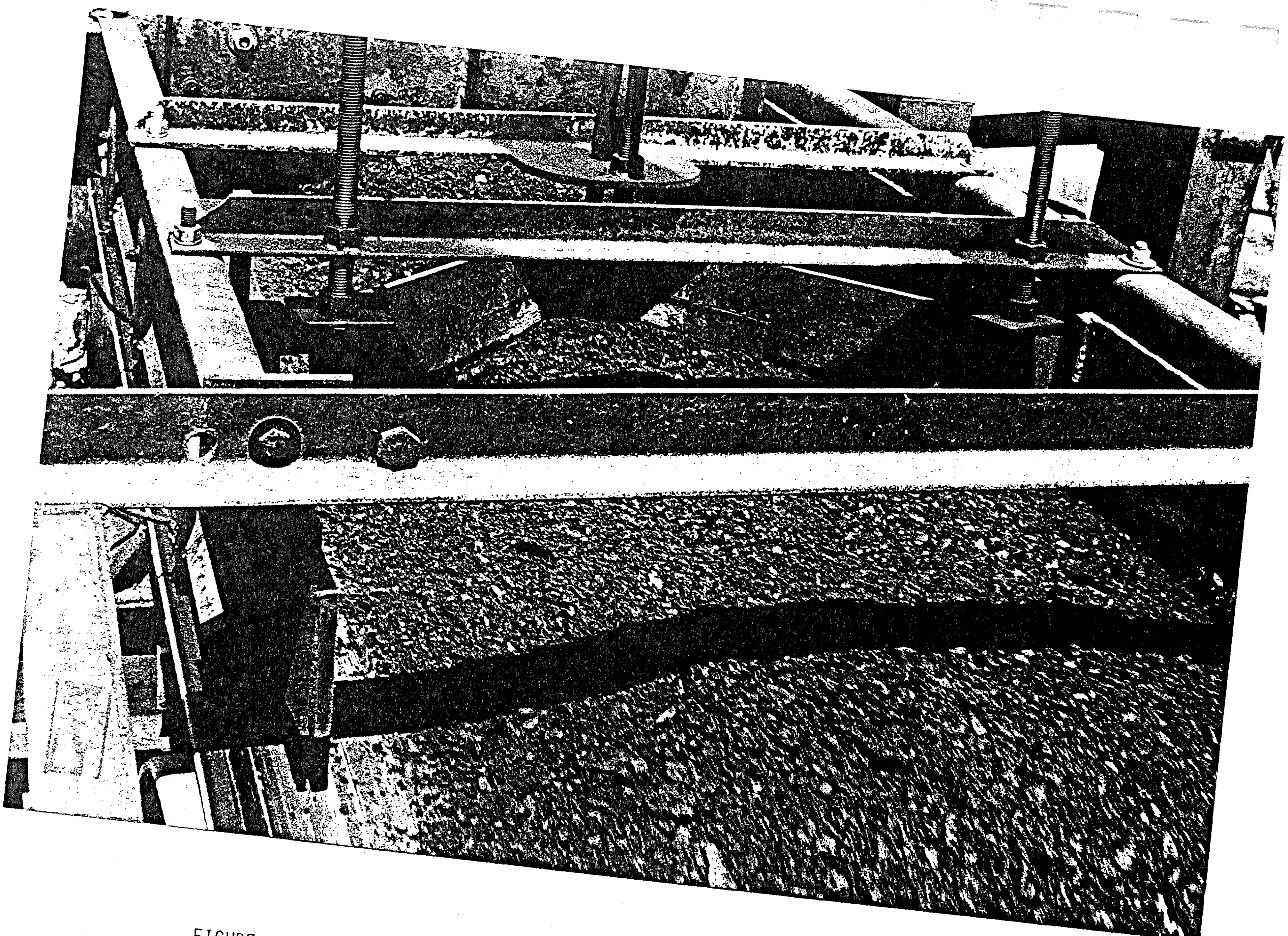

FIGURE 5. - Material distribution onto feed conveyor belt during a test run.

test apparatus. The belt bed depth for the analyzed tests measured 2 inches for the fine ore and 3.5 inches for the coarse ore. Since bed depth was impacted by feed conveyor belt speed, only one bed depth per each composite ore size was possible.

Splitter Position

The cobber discharge splitter position was recorded as a percentage of the maximum distance (8 inches) away from the magnetic pulley face. Three opening positions identified as 25 pct, 50 pct, and 100 pct of maximum opening were tested. More feed material is naturally directed to the concentrate portion as the splitter opening is increased. Hand operated (see figure 6), the splitter deflector plate helps to improve and maintain a clean separation between the two cobbing products. This plate (see figure 7), which can come within inches of the belt, is located below the magnetic pulley at a point close to where the belt is leaving the pulley. The splitter opening consequently aids the magnetic separation of iron ore and increases the magnetic iron recovery by controlling the amount of feed material which is ultimately directed to the concentrate pile.

Magnetic Iron Content

The three ore types tested provided a span of values ranging from 11 pct to 22 pct in magnetic iron content. The present cutoff grade at the Minorca mine is 16 pct magnetic iron.

Size Consist

Size consist of the cobber feed was limited to the secondary crusher discharge (3 inches x 0 inches) and the tertiary crusher discarge (1 inch x 0 inches).

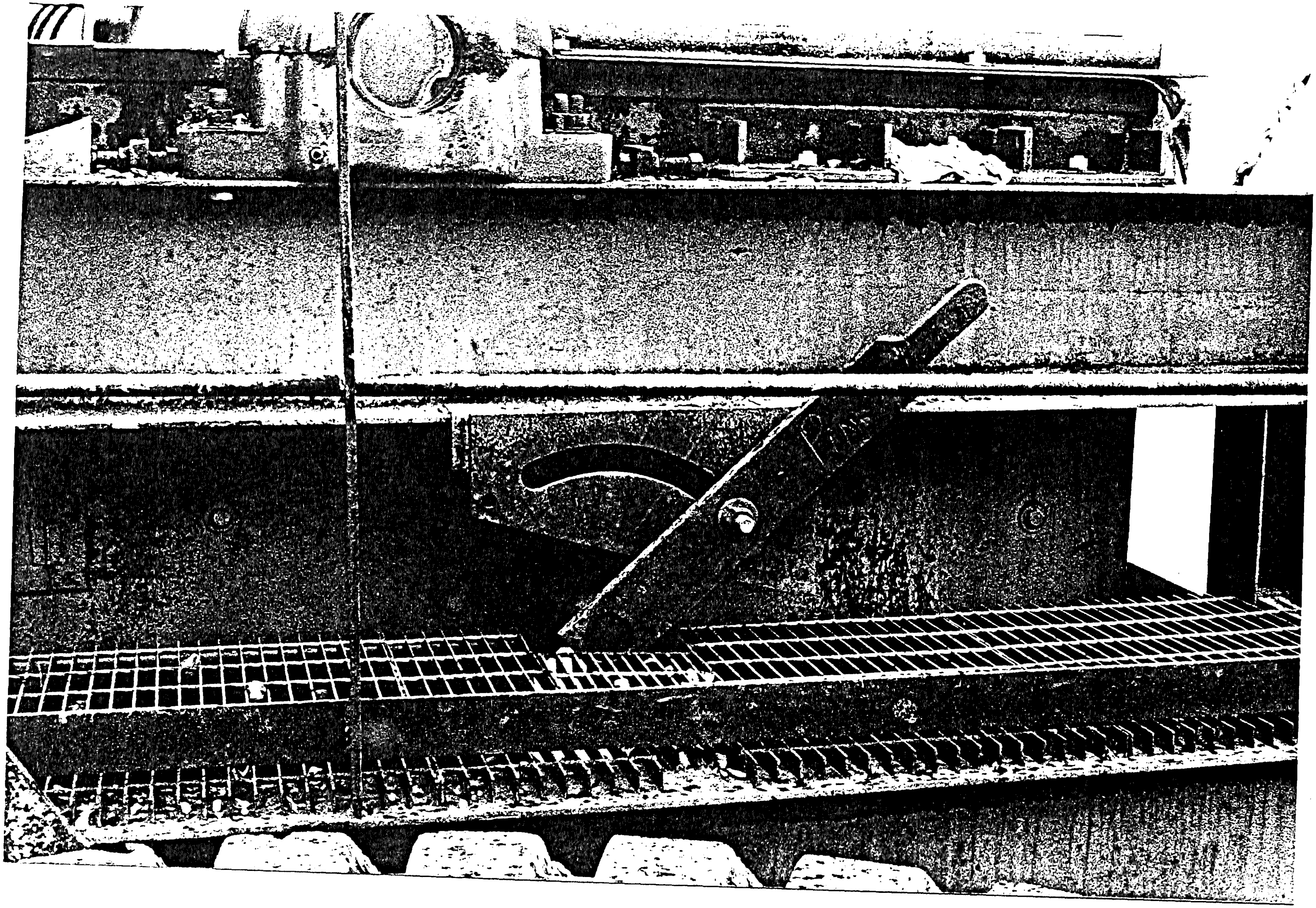

FIGURE 6. - Hand operated mechanical lever used to adjust splitter opening plate

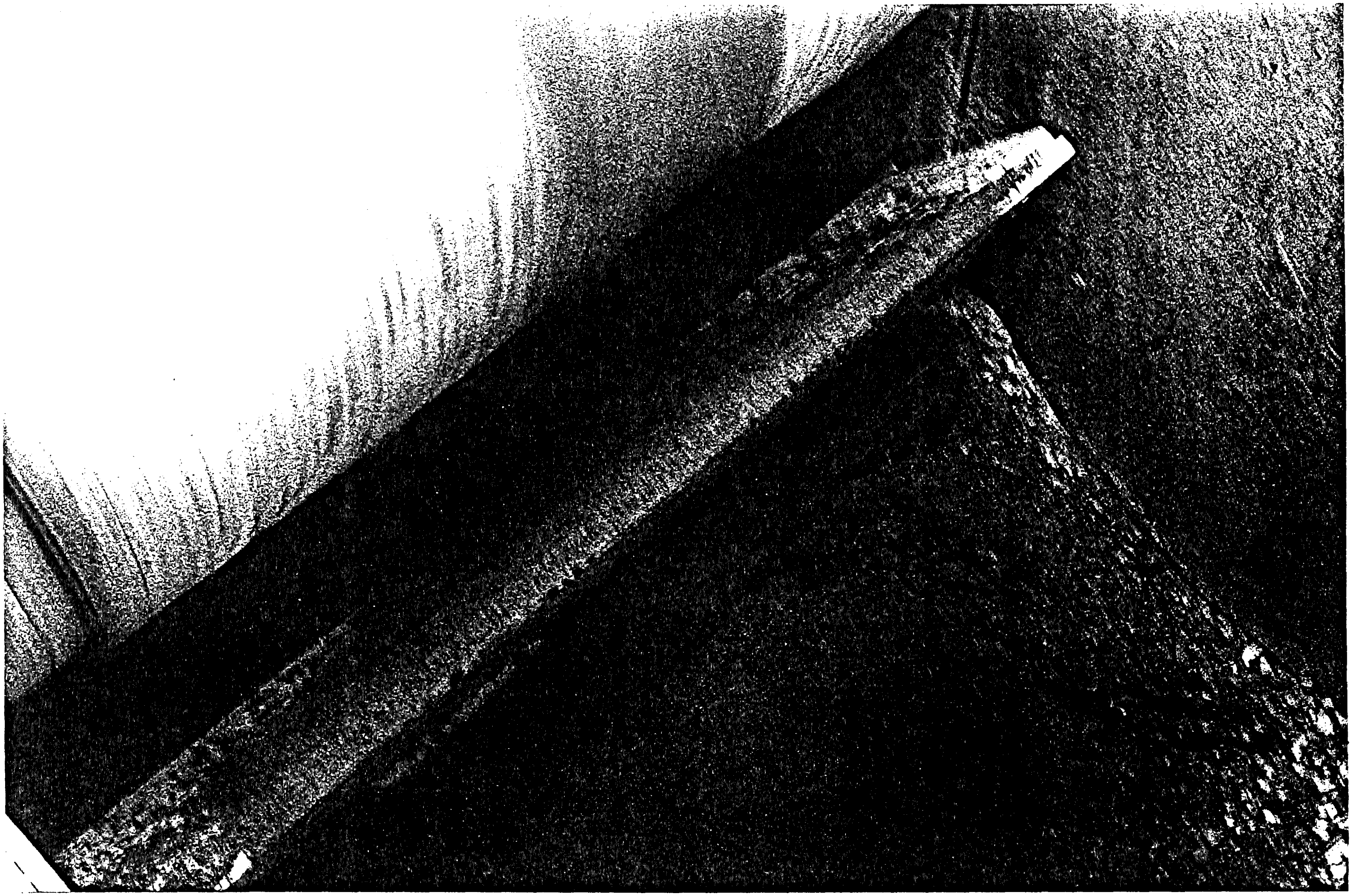

FIGURE 7. - Splitter plate adjacent to Dings magnetic head pulley shown in the 100 pct opening position

Magnetic Field Strength

Since budgetary constraints did not permit major modification to the original cobber design, i.e., the installation of an electromagnetic head pulley, the magnetic strength of the cobber was a single maximum value of approximately 980 gauss for all field tests.

The unit of measure of magnetic field intensity or magnetic flux density is the gauss. This is the measurement of the number of magnetic lines of force present in a 1^2-centimeter area within the field of the magnet. Since field intensity varies with position related to the face of the magnet, the gauss rating method of evaluating magnetic strength involves the determination of flux density (gauss) at specific given distances from the face of the magnet (see figure 8).

The force index (FI) is an indication of the force that a magnet can exert on an object in its field. The force index is defined as the magnetic field intensity times its gradient.

$$FI = B \left[\frac{\Delta B}{\Delta \lambda} \right]$$

Where:

FI = Forced index

B = Field intensity (gauss)

$\frac{\Delta B}{\Delta \lambda}$ = Gradient (gauss/inch)

The gradient of a magnetic field is simply the change in gauss from one point to another, divided by the distance between the points (see figure 9). At the maximum magnetic field strength of 980 gauss at a distance of 2 inches from the face of the magnet the force index for this magnetic pulley was 142,100 $gauss^2$/inch.

TABLE 3. - Chemical analysis of Minorca test specimens

Ore type	Head analysis, pct			Davis tube[1]				
				Concentrate, pct				Tailing, pct
	Total Fe	Fe^{+2}	Mag Fe	Weight	Total Fe	SiO_2	Fe recovery	Total Fe
LC2:								
Fine...	31.9	10.0	13.49	19.47	69.3	2.6	43.56	21.7
Coarse.	31.9	10.0	17.07	24.60	69.4	3.2	59.35	15.5
LC3/4:								
Fine...	39.9	10.5	21.34	30.67	69.6	2.8	62.45	18.5
Coarse.	30.4	10.0	19.13	27.40	69.8	3.4	62.97	15.5
LC5:								
Fine...	35.6	7.3	12.95	18.60	69.6	2.4	38.80	25.1
Coarse.	31.0	3.2	10.86	15.60	69.6	3.0	33.80	25.2

[1]600 gram charges ground for 20 minutes in rod mill.

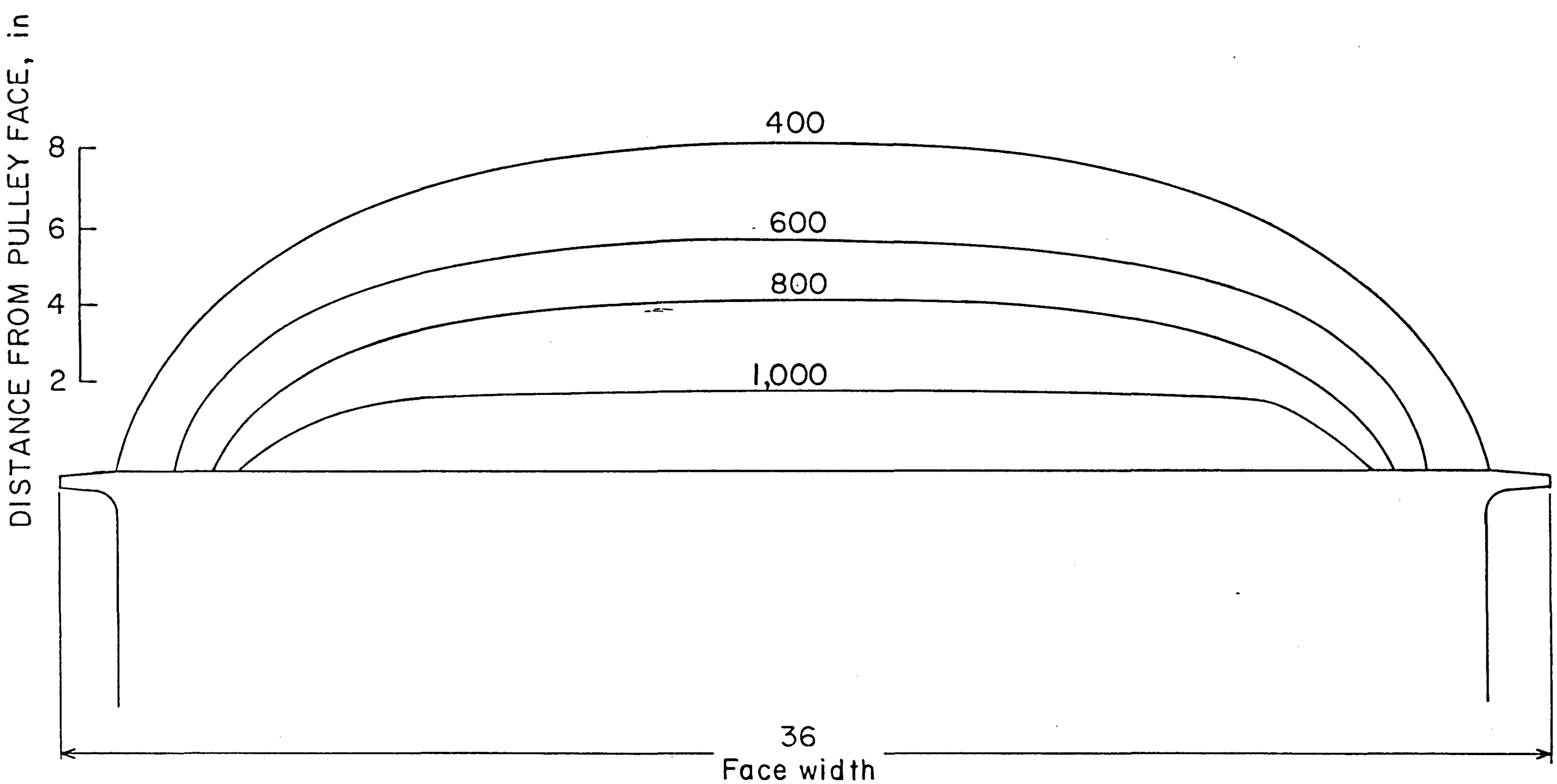

FIGURE 8. - Gauss pattern for 36-inch-diameter DFC pulley

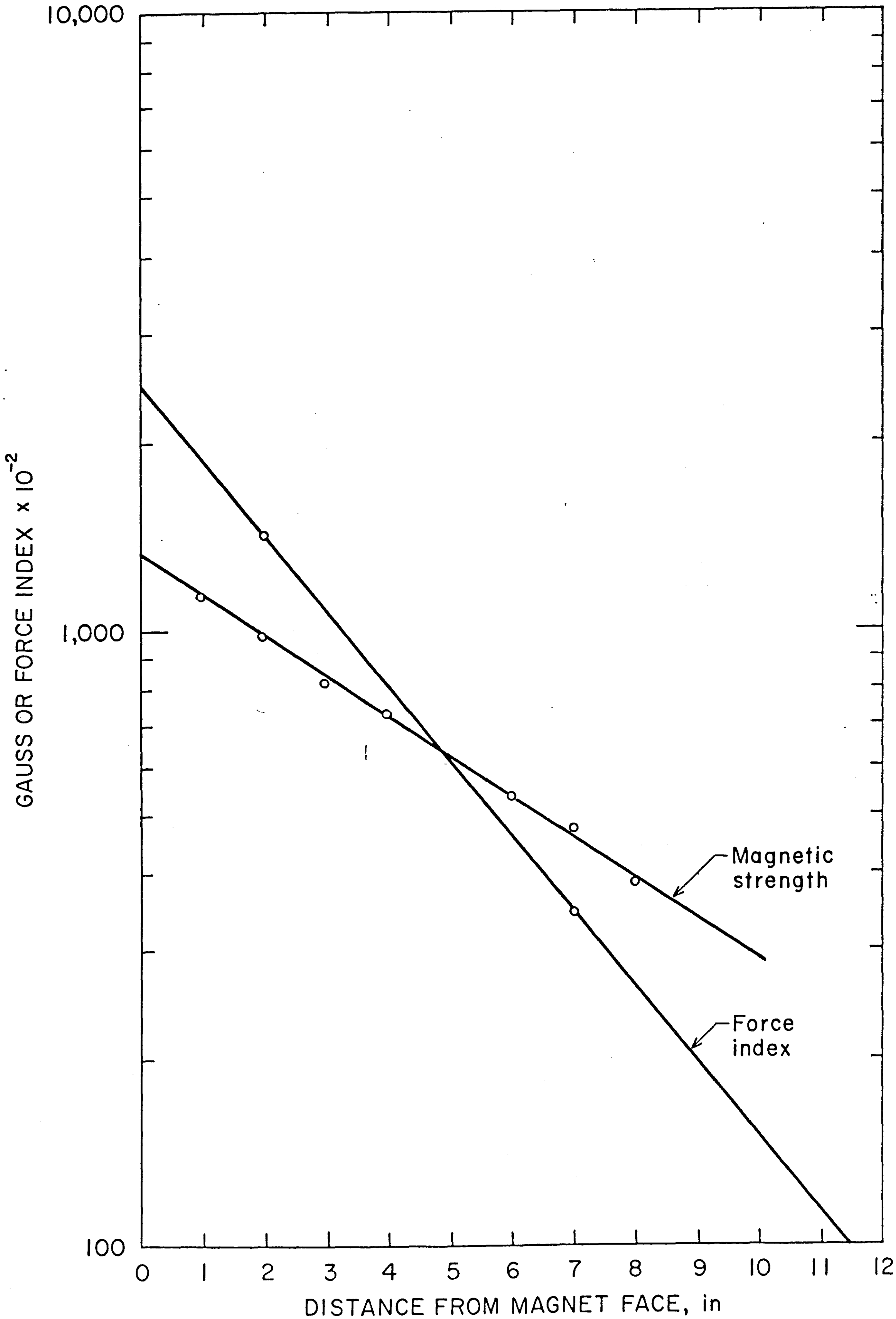

FIGURE 9. - Gauss and force index values for 36-inch-diameter DFC pulley

Field and Laboratory Testing

Bureau and Inland Steel personnel conducted 67 dry magnetic field cobbing iron ore tests during August 1986 (see appendix A). Material from the various feed stockpiles was loaded into the cobber hopper with a front-end loader (see figure 10). Feed material (10-30 tons per test) was fed from a hopper and discharged onto a conveyor which passed over the magnetic head pulley (see diagram figure 11). The dry cobbing test facility successfully separated the feed material into an upgraded magnetic iron concentrate and a waste or reject material containing a low amount of magnetic iron. Figure 12 shows a typical field test separation in progress. After separation the diameter and height of the cobber concentrate and reject conical piles were measured, the volumes determined, and the tonnages calculated using the respective material densities as determined in the laboratory. These weights were used for all material balances.

Homogenous 55-gallon drum samples of each feed stock material were collected by Minorca engineers in advance of planned testing and shipped to the Bureau. Bureau personnel received, mixed, and coned and quartered each ore type and separated out three representative 20-kilogram samples of each for analyses. One 20-kilogram sample was screened, sized, stage crushed, and wet ground to prepare specimens for chemical and magnetic iron analyses. A second 20-kilogram sample was stage crushed and used to determine the bond grindability work index. Composite chemistry was determined from this sample also. The third 20-kilogram sample was stored for future use.

As each cobbing field test was run, four 3-1/2-gallon bucket-size samples were collected from each test concentrate and reject product,

FIGURE 10. - Front-end loader delivering feed material to the dry cobber facility during a test run

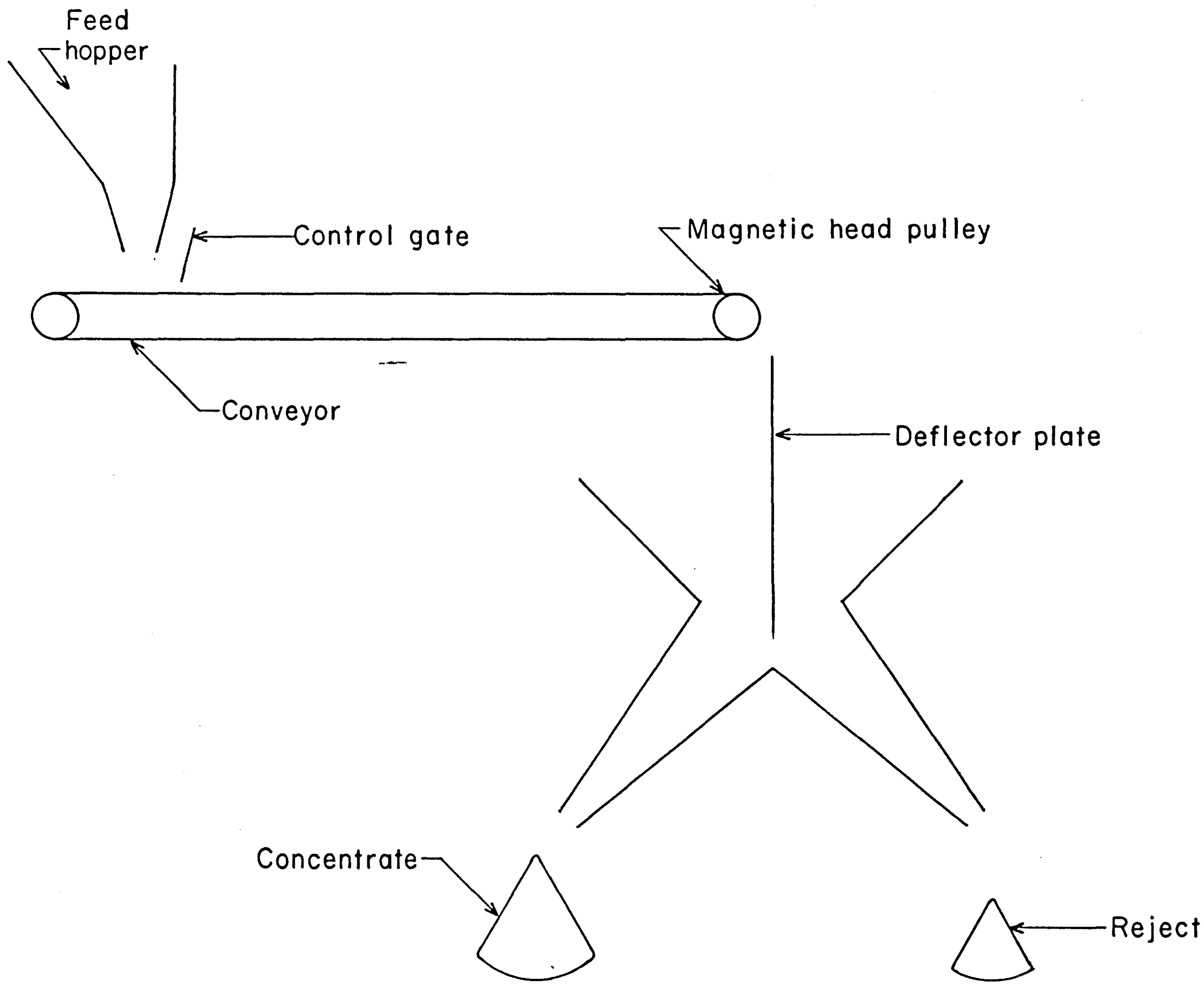

FIGURE 11. - Dry cobbing test flowscheme

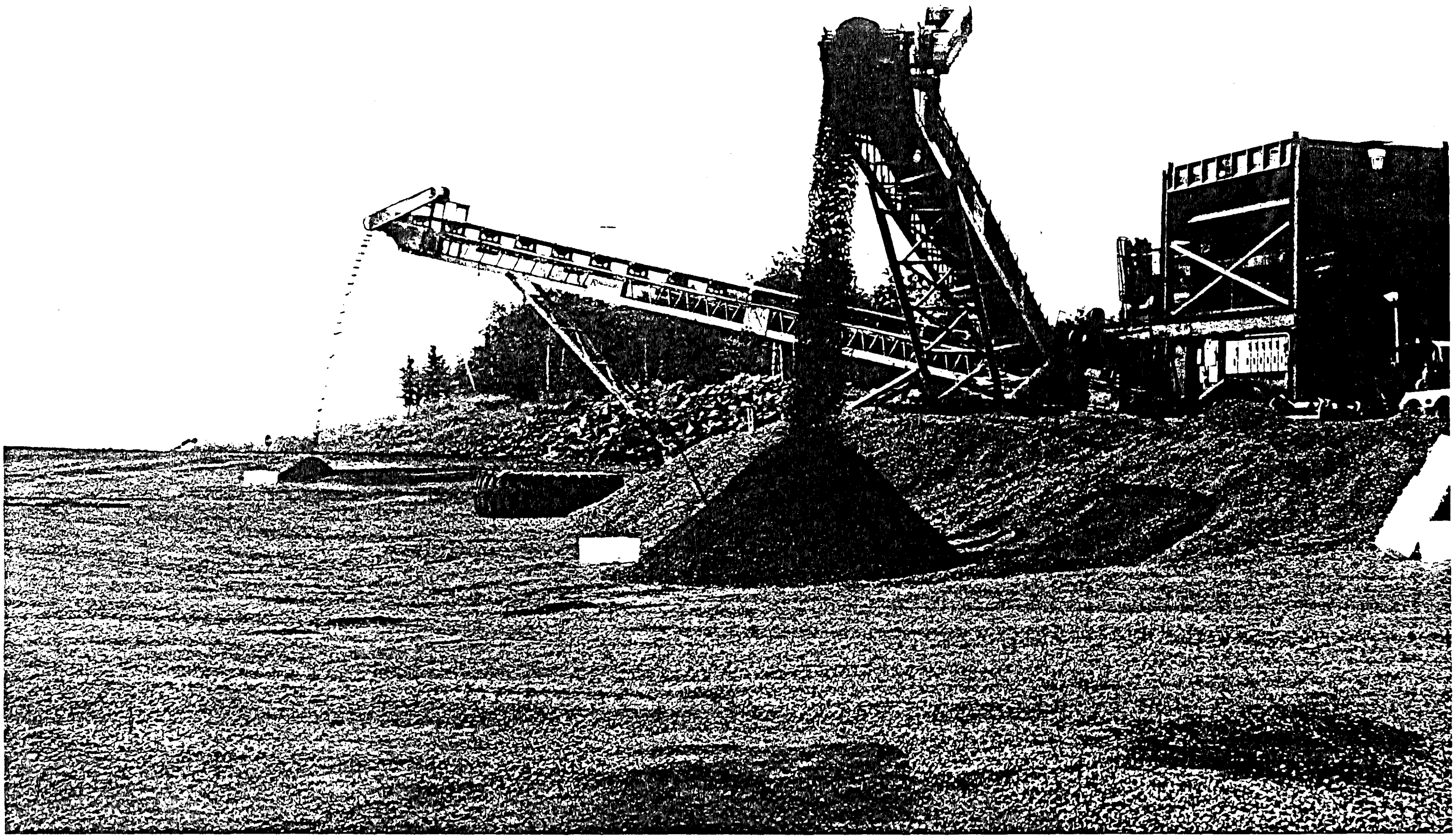

FIGURE 12. - Typical magnetic cobbing field test in progress

with three of these buckets shipped to the Bureau. The fourth bucket was used by Inland Steel lab personnel to determine approximate magnetic iron values using a satmagan. These magnetic iron analyses were run relatively quickly and provided the initial weight and magnetic iron recovery data to optimize the field test conditions. Upon receipt of the test samples, Bureau lab personnel mixed, and coned and quartered each and separated out 3 representative 20-kilogram samples to be treated in the same manner as the head samples. Figure 13 details the lab testing plan for the treatment of the test samples.

The Bureau laboratory investigation included sizing and chemical analyses, bond grindability determinations, rod mill grind liberation, and Davis tube determinations on selected cobber feed, concentrate, and reject products.

To find the point of liberation size and optimum grind time, each charge of the Minorca LC5 fine ore was ground separately for 5, 10, 15, 20, 25, or 30 minutes. Magnetic separation by Davis tube and sizing by Leeds and Nothrup microtrac were made on the ore sample for each of the six grinding times. The effect of grind time on particle (microtrac) sizings and Davis tube grade and iron recovery are presented in table 4. The Davis tube results include analysis and distribution of total iron, ferrous iron, and silica in the magnetic concentrate. The microtrac sizings of the ore include surface area and mean and median particle diameter.

The effect of the grind time on (1) the recovery of weight and total iron and (2) assay of total iron and SiO_2 in the magnetic concentrate from the Davis tube separation are plotted in figure 14. The effect of grind time on mean and median particle diameter and surface area for

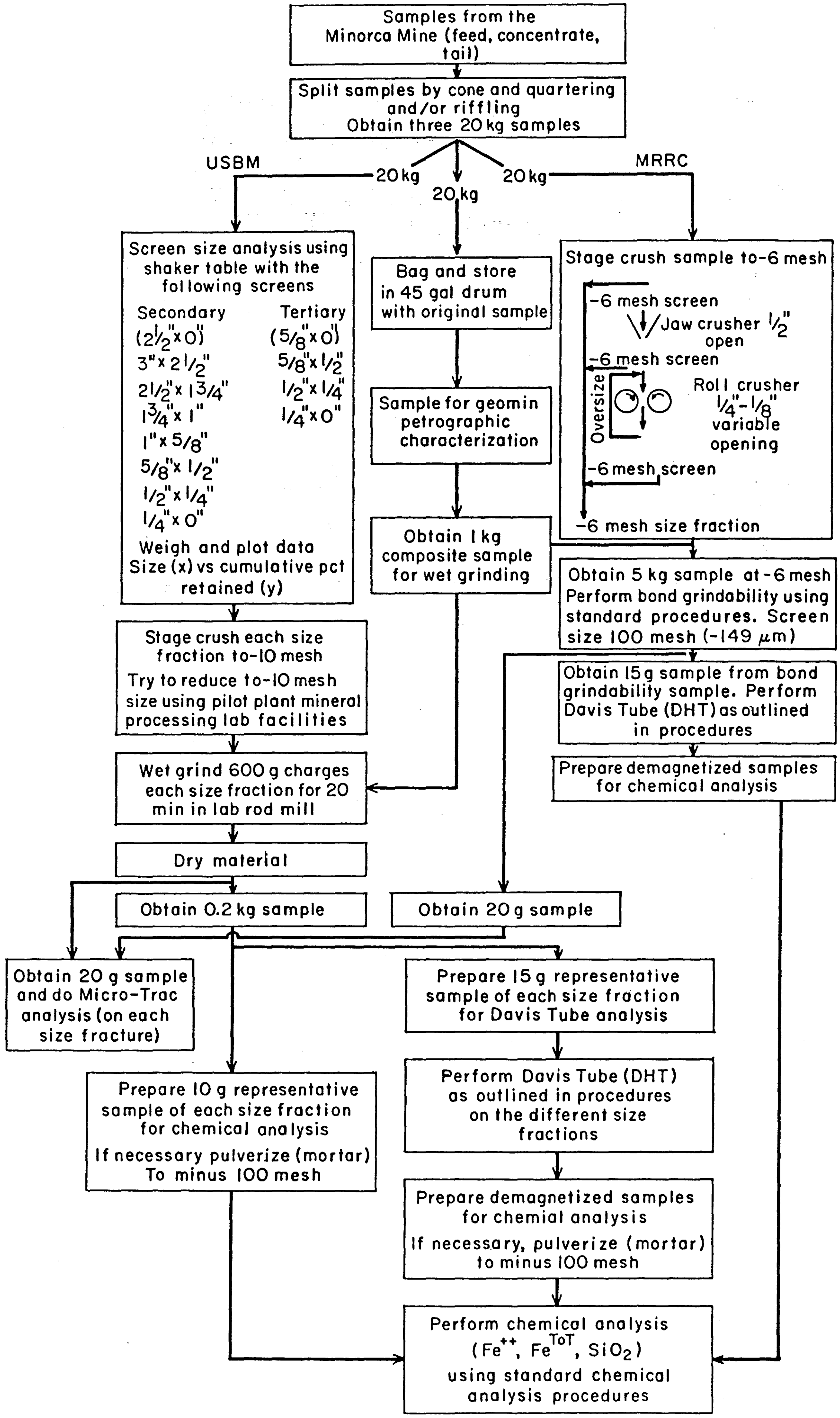

FIGURE 13. - Bureau laboratory testing plan

TABLE 4. - Effect of grinding time on particle size and magnetic Davis tube separation of Minorca LC5-fine taconite ore

Grind time,[1] min	Tube feed				Tube concentrate,[3] pct					Tube tailings, pct				
	Mag Fe, pct	Particle diam,[2] µm		Surface area,[2] cm²/g	Weight rec.	Analyses		Distribution		Weight reject.	Analyses		Distribution	
		Median	Mean			Tot Fe	SiO_2	Tot Fe	SiO_2		Tot Fe	SiO_2	Tot Fe	SiO_2
5.0	14.2	35.0	55.0	1,000	24.6	57.7	15.0	39.8	7.9	75.4	28.5	57.1	60.2	92.1
10.0	13.1	26.8	39.4	1,407	19.7	66.7	6.0	38.6	2.5	80.3	26.0	56.1	61.4	97.5
15.0	12.1	21.2	28.3	1,733	17.5	69.1	2.8	36.3	1.0	82.5	25.8	56.1	63.7	99.0
20.0	12.3	19.4	24.2	1,757	17.6	69.6	1.9	36.8	0.7	82.4	25.6	55.6	63.2	99.3
25.0	12.3	12.6	16.4	2,347	17.5	70.0	1.8	36.4	0.7	82.5	26.0	56.1	63.6	99.3
30.0	12.3	11.7	15.1	2,413	17.4	70.5	1.4	36.7	0.5	82.6	25.6	56.5	63.3	99.5

[1] 600 grams of -10 mesh ore ground in 8 in x 10 in laboratory rod mill at 60 pct solids.
[2] Sizing test conducted with Leeds and Northrup microtrac analyzer.
[3] 15 grams charge of ground material processed in a Davis tube (wet) at 5,000 gauss.

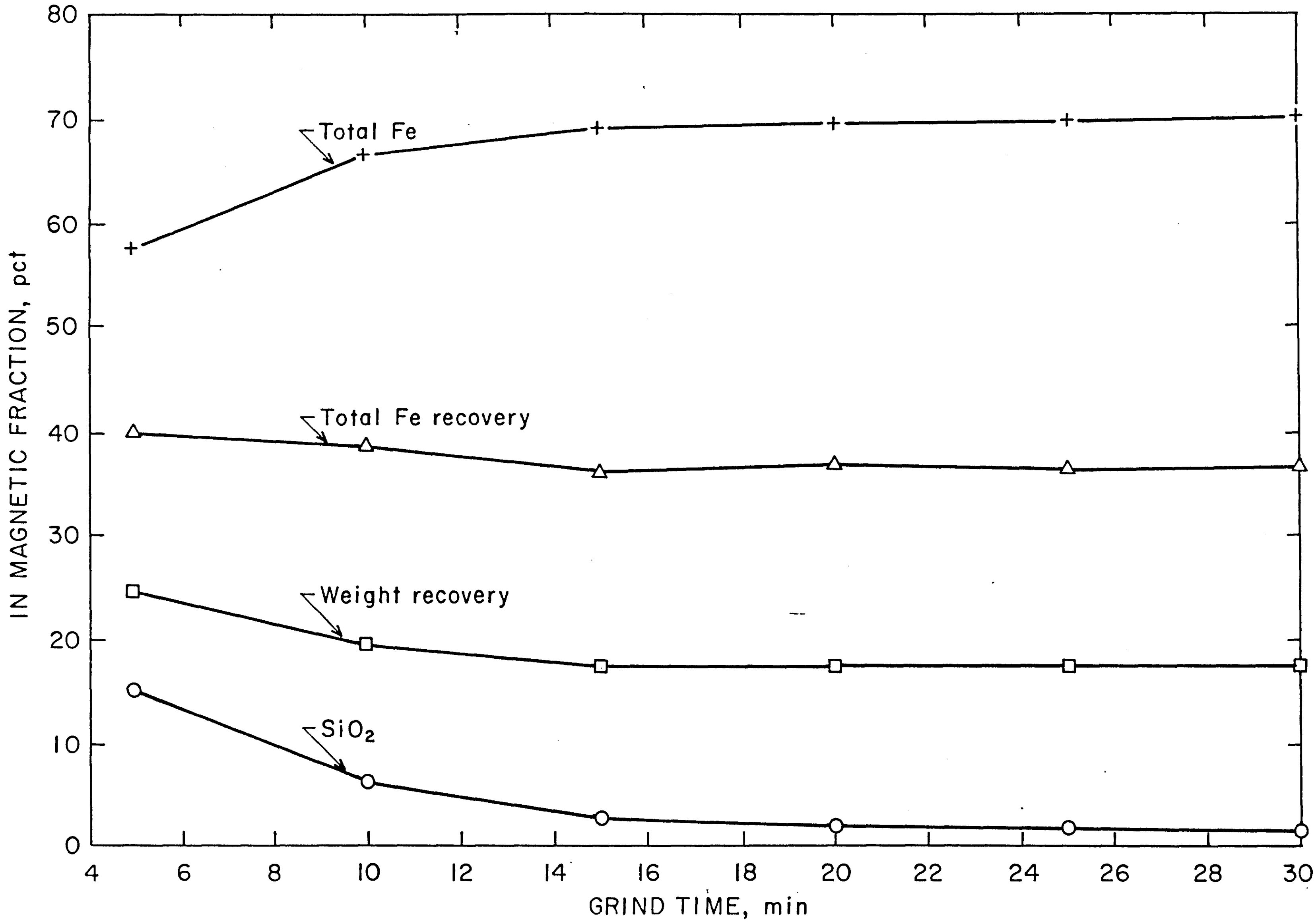

FIGURE 14. - Effect of grind time on magnetic separation by Davis tube of LC5-fine ore with 12.7 pct magnetic Fe

particle size of the ore are plotted in figure 15. A grind time of 12 minutes (25 microns) was required to produce an acceptable grade of 68 pct iron and 5 pct SiO_2 in the magnetic fraction (see figure 14).

As shown in figure 14, extending the grind time produced a higher-grade magnetic concentrate product. The iron grade and recovery begin to level off after about a 20-minute grind, yielding 69.6 pct iron and 1.9 pct SiO_2 in the magnetic fraction. This grind produced a medium particle diameter of 19.4 microns (see figure 15). A 20-minute rod mill grind was used to treat all feed samples in the Davis tube tests.

Chemical analyses included a determination of total and ferrous iron and silica using standard wet chemistry techniques. Davis tube analyses and bond ball mill indices were determined using standard procedures.

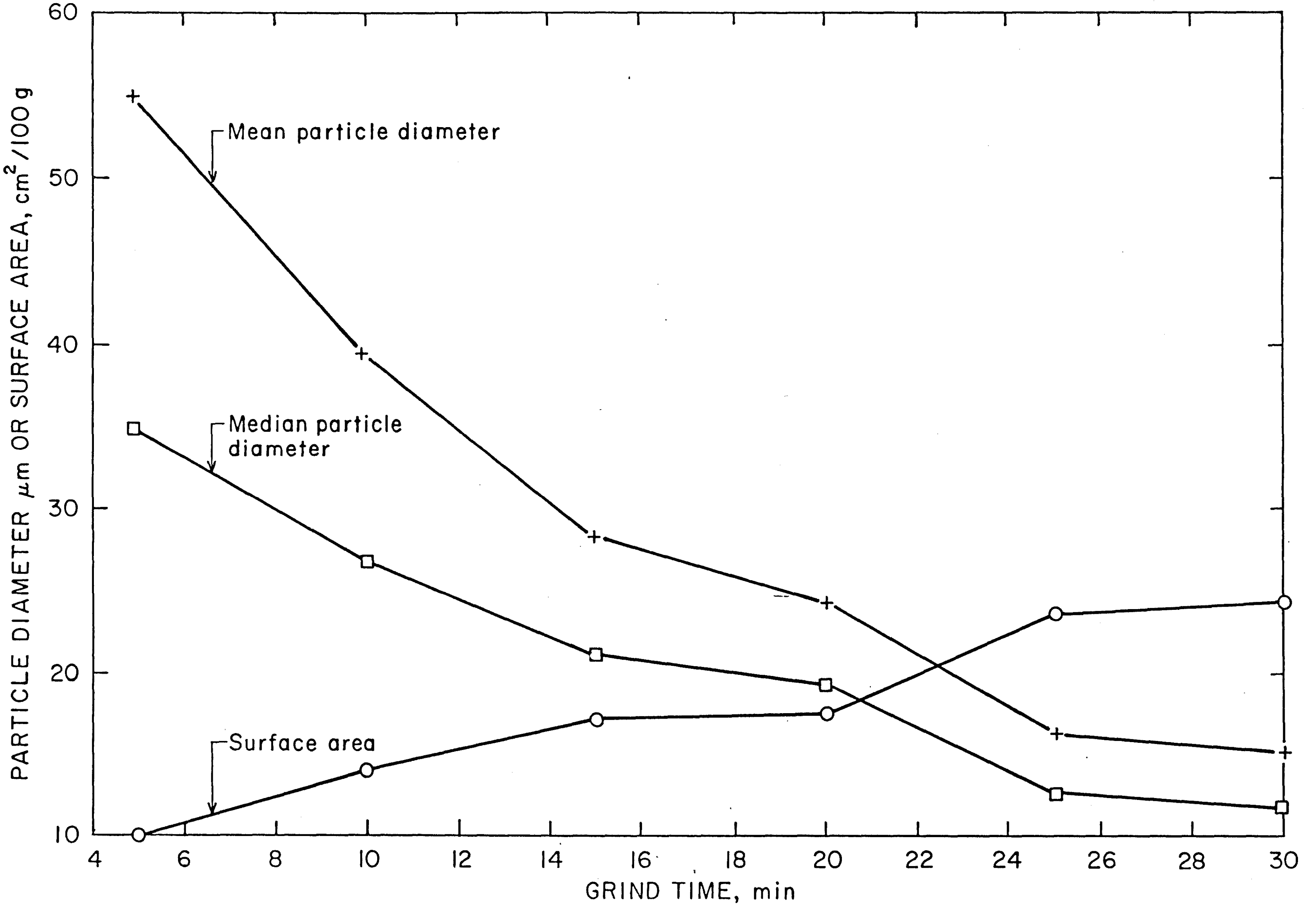

FIGURE 15. - Effect of grind time on particle size and surface area of LC5-fine magnetic Fe ore

Section IV

TEST RESULTS

Cobber Field Data and Material Balances

Sixty-seven tests were conducted in the field. The field data for all tests are given in appendix A. Of these, only the 12 best tests, those run at the slowest permissible conveyor belt speed (197 feet/minute) and at the optimum belt bed depth (3.5 inches for coarse ore and 2 inches for fine ore), were selected for detailed analysis. This was the lowest speed obtainable due to the constraints imposed by equipment design. Operating data from these tests are summarized in table 5. No comparable data exist relating belt speed with other important parameters. Chemical analyses as per the lab testing plan were performed on the 12 test samples and the analyzed and calculated (from individual size fractions) material balances are summarized in tables 6 and 7, respectively. Detailed chemical analyses and Davis tube results on the individual size fractions of cobber feed, concentrate, and reject products from the 12 tests are listed in appendix B.

Field cobbing of the test materials produced an enriched iron ore concentrate and a low-grade reject material. Cobber concentrate weight recoveries ranged from approximately 25 to 98 pct for the fine ores and 36 to 86 pct for the coarse ores tested (see tables 6 and 7). The weight loss for the fine ore occurred principally in the -1/2-inch size fractions, while weight loss for the coarse ores occurred principally in the +1-inch size fractions, and particularly in the +5/8-inch -2-1/2-inch size fraction (see figure 16). Magnetic iron recovery similarly ranged

TABLE 5. - Dry magnetic belt cobbing test parameters[1]

est number	Ore code	Cobber feed		Belt speed, ft/min	Bed depth, inch	Splitter setting, pct open	Concentrate, ton	Reject, ton
		Ton	Ton/hr					
Fine:								
86-023...	LC2	26.89	396	197	2.0	100	22.92	3.97
86-025...	LC2	25.30	396	197	2	50	14.99	10.31
86-026...	LC3/4	24.01	396	197	2	50	20.91	3.10
86-028...	LC3/4	28.77	600	197	2	100	12.77	16.00
86-035...	LC5	32.12	400	197	2	100	14.87	17.25
86-037...	LC5	27.64	400	197	2	50	6.14	21.50
Coarse:								
86-040...	LC3/4	21.61	533	197	3.5	50	13.25	8.36
86-042...	LC2	23.97	533	197	3.5	50	12.00	11.97
86-044...	LC2	24.51	489	197	3.5	100	17.63	6.88
86-045...	LC5	22.12	489	197	3.5	100	12.51	9.61
86-047...	LC5	21.63	489	197	3.5	50	7.33	14.30
86-048...	LC3/4	23.48	489	197	3.5	100	20.16	3.32

[1]All tests run at constant magnetic field strength of 900 gauss.

TABLE 6. - Analyzed cobber test summary data[1]

Test number	Ore code	Head, pct: Total Fe	Head, pct: Mag Fe	Cobber conc., pct: Total Fe	Cobber conc., pct: Mag Fe	Cobber tails, pct: Total Fe	Cobber tails, pct: Mag Fe	Cobber recovery, pct: Weight	Cobber recovery, pct: Mag Fe	Cobber recovery, pct: Total Fe	Davis tube final grade,[2] pct: Head Fe^t	Davis tube final grade,[2] pct: Concentrate Fe^t	Davis tube final grade,[2] pct: Tails Fe^t
Fine:													
86-023..	LC2	31.9	13.49	34.5	16.24	26.8	4.47	85.61	95.43	88.41	69.3	69.6	67.1
86-025..	LC2	31.9	13.49	40.8	22.18	32.6	7.87	41.70	66.76	47.28	69.3	70.5	67.4
86-026..	LC3/4	39.9	21.34	37.4	23.36	24.0	10.03	87.63	94.38	91.71	69.6	69.1	64.6
86-028..	LC3/4	39.9	21.34	32.2	20.81	23.3	5.17	98.03	99.58	98.53	69.6	68.9	67.4
86-035..	LC5	35.6	12.95	34.1	14.46	33.3	3.58	47.19	78.37	47.75	69.6	69.1	67.2
86-037..	LC5	35.6	12.95	39.7	26.12	31.7	7.20	24.87	54.58	29.36	69.6	69.1	68.4
Coarse:													
86-040..	LC3/4	30.4	19.13	24.2	24.60	26.5	10.86	64.10	80.19	61.91	69.8	68.2	64.4
86-042..	LC2	31.9	17.07	35.3	24.03	23.8	8.75	52.55	75.17	62.10	69.4	68.4	62.8
86-044..	LC2	31.9	17.07	34.4	21.81	19.1	4.98	74.43	92.70	83.99	69.4	68.6	64.9
86-045..	LC5	31.0	10.86	32.9	22.04	29.0	3.81	60.91	89.78	63.92	69.6	69.1	66.0
86-047..	LC5	31.0	10.86	35.3	25.89	28.1	6.60	36.09	68.94	41.57	69.6	69.1	66.0
86-048..	LC3/4	30.4	19.13	31.7	22.14	23.6	6.97	86.36	95.18	89.50	69.8	67.9	65.8

[1]Data calculated from analysis on composite sample.
[2]Davis tube concentrate produced from cobber head, concentrate and tailing (all at 20 minute grind).

TABLE 7. - Calculated cobber test summary data[1]

Test number	Ore code	Head, pct		Cobber concentrate, pct		Cobber tails, pct		Cobber recovery, pct			Davis tube final grade,[2] pct		
		Total Fe	Mag Fe	Total Fe	Mag Fe	Total Fe	Mag Fe	Weight	Mag Fe	Total Fe	Head Fe[t]	Concentrate Fe[t]	Tails Fe[t]
Fine:													
86-023..	LC2	32.9	13.64	36.4	15.93	27.2	4.32	85.61	95.62	88.85	69.8	69.5	69.8
86-025..	LC2	32.9	13.64	43.0	21.36	29.3	7.52	41.70	66.10	51.14	69.8	70.0	69.1
86-026..	LC3/4	34.9	21.95	34.7	22.35	24.5	9.60	87.63	94.13	91.00	69.9	70.5	69.4
86-028..	LC3/4	34.9	21.95	33.7	20.63	21.6	4.61	98.03	99.58	98.72	69.9	70.1	70.2
86-035..	LC5	34.7	12.77	36.3	14.50	31.9	3.69	47.19	77.89	50.41	69.4	69.4	69.9
86-037..	LC5	34.7	12.77	41.3	24.82	30.0	6.48	24.87	55.99	31.32	69.4	70.5	69.1
Coarse:													
86-040..	LC3/4	31.4	17.61	32.3	23.26	22.4	7.94	64.10	83.86	72.06	69.3	70.6	69.4
86-042..	LC2	32.6	18.08	36.2	25.22	22.3	9.01	52.55	75.55	64.28	69.8	71.3	69.3
86-044..	LC2	32.6	18.08	33.9	19.90	20.4	4.80	74.43	92.27	82.82	69.8	69.3	68.5
86-045..	LC5	32.6	10.46	34.2	21.45	28.1	3.05	60.91	91.59	65.55	69.3	70.0	68.9
86-047..	LC5	32.6	10.46	34.2	25.26	27.2	7.23	36.09	66.33	41.52	69.3	71.0	69.8
86-048..	LC3/4	31.4	17.61	33.4	22.63	21.5	7.53	86.36	95.07	90.72	69.3	70.3	68.5

[1]Data calculated from analysis from individual size fractions (see appendix B).
[2]Davis tube concentrates produced from cobber head, concentrate and tailings (all at 20 minute grind).

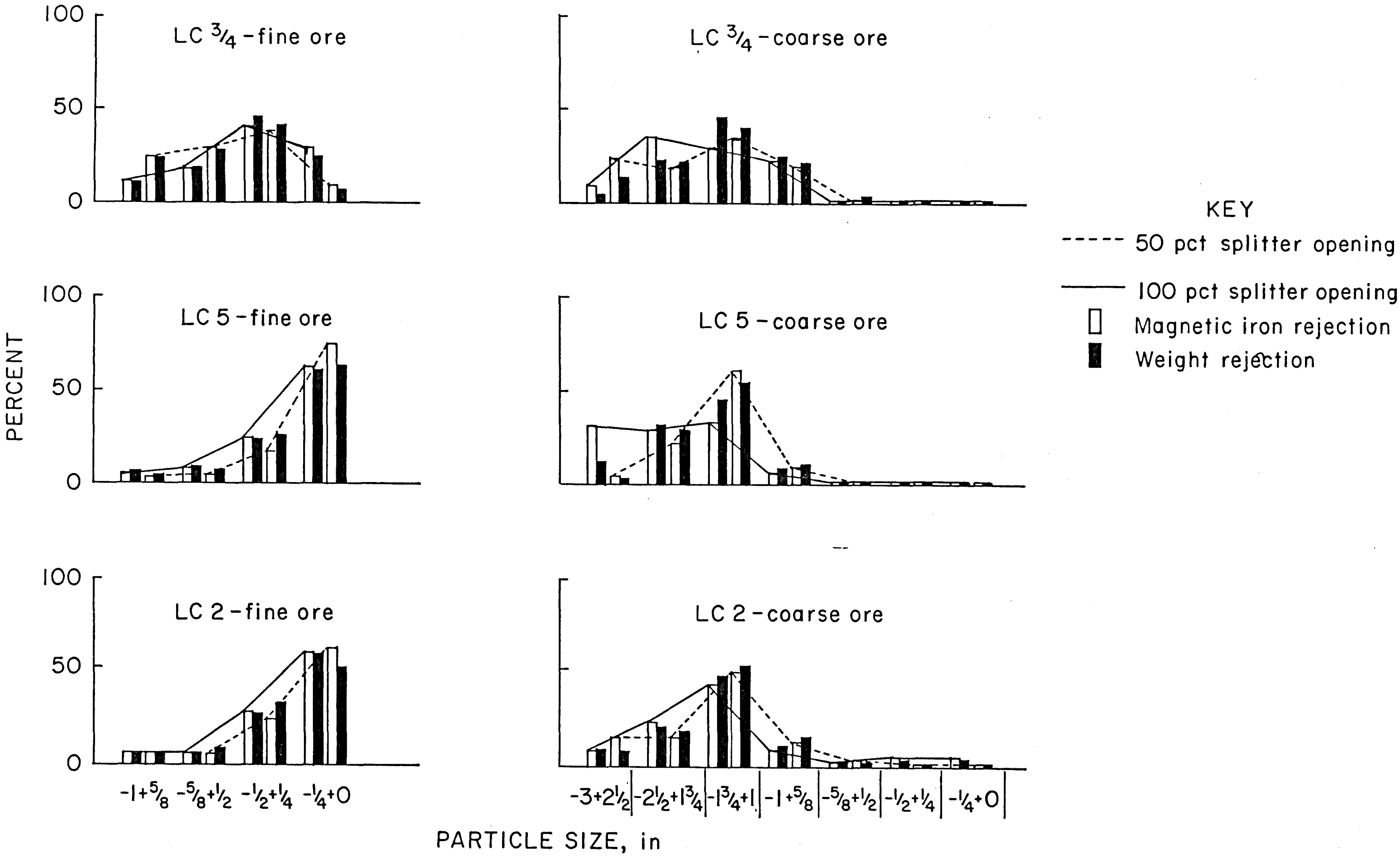

FIGURE 16. - Cobber tail weight and magnetic iron rejection by individual size fraction (see appendix C)

from approximately 55 to 99 pct for the fine ores and 66 to 95 pct for the coarse ores tested (see tables 6 and 7). Magnetic iron loss in the fine ore occurred principally in the -1/2-inch size fractions, while magnetic iron loss for the coarse ore occurred principally in the +1-inch size fractions, and particularly in the +1-inch -2-1/2-inch size fraction (see figure 16). These observations generally occur throughout the 12 test runs and appear to be independent of splitter setting. Figures 17 and 18 generally support this contention.

Figures 19 and 20 show weight and magnetic iron recovery as a function of particle size. The displacements of the comparable curves indicate the impact of varying the dry cobbing machines splitter opening from 50 pct open to 100 pct open. Table 8 summarizes the results on cobber concentrate, magnetic iron weight, and magnetic iron recoveries as the splitter adjustment is opened. Varying the splitter opening impacted greatly on recoveries associated with the lean type ore materials (LC-2 and LC-5) and impacted to a lesser extent with the higher grade type material (LC-3/4).

Table 8 also generally suggests that for the leaner grade ore (LC2 and LC5) the weight and magnetic iron recoveries increased as ore size (fine vs. coarse) increased. For the high-grade ore (LC-3/4) the opposite results occurred. This observation is based on limited data, and additional testing is needed before specific recommendations relating to the impacts of varying feed size can be made.

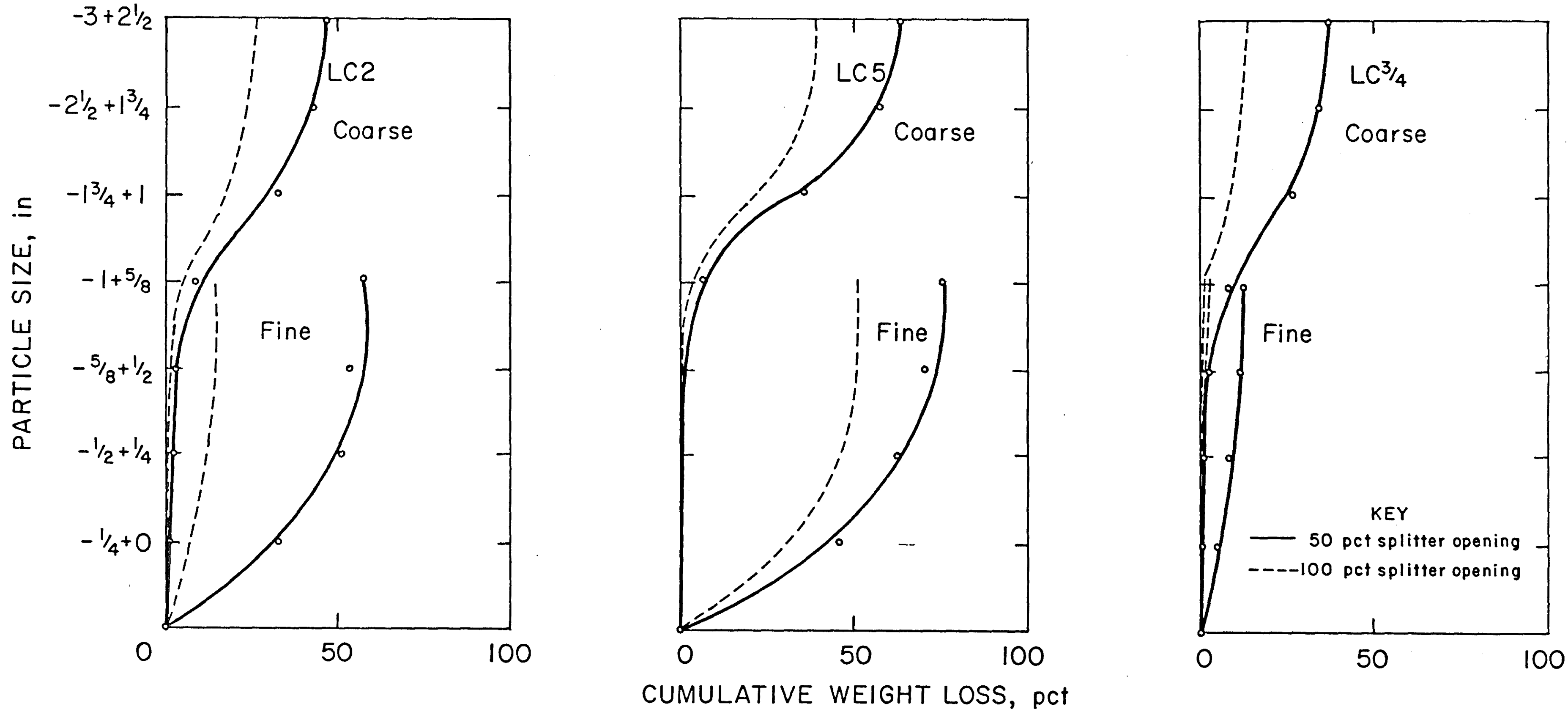

FIGURE 17. - Cobber tail cumulative weight loss as a function of particle size (see appendix C)

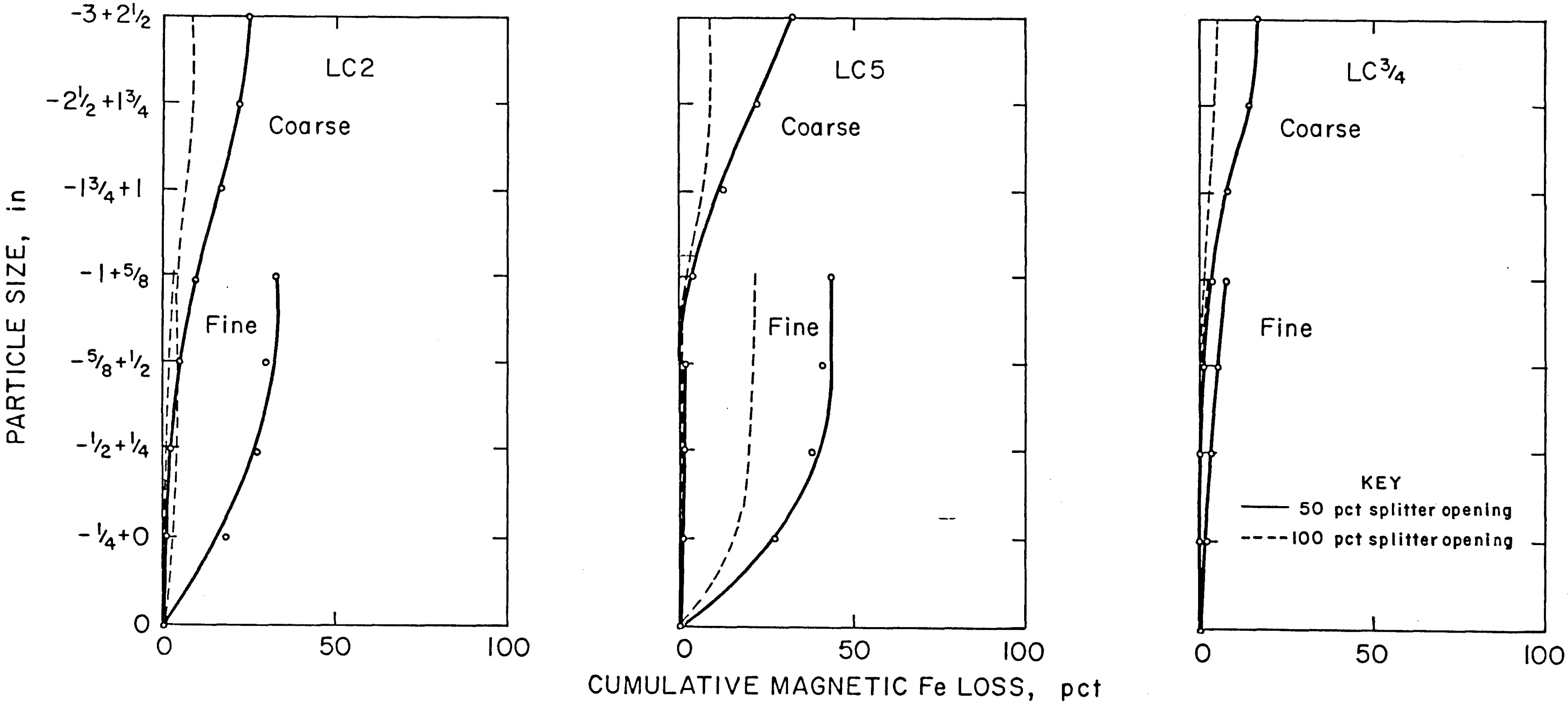

FIGURE 18. - Cobber tail cumulative magnetic iron loss as a function of particle size (see appendix C)

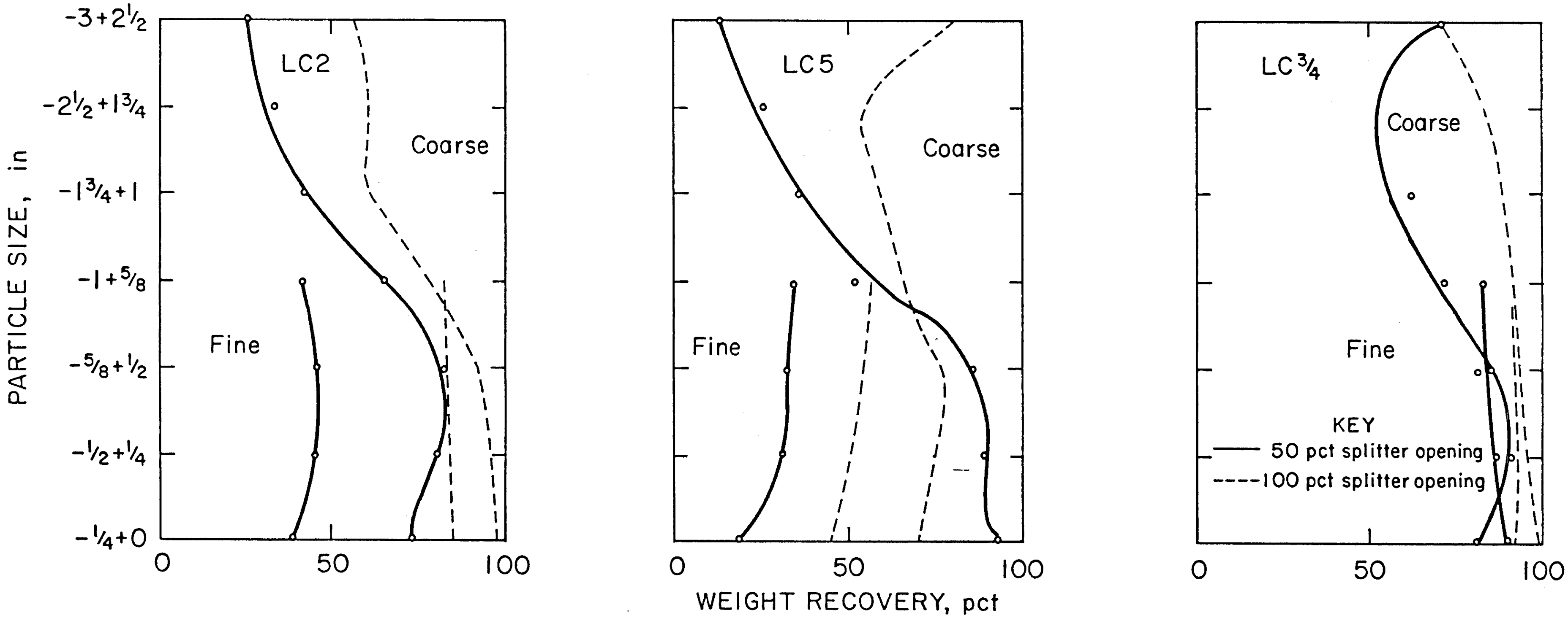

FIGURE 19. - Cobber concentrate weight recovery as a function of particle size (see appendix C)

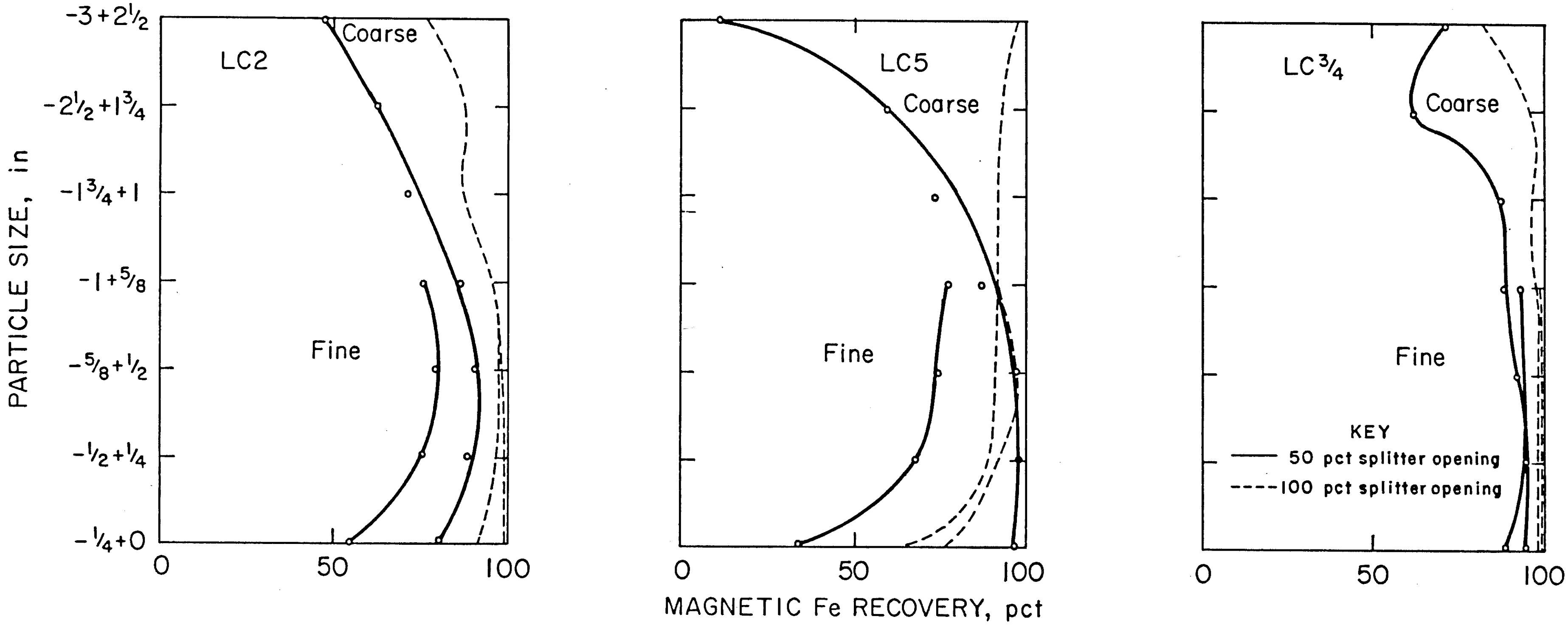

FIGURE 20. - Cobber concentrate magnetic iron recovery as a function of particle size (see appendix C)

TABLE 8. - Impact of splitter setting on cobber concentrate weight, magnetic iron, and magnetic iron recovery[1]

Feed material	Splitter setting		Improvement, pct
	50 pct open	100 pct open	
	WEIGHT RECOVERY, pct		
LC2-fine......	41.70	85.61	105.30
LC2-coarse....	52.55	74.43	41.64
LC3/4-fine....	87.63	98.03	11.87
LC3/4-coarse..	64.10	86.36	34.73
LC5-fine......	24.87	47.19	89.75
LC5-coarse....	36.09	60.91	68.77
	MAGNETIC IRON, pct		
LC2-fine......	22.18	16.24	NA
LC2-coarse....	24.03	21.81	NA
LC3/4-fine....	23.36	20.81	NA
LC3/4-coarse..	24.60	22.14	NA
LC5-fine......	26.12	14.46	NA
LC5-coarse....	25.89	22.04	NA
	MAGNETIC IRON RECOVERY, pct		
LC2-fine......	66.76	95.43	42.94
LC2-coarse....	75.17	92.34	22.84
LC3/4-fine....	94.38	99.58	5.51
LC3/4-coarse..	80.19	95.18	18.69
LC5-fine......	54.58	78.37	43.59
LC5-coarse....	68.94	89.78	30.23

NA Not applicable.
[1]Analyzed cobber test data.

Bond Grindability Work Indices

Bond grindability work indices were determined for the 12 magnetic cobbing field tests (see appendix D). Work indices were obtained for the feed concentrates and the reject materials produced from each test. The work index is defined as the total work input in kWh/short ton required to reduce from theoretically infinite particle size to 80 pct passing 149 micrometers (approximately 67 pct passing 200 mesh). Using figures obtained from screen analysis and grinding tests, a work index was obtained using the following equation.

$$W_i = \frac{4.45}{(p)^{0.23} \times (G_{BP})^{0.82} \times \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]}$$

where:

W_i = Work index, kWh/ton

F = 80 pct passing size of feed (microns)

p = 80 pct passing size of product undersize (microns)

G_{BP} = average grams of undersize produced per revolution

P = screen size tested (100 mesh = 149 microns).

Work index values obtained from the taconite test products ranged from 11 kWh/ton for the cobber concentrates to 15 kWh/ton for the reject material (see table 9). Analysis of the data suggest a correlation between the work index and the total iron content of the ore, i.e., the higher the grade the lower the work index (see figure 21). Correlation between the work index and magnetic iron (see figure 22) and silica (see figure 23) was also apparent. These data suggest that the crushing and grinding energy consumption could be reduced by rejecting the low-grade (lean) material at the coarsest size possible.

TABLE 9. - Bond grindability work index

Test identification number	Splitter setting, pct open	Ore description	Head, KWh/ton	Concentrate, KWh/ton	Tail, KWh/ton
Fine:					
86-023......	100	LC2-fine	12.44	12.03	13.28
86-025......	50	LC2-fine	12.44	11.41	12.61
86-026......	50	LC3/4-fine	12.19	11.50	13.10
86-028......	100	LC3/4-fine	12.19	12.44	14.65
86-035......	100	LC5-fine	11.63	12.55	13.33
86-037......	50	LC5-fine	11.63	11.19	12.22
Coarse:					
86-040......	50	LC3/4-coarse	12.15	11.99	13.60
86-042......	50	LC2-coarse	13.15	11.90	13.30
86-044......	100	LC2-coarse	13.15	12.27	14.89
86-045......	100	LC5-coarse	11.26	11.98	13.22
86-047......	50	LC5-coarse	11.26	11.02	12.50
86-048......	100	LC3/4-coarse	12.15	11.32	14.03

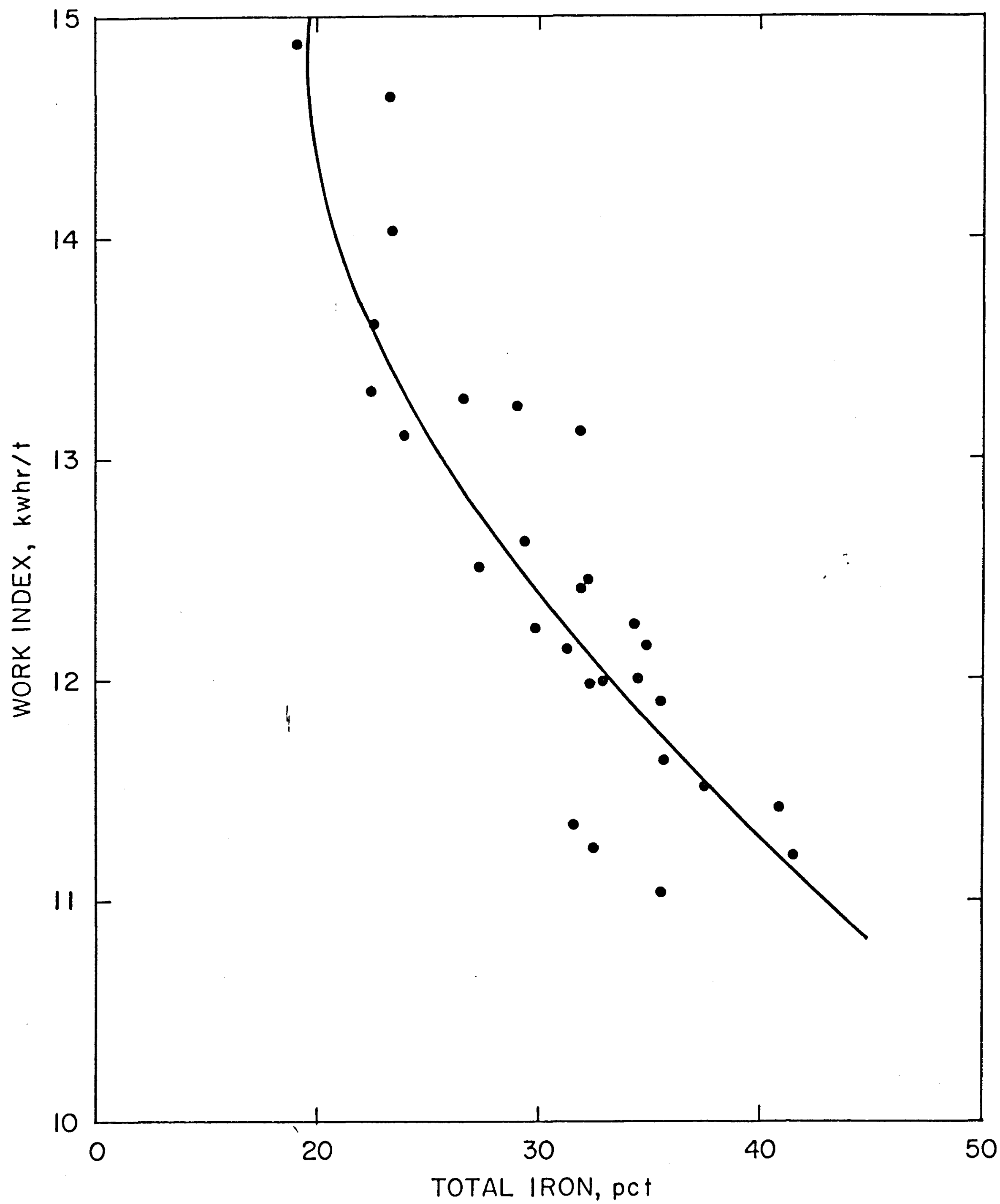

FIGURE 21. - Work index as a function of the percent total iron

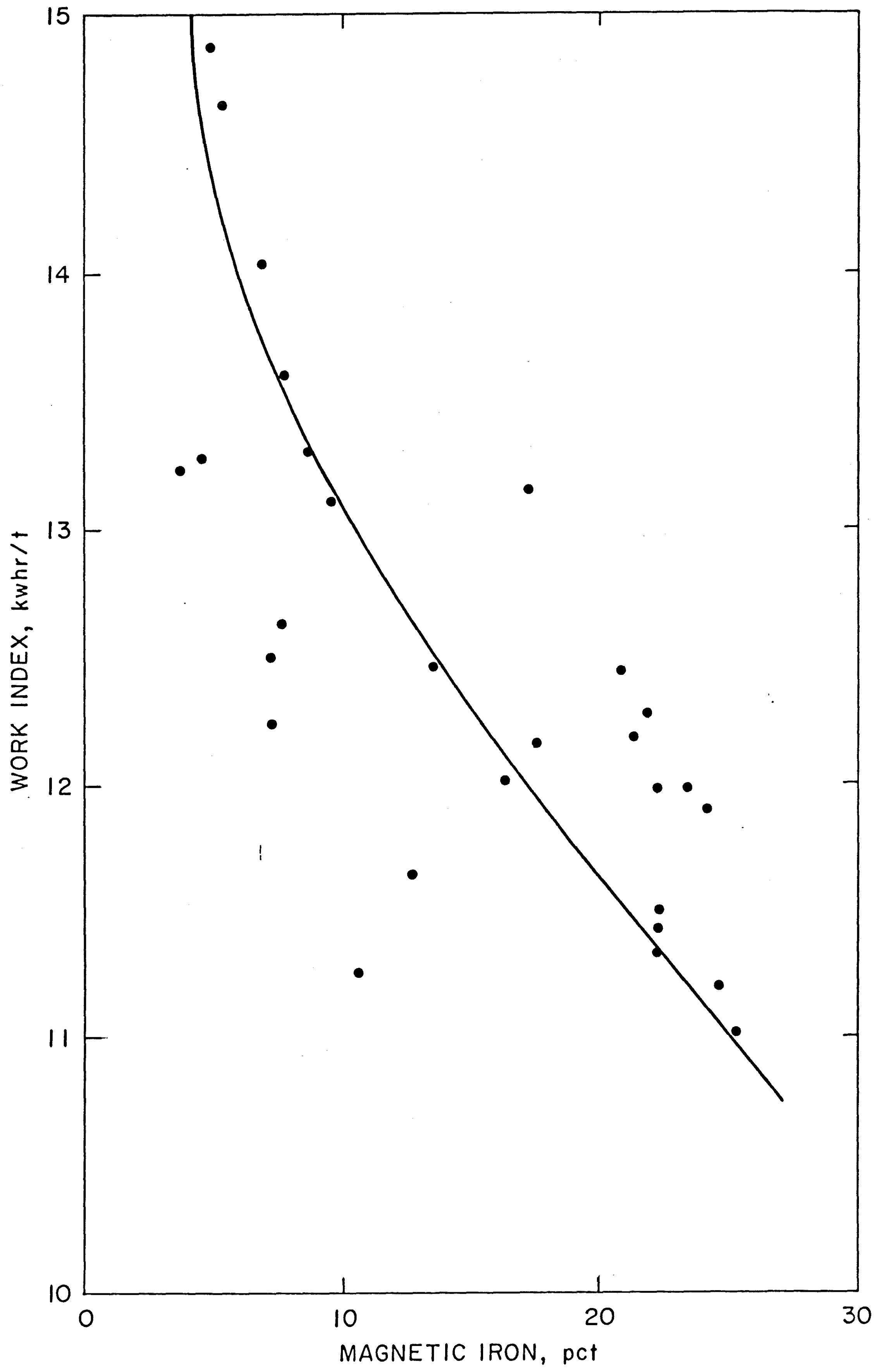

FIGURE 22. - Work index as a function of the percent magnetic iron

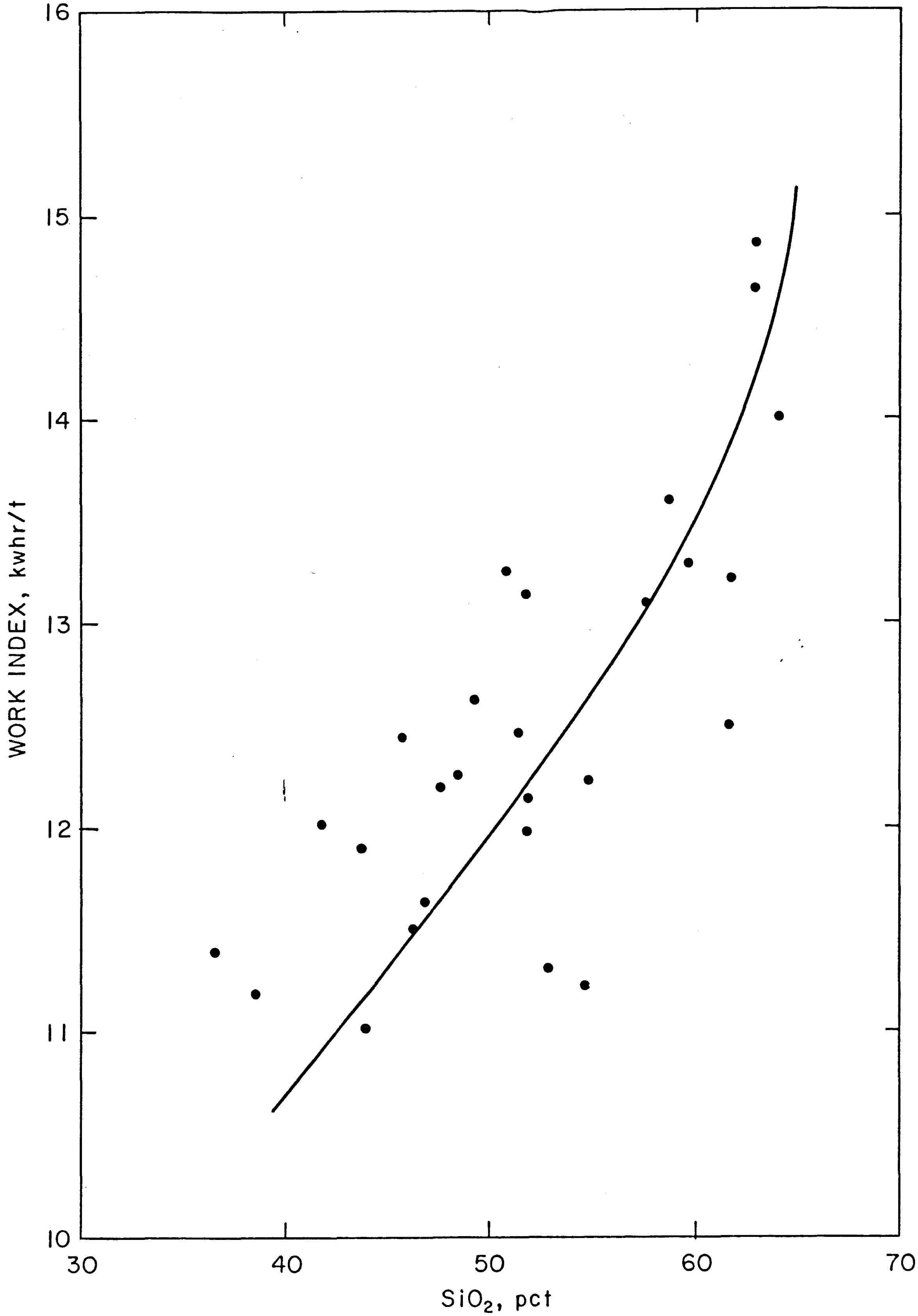

FIGURE 23. - Work index as a function of the percent SiO_2

ECONOMICS OF DRY COBBING

Because of the proprietary nature of company cost information and the differences between flow sheets of the various mines, a range of costs will be used to illustrate potential savings and expenses of dry cobbing. Listed below are some potential areas of cost savings of dry cobbing. It is assumed that the plant used in these calculations has a conventional rod mill-ball mill-grinding circuit and is capable of producing 3.0 million tons of pellets per year.

Assumptions:

- Plant has a conventional rod mill-ball mill-grinding circuit.
- Pellet production: 3,000,000 lt pellets/year
- Crude ore production: 9,650,000 lt crude ore/year
- Weight recovery: 30 pct
- Magnetic iron recovery: 94 pct
- Concentrate magnetic iron: 65 pct
- Economic savings in the concentrator, excluding the impact of the capital costs of installation of a dry cobbing unit, are found in table 10.

TABLE 10. - Potential economic savings (ISMC)

	Low end[1]	High end[1]	Average[1]
Savings in rod mill liners....	$0.05	$0.10	$0.075
Savings in rod costs..........	.15	.30	.225
Power savings.................	.12	.24	.180

[1]All figures per long ton (lt) of run of mine feed (RMF).

It is assumed that 9,650,000 lt of crude ore mined was from material similar to test No. 86-026 LC3/4 (cobber weight reject of 12.37 pct, containing 9.6 pct magnetic iron and magnetic iron recovery of 94.14 pct). The annual economic savings by not treating the material rejected at the dry cobber is calculated as follows.

9,650,000 x 0.1237 = 1,193,705 lt reject material

1,193,705 x \$0.075 = \$90,000.00 - rod mill liners

1,193,705 x \$0.225 = \$269,000.00 - rods

1,193,705 x \$0.18 = \$215,000.00 - power

\$574,000.00 - total

\$574,000 ÷ 3,000,000 lt pellets/year = \$0.19/lt pellets

This calculation shows a potential savings in the concentration of \$0.19/lt pellets. There may be additional savings in ball mill media and liner wear not accounted for in this calculation.

There is an offsetting factor to consider when looking at the savings calculated above and that is the magnetic iron lost in the reject at the dry cobber. The average magnetic iron recovery for sample No. 86-026 is 94.14 pct. Assume with higher grade run of mine feed (RMF) the concentrator magnetic iron recovery goes up to 95 pct. The overall magnetic iron recovery becomes 94.14 x 0.95 = 89.42 pct. Additional crude ore will have to be mined to make up for the lost concentrate. For sample No. 86-026 that amounts to 553,000 lt crude as shown below.

1,193,705 lt reject x 0.096 Mag Fe = 114,596 Mag tons

114,596 Mag tons x 0.9413 Mag Fe rec. = 107,869 Mag tons

107,869 Mag tons ÷ 0.65 Mag Fe in conc. = 165,952 lt conc.

165,952 lt conc. ÷ 0.30 wt. rec. = 553,000 lt crude

An additional 553,000 lt crude ore must be mined to make up for the lost magnetic iron tons. Depending upon the mining and crushing costs of a given mine, the cost to mine and crush this additional crude ore could more than offset the savings incurred in the concentrator.

There are other opportunities for savings with dry cobbing. At Inland 60,000 lt of road rock is crushed per year to use on pit and dump roads. The reject from a dry cobber could supply road rock for pit and dump roads. In addition to this savings, any excess dry cobbing reject not used by the mining company could be a saleable by-product to contractors in the area.

Periodically, companies that have constructed a man-made dike to enclose a tailings basin have to raise the dike to maintain the water level within dam safety requirements and maintain the necessary water volume to supply reclaim water to the plant. Raising these dikes can be a very expensive venture. The net result of rejecting material before it reaches the concentrator and raising the concentrator feed grade through dry cobbing would be less tailing going to the tailings dike. Less tailing going to the dike would mean longer periods of time between dike lifts, resulting in fewer lifts during the life of the mine.

Section VI

CONCLUSIONS AND RECOMMENDATIONS

Field testing and laboratory analysis of dry magnetic cobbing taconite ores discerned the following:

- Successful upgrading of taconite ores at both coarse and fine size fractions was achieved, but magnetic iron recoveries were unacceptable under these field test operating conditions.
- Magnetic strength, conveyor belt throughput speed and splitter setting are important parameters for dry magnetic cobbing. Field tests were not run using optimum settings for these parameters. Indications suggest that magnetic iron recovery will improve as more ideal operating conditions are realized. Additional testing is warranted to optimize these variables.
- Noticeable magnetic iron upgrading of lean grade taconite material was attained. Certain material types currently uneconomic could be upgraded using magnetic cobbing to produce an economically mineable and millable ore concentrate.
- Bond work index values indicate that as the iron content of the cobber concentrate increases, the energy associated with grinding that material to liberation decreases. Crushing and grinding energy consumption could be reduced by rejecting the low-grade (lean) material at the coarsest size possible.

The following recommendations are made relative to the results obtained from the cobbing test program.

1. Modify the dry cobbing facility to accommodate testing at optimum conditions, i.e., this will require structural changes and safety improvements.
2. Construct test facility with variable electromagnet to determine maximum field strength required to test various ore sizes.
3. Conduct tests using other taconite companies ore material.

Appendix A--Field Test Data Sheets

TABLE A-1. - Field test data sheets

Test number	Date, 1986	Size, type	Loads per run	Loader bucket size, yd^3	Total feed, yd^3	Feed, tons FO=1.5669 TF=1.40	Diameter concentrate	Height concentrate, ft	Volume concentrate	Tons concentrate	Diameter reject, ft	Height reject, ft	Volume reject	Tons reject	Splitter position open, pct	Bed thickness, in.	Bed width, ft	Belt speed, fpm	Tons, tph
86-001..	7-28	LC-4 F	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	100	4	(1)	323	(1)
86-002..	7-28	LC-4 F	4	4	16	25	13.3	5.43	251.46	14.59	8.7	3.51	69.55	4.04	100	3	2.9	323	815
86-003..	7-28	LC-4 F	4	4	16	25	11.3	4.72	157.79	9.16	8.8	3.56	72.17	4.19	75	3	2.9	323	815
86-004..	7-28	LC-4 F	4	4	16	25	10.0	4.56	119.38	6.93	10.4	4.36	123.46	7.16	50	3	2.9	323	815
86-005..	7-28	LC-5 F	4	4	16	25	7.0	2.75	35.28	2.05	12.1	5.02	192.42	11.17	50	3	2.9	323	815
86-006..	7-28	LC-5 F	4	4	16	25	7.8	3.44	54.79	3.18	10.9	4.52	140.59	8.16	75	3	2.9	323	815
86-007..	7-29	LC-5 F	4	4	16	25	8.2	3.31	58.27	3.38	8.6	3.78	73.19	4.25	100	3	2.9	323	815
86-008..	7-29	LC-5 F	4	4	16	25	8.6	3.32	64.28	3.73	12.1	4.68	179.38	10.41	50	2	3.4	323	650
86-009..	7-30	LC-5 F	4	4	16	25	7.9	3.35	54.74	3.18	11.7	4.90	175.60	10.19	75	2	3.4	323	650
86-010..	7-30	LC-5 F	4	4	16	25	12.3	5.39	213.49	12.39	10.4	3.97	112.42	6.52	100	2	3.4	323	650
86-011..	8-04	LC-4 F	4	4	16	25	12.6	5.76	239.40	13.89	5.8	2.20	19.37	1.12	100	2	3.5	320	663
86-012..	8-04	LC-4 F	4	4	16	25	13.6	5.93	287.14	16.66	7.4	2.73	117.41	6.81	75	2	3.5	320	663
86-013..	8-04	LC-4 F	4	4	16	25	14.2	5.83	307.76	17.86	10.4	3.82	108.17	6.28	50	2	3.5	320	663
86-014..	8-04	LC-2 F	4	4	16	25	10.3	4.44	123.32	7.16	14.1	5.45	283.66	16.46	50	2	3.5	320	663
86-015..	8-04	LC-2 F	4	4	16	25	11.9	5.05	187.22	10.87	13.2	5.25	239.48	13.90	75	2	3.5	320	663
86-016..	8-05	LC-2 F	4	4	16	25	13.3	5.94	275.08	15.96	12.3	4.68	185.36	10.76	100	2	3.5	320	663
86-017..	8-05	LC-2 F	4	4	16	25	12.4	5.36	215.76	12.52	13.3	5.21	241.27	14.00	100	3	3.4	320	947
86-018..	8-05	LC-2 F	4	4	16	25	11.5	4.96	171.73	9.97	14.6	5.72	319.21	18.52	75	3	3.4	320	947
86-019..	8-05	LC-2 F	4	4	16	25	9.3	4.09	92.61	5.37	15.5	6.10	383.67	22.27	50	3	3.4	320	947

See footnotes at end of table.

TABLE A-1. - Field test data sheets--Continued

Test number	Date, 1986	Size, type	Loads per run	Loader bucket size, yd^3	Total feed, yd^3	Feed, tons F0=1.5669 TF=1.40	Diameter concentrate	Height concentrate, ft	Volume concentrate	Tons concentrate	Diameter reject, ft	Height reject, ft	Volume reject	Tons reject	Splitter position open, pct	Bed thickness, in.	Bed width, ft	Belt speed, fpm	Tons, tph
86-020..	8-06	LC-2 F	4	4	16	25.00	10.7	4.28	128.29	7.44	15.2	5.97	361.10	20.96	50	3	3.2	197	549
86-021..	8-06	LC-2 F	4	4	16	25	12.5	5.38	220.08	12.77	12.6	5.39	224.03	13.00	75	3	3.2	197	549
86-022..	8-06	LC-2 F	4	4	16	25	13.5	5.80	276.74	16.06	11.5	4.39	151.99	8.82	100	3	3.2	197	549
86-023..	8-06	LC-2 F	4	4	16	25	15.4	6.36	394.88	22.92	8.7	3.45	68.36	3.97	100	2	3.4	197	396
86-024..	8-06	LC-2 F	4	4	16	25	13.5	5.97	284.85	16.53	11.2	4.52	148.44	8.61	75	2	3.4	197	396
86-025..	8-06	LC-2 F	4	4	16	25	11.4	5.22	177.60	10.31	13.1	5.75	258.33	14.99	50	2	3.4	197	396
86-026..	8-06	LC-4 F	4	4	16	25	14.7	6.37	360.37	20.91	7.9	3.27	53.43	3.10	50	2	3.4	197	396
86-027..	8-06	LC-4 F	4	4	16	25	15.6	6.36	405.21	23.52	6.1	2.36	22.99	1.33	75	2	3.4	197	396
86-028..	8-06	LC-4 F	4	4	16	25	15.4	6.52	404.82	23.49	4.8	1.55	9.35	0.54	100	2	3.4	197	396
86-029..	8-11	LC-4 F	2	10	20	31.34	15.0	6.52	384.06	22.29	6.3	2.27	23.59	1.37	100	3	3.5	197	600
86-030..	8-11	LC-4 F	2	10	20	31.34	15.5	6.38	401.28	23.29	8.0	3.04	50.94	2.96	75	3	3.5	197	600
86-031..	8-11	LC-4 F	2	10	20	31.34	14.3	6.23	333.53	19.36	10.7	4.20	125.89	7.31	50	3	3.5	197	600
86-032..	8-11	LC-5 F	2	10	20	31.34	10.7	4.46	133.68	7.76	14.0	5.36	275.04	15.96	50	3	3.5	197	600
86-033..	8-11	LC-5 F	2	10	20	31.34	14.5	5.71	314.30	18.24	12.7	4.26	179.88	10.44	75	3	3.5	197	600
86-034..	8-11	LC-5 F	2	10	20	31.34	12.7	5.21	220.02	12.77	13.8	5.53	275.71	16.00	100	3	3.5	197	600
86-035..	8-11	LC-5 F	2	10	20	31.34	13.5	5.37	256.22	14.87	14.2	5.63	297.20	17.25	100	2	3.5	197	400
86-036..	8-11	LC-5 F	2	10	20	31.34	10.5	4.10	118.34	6.87	16.0	6.06	406.15	23.57	75	2	3.5	197	400
86-037..	8-11	LC-5 F	2	10	20	31.34	10.0	4.04	105.77	6.14	15.5	5.89	370.47	21.50	50	2	3.5	197	400
86-038[2].	8-11	LC-5 F	2	10	20	31.34	4.4	1.43	7.25	0.42	12.3	4.97	196.85	11.42	50	2	3.5	197	400

See footnotes at end of table.

TABLE A-1. - Field test data sheets--Continued

Test number	Date, 1986	Size, type	Loads per run	Loader bucket size, yd^3	Total feed, yd^3	Feed, tons F0=1.5669 TF=1.40	Diameter concen-trate	Height concen-trate, ft	Volume concen-trate	Tons concen-trate	Diameter reject, ft	Height reject, ft	Volume reject	Tons reject	Splitter position open, pct	Bed thick-ness, in.	Bed width, ft	Belt speed, fpm	Tons, tph
86-039[3].	8-11	LC-5 F	1	10	10	15.67	6.6	2.59	29.54	1.71	3.4	1.01	3.06	0.18	50	2.0	3.50	197	400
86-040..	8-12	LC-4 C	2	10	20	28	13.7	5.20	255.51	13.25	11.9	4.35	161.27	8.36	50	3.5	3.0	197	533
86-041..	8-12	LC-4 C	2	10	20	28	15.0	5.75	338.70	17.56	10.3	3.71	103.04	5.34	75	3.5	3.0	197	533
86-042..	8-12	LC-2 C	2	10	20	28	13.0	5.23	231.40	12.00	13.5	4.84	230.93	11.97	50	3.5	3.0	197	533
86-043..	8-12	LC-2 C	2	10	20	28	13.4	5.41	254.32	13.19	12.5	4.38	179.17	9.29	75	3.5	3.0	197	533
86-044..	8-12	LC-2 C	2	10	20	28	14.9	5.85	340.01	17.63	11.2	4.04	132.67	6.88	100	3.5	2.75	197	489
86-045..	8-12	LC-5 C	2	10	20	28	13.3	5.21	241.27	12.51	12.5	4.53	185.30	9.61	100	3.5	2.75	197	489
86-046..	8-12	LC-5 C	2	10	20	28	12.2	5.12	199.51	10.34	13.6	5.08	245.99	12.75	75	3.5	2.75	197	489
86-047..	8-12	LC-5 C	2	10	20	28	10.8	4.63	141.38	7.33	14.3	5.15	275.71	14.30	50	3.5	2.75	197	489
86-048..	8-13	LC-4 C	6	4	24	33.6	15.8	5.95	388.87	20.16	8.8	3.16	64.07	3.32	100	3.5	2.75	197	489
86-049..	8-13	LC-4 C	4	4	16	22.4	13.2	4.88	222.61	11.54	12.5	3.76	153.81	7.98	50	3.5	2.75	197	489
86-050..	8-18	LC-4 C	4	4	16	22.4	13.3	5.48	253.78	13.16	12.6	4.32	179.55	9.31	50	3.5	2.75	197	489
86-051[4].	8-18	LC-4 C	4	4	16	22.4	4.8	1.50	9.05	0.47	7.1	2.37	31.28	1.62	50	3.5	2.75	197	489
86-052[5].	8-18	LC-4 C	3	10	30	42	11.0	4.65	147.30	7.64	6.5	1.71	18.91	0.98	50	3.5	2.75	197	489
86-053 .	8-18	LC-2 C	2	10	20	28	12.3	5.12	202.79	10.52	12.9	5.00	217.83	11.29	50	3.5	2.75	197	489
86-054[6].	8-18	LC-2 C	2	10	20	28	5.4	2.65	20.23	1.05	9.8	3.94	99.06	5.14	50	3.5	2.75	197	489
86-055[7].	8-18	LC-2 C	2	10	20	28	10.4	4.25	120.34	6.24	5.8	3.54	27.02	1.40	50	3.5	2.75	197	489
86-056..	8-18	LC-5 C	2	10	20	28	10.4	4.35	123.18	6.39	13.0	5.03	222.55	11.54	50	3.5	2.75	197	489
86-057[8].	8-18	LC-5 C	2	10	20	28	4.7	1.81	10.47	0.54	10.7	4.13	123.79	6.42	50	3.5	2.75	197	489

See footnotes at end of table.

TABLE A-1. - Field test data sheets--Continued

Test number	Date, 1986	Size, type	Loads per run	Loader bucket size, yd^3	Total feed, yd^3	Feed, tons FO=1.5669 TF=1.40	Diameter concentrate	Height concentrate, ft	Volume concentrate	Tons concentrate	Diameter reject, ft	Height reject, ft	Volume reject	Tons reject	Splitter position open, pct	Bed thickness, in.	Bed width, ft	Belt speed, fpm	Tons, tph
86-058[9].	8-18	LC-5 C	2	10	20	28.0	8.8	3.59	72.78	3.77	4.6	1.84	10.19	0.52	50	3.5	2.75	197	489
86-059..	8-19	LC-4 F	4	4	16	25	13.5	5.89	281.03	16.31	7.5	2.79	41.09	2.38	50	2	3.5	197	400
86-060[10]	8-19	LC-4 F	4	4	16	25	4.4	2.62	13.30	0.77	3.7	1.55	5.56	0.32	50	2	3.5	197	400
86-061[11]	8-19	LC-4 F	4	4	16	25	11.3	3.66	122.35	7.1	6.0	2.24	21.11	1.23	50	2	3.5	197	400
86-062..	8-19	LC-2 F	4	4	16	25	11.7	4.52	161.99	9.4	13.1	5.14	230.93	13.40	50	2	3.5	197	400
86-063[12]	8-19	LC-2 F	2	4	8	12.5	4.6	1.97	10.91	0.63	10.7	4.03	120.79	7.01	50	2	3.5	197	400
86-064[13]	8-19	LC-2 F	2	4	8	12.5	8.7	3.71	73.52	4.27	4.9	1.72	10.81	0.63	50	2	3.5	197	400
86-065..	8-20	LC-5 F	4	4	16	25	9.1	3.87	83.90	4.87	14.0	5.88	301.72	17.51	50	2	3.5	197	400
86-066[14]	8-20	LC-5 F	2	4	8	12.5	3.9	1.62	6.45	0.37	11.9	4.91	182.03	10.56	50	2	3.5	197	400
86-067[15]	8-20	LC-5 F	2	4	8	12.5	6.8	3.19	38.62	2.24	5.6	2.62	21.51	1.25	50	2	3.5	197	400

F fine ore.
C coarse ore.
[1]Test material would not spread evenly over conveyor belt.
[2]Tails from 86-037.
[3]Concentrate from 86-037.
[4]Tails from 86-050.
[5]Concentrate from 86-050.
[6]Tails from 86-053.
[7]Concentrate from 86-053.
[8]Tails from 86-056.
[9]Concentrate from 86-056.
[10]Tails from 86-059.
[11]Concentrate from 86-059.
[12]Tails from 86-062.
[13]Concentrate from 86-062.
[14]Tails from 86-065.
[15]Concentrate from 86-065.

Appendix B.--Detailed Chemistry Davis Tube Analysis by Particle Size

TABLE B-1. - Sample identification head, LC2-fine ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.2	34.9	10.3	18.6	24.53	69.8	23.0	1.1	17.12	5.64	0.27	46.98
-5/8 + 1/2.......	10.8	30.1	9.8	24.1	26.60	70.1	23.3	1.3	18.65	6.20	0.35	55.84
-1/2 + 1/4.......	36.2	34.0	11.4	19.6	22.87	70.0	22.6	1.1	16.01	5.17	0.25	44.77
-1/4 + 0.........	46.8	32.4	8.4	22.4	14.67	69.5	22.6	1.2	10.19	3.31	0.18	35.08
Composite (calculated)..	100.0	32.9	9.8	21.3	-	-	-	-	13.64	4.44	0.23	42.09
Composite (analysis)....	-	31.9	10.0	21.3	19.47	69.3	22.8	1.2	13.49	4.44	0.23	43.56
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.2	34.9	10.3	18.6	75.47	25.6	8.4	24.5	19.32	6.34	18.49	53.02
-5/8 + 1/2.......	10.8	30.1	9.8	24.1	73.40	20.1	4.6	32.8	14.75	3.38	24.08	44.16
-1/2 + 1/4.......	36.2	34.0	11.4	19.6	77.13	25.6	7.3	22.6	19.75	5.63	17.43	55.23
-1/4 + 0.........	46.8	32.4	8.4	22.4	85.33	22.1	5.7	26.0	18.86	4.86	22.19	64.92
Composite (calculated)..	100.0	32.9	9.8	21.3	-	-	-	-	18.77	5.07	20.44	57.91
Composite (analysis)....	-	31.9	10.0	21.3	80.53	21.7	6.8	26.1	17.48	5.48	21.02	56.44

[1]Value based on calculated Davis tube products.

TABLE B-2. - Sample identification head, LC2-coarse ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution[1], pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	2.5	36.1	11.0	19.5	36.93	69.4	23.5	1.0	25.63	8.68	0.37	69.31
-2-1/2 + 1-3/4...	14.6	34.2	9.4	21.8	26.00	70.7	23.3	1.3	18.38	6.06	0.34	54.78
-1-3/4 + 1.......	28.5	28.5	8.4	26.2	24.73	69.6	23.3	1.4	17.21	5.76	0.35	58.84
-1 + 5/8.........	18.4	36.5	9.8	23.4	25.13	69.6	23.0	1.2	17.49	5.78	0.30	57.74
-5/8 + 1/2.......	15.0	35.1	10.7	20.2	24.80	70.3	25.1	0.75	17.43	6.22	0.19	48.22
-1/2 + 1/4.......	20.6	30.8	9.6	22.5	27.60	69.4	22.1	1.4	19.15	6.10	0.39	56.82
-1/4 + 0.........	3.5	32.7	9.8	22.4	25.13	69.4	23.0	1.3	17.44	5.78	0.33	55.74
Composite (calculated)..	100.0	32.6	9.5	23.1	-	-	-	-	18.08	6.02	0.32	56.01
Composite (analysis)....	-	31.9	10.0	24.1	24.60	69.4	22.4	1.5	17.07	5.51	0.37	59.35
					NONMAGNETIC							
-3 + 2-1/2.......	2.5	36.1	11.0	19.5	63.07	18.0	5.7	30.5	11.35	3.59	19.24	30.69
-2-1/2 + 1-3/4...	14.6	34.2	9.4	21.8	74.00	20.5	5.9	29.2	15.17	4.37	21.61	45.22
-1-3/4 + 1.......	25.4	28.5	8.4	26.2	75.27	16.0	5.5	31.9	12.04	4.14	24.01	41.16
-1 + 5/8.........	18.4	36.5	9.8	23.4	74.87	17.1	5.5	30.6	12.80	4.12	22.91	42.26
-5/8 + 1/2.......	15.0	35.1	10.7	20.2	75.20	24.9	10.5	26.2	18.72	7.90	19.70	51.78
-1/2 + 1/4.......	20.6	30.8	9.6	22.5	72.40	20.1	5.0	30.6	14.55	3.62	22.15	43.18
-1/4 + 0.........	3.5	32.7	9.8	22.4	74.87	18.5	5.2	29.7	13.85	3.89	22.24	44.26
Composite (calculated)..	100.0	32.6	9.5	23.1	-	-	-	-	14.20	4.60	22.25	43.99
Composite (analysis)....	-	31.9	10.0	24.1	75.40	15.5	5.0	31.3	11.69	3.77	23.60	40.65

[1]Value based on calculated Davis tube products.

TABLE B-3. - Sample identification head, LC3/4-fine ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution[1], pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	16.8	37.7	10.3	21.3	31.67	70.4	16.1	1.2	22.29	5.10	0.38	62.70
-5/8 + 1/2.......	25.2	34.7	11.0	21.3	33.60	70.4	22.8	1.1	23.65	7.66	0.37	59.74
-1/2 + 1/4.......	44.9	34.5	10.5	21.6	30.80	69.6	23.7	0.94	21.44	7.30	0.29	60.65
-1/4 + 0.........	13.1	33.1	10.3	21.9	28.73	69.6	24.0	0.93	20.00	6.90	0.27	58.88
Composite (calculated)..	100.0	34.9	10.6	21.5	-	-	-	-	21.95	6.97	0.32	60.52
Composite (analysis)....	-	39.9	10.5	22.1	30.67	69.6	22.8	1.3	21.34	6.99	0.40	62.45
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	16.8	37.7	10.3	21.3	68.33	19.4	4.6	31.0	13.26	3.14	21.18	37.30
-5/8 + 1/2.......	25.2	34.7	11.0	21.3	66.40	24.0	5.0	31.7	15.94	3.32	21.05	40.26
-1/2 + 1/4.......	44.9	34.5	10.5	21.6	69.20	20.1	6.8	31.2	13.91	4.71	21.59	39.35
-1/4 + 0.........	13.1	33.1	10.3	21.9	71.27	19.6	6.4	30.3	13.97	4.56	21.59	41.12
Composite (calculated)..	100.0	34.9	10.6	21.5	-	-	-	-	14.32	4.08	21.39	39.48
Composite (analysis)....	-	39.9	10.5	22.1	69.33	18.5	5.2	31.3	12.83	3.61	21.70	37.55

[1]Value based on calculated Davis tube products.

TABLE B-6. - Sample identification head, LC5-coarse ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution[1], pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	4.8	34.7	5.0	23.4	10.07	69.1	24.0	1.6	6.96	2.42	0.16	22.34
-2-1/2 + 1-3/4...	21.6	34.2	5.7	23.6	16.40	70.3	23.5	1.2	11.53	3.85	0.20	36.79
-1-3/4 + 1.......	51.8	32.2	5.7	24.5	12.73	69.1	22.8	1.6	8.80	2.90	0.20	29.07
-1 + 5/8.........	14.6	30.6	7.3	24.7	17.73	68.5	24.0	1.5	12.15	4.26	0.27	37.04
-5/8 + 1/2.......	2.7	31.7	10.0	24.0	33.93	69.1	22.4	1.2	23.45	7.60	0.41	67.48
-1/2 + 1/4.......	2.2	35.8	9.2	21.0	25.40	70.7	22.8	0.88	17.96	5.79	0.22	50.08
-1/4 + 0.........	2.3	34.0	3.8	22.1	17.40	69.6	22.4	0.92	12.11	3.90	0.16	36.88
Composite (calculated)..	100.0	32.6	6.1	24.1	-	-	-	-	10.46	3.98	0.21	33.51
Composite (analysis)....	-	31.0	3.2	25.4	15.60	69.6	22.8	1.4	10.86	3.56	0.22	33.80
					NONMAGNETIC							
-3 + 2-1/2.......	4.8	34.7	5.0	23.4	89.93	26.9	2.3	25.9	24.19	2.07	23.29	77.66
-2-1/2 + 1-3/4...	21.6	34.2	5.7	23.6	83.60	23.7	2.3	28.5	19.81	1.92	23.83	63.21
-1-3/4 + 1.......	51.8	32.2	5.7	24.5	87.27	24.6	2.3	28.1	21.47	2.01	24.52	70.93
-1 + 5/8.........	14.6	30.6	7.3	24.7	82.27	25.1	5.7	30.1	20.65	4.69	24.76	62.96
-5/8 + 1/2.......	2.7	31.7	10.0	24.0	66.07	17.1	2.3	36.4	11.30	1.52	24.05	32.52
-1/2 + 1/4.......	2.2	35.8	9.2	21.0	74.60	24.0	3.4	28.1	17.90	2.54	20.96	49.92
-1/4 + 0.........	2.3	34.0	3.8	22.1	82.60	25.1	2.7	27.1	20.73	2.23	22.38	63.12
Composite (calculated)..	100.0	32.6	6.1	24.1	-	-	-	-	20.75	2.39	24.21	66.49
Composite (analysis)....	-	31.0	3.2	25.4	84.40	25.2	2.3	29.4	21.27	1.94	24.81	66.20

[1]Value based on calculated Davis tube products.

TABLE B-4. - Sample identification head, LC3/4-coarse ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis tube magnetic tube test							Total Fe distribution[1], pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	3.8	35.4	9.6	21.1	26.40	69.6	22.8	1.1	18.37	6.02	0.29	52.26
-2-1/2 + 1-3/4...	14.1	33.3	9.2	21.6	20.40	69.8	22.8	1.5	14.24	4.65	0.31	40.57
-1-3/4 + 1.......	34.0	31.0	8.9	23.6	25.67	69.7	23.5	1.3	17.89	6.03	0.33	55.37
-1 + 5/8.........	33.8	29.7	9.2	24.3	25.87	69.4	25.8	1.4	17.95	6.67	0.36	62.07
-5/8 + 1/2.......	8.5	34.5	10.0	21.7	29.67	69.6	24.0	1.4	20.65	7.12	0.42	60.22
-1/2 + 1/4.......	5.4	31.5	9.6	24.1	24.67	69.6	25.1	1.2	17.17	6.19	0.30	59.51
-1/4 + 0.........	0.4	33.1	10.3	21.9	25.33	69.3	24.9	1.1	17.56	6.30	0.28	55.83
Composite (calculated)..	100.0	31.4	9.2	23.3	-	-	-	-	17.61	6.15	0.34	55.64
Composite (analysis)....	-	30.4	10.0	24.2	27.40	69.8	23.0	1.6	19.13	6.30	0.44	62.97
					NONMAGNETIC							
-3 + 2-1/2.......	3.8	35.4	9.6	21.1	73.60	22.8	5.5	28.7	16.78	4.05	21.12	47.74
-2-1/2 + 1-3/4...	14.1	33.3	9.2	21.6	79.60	26.2	5.5	27.2	20.86	4.38	21.65	59.43
-1-3/4 + 1.......	34.0	31.0	8.9	23.6	74.33	19.4	5.5	1.8	14.42	4.09	23.64	44.63
-1 + 5/8.........	33.8	29.7	9.2	24.3	74.13	14.8	7.8	32.8	10.97	5.78	24.32	37.93
-5/8 + 1/2.......	8.5	34.5	10.0	21.7	70.33	19.4	7.5	30.5	13.64	5.28	21.45	39.78
-1/2 + 1/4.......	5.4	31.5	9.6	24.1	75.33	15.5	6.4	32.1	11.68	4.82	24.18	40.49
-1/4 + 0.........	0.4	33.1	10.3	21.9	74.67	18.6	5.2	29.0	13.89	3.88	21.65	44.17
Composite (calculated)..	100.0	31.4	9.2	23.3	-	-	-	-	14.04	4.84	23.34	44.36
Composite (analysis)....	-	30.4	10.0	24.2	72.60	15.5	4.8	32.5	11.25	3.48	23.60	37.03

[1]Value based on calculated Davis tube products.

TABLE B-5. - Sample identification head, LC5-fine ore

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	0.0	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	0.0	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	0.0	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	4.6	37.7	6.2	20.4	17.80	68.7	23.3	1.4	12.23	4.15	0.25	33.60
-5/8 + 1/2.......	5.8	34.9	6.8	21.2	20.87	69.1	27.4	1.1	14.42	5.72	0.23	42.75
-1/2 + 1/4.......	25.2	37.4	7.1	21.4	20.53	69.1	23.5	1.1	14.19	4.83	0.23	42.06
-1/4 + 0.........	64.4	33.3	6.8	21.6	17.40	69.6	22.8	0.9	12.11	3.97	0.16	36.41
Composite (calculated)..	100.0	34.7	6.7	21.5	-	-	-	-	12.77	4.30	0.19	38.06
Composite (analysis)....	-	35.6	7.3	21.9	18.60	69.6	23.3	1.1	12.95	4.33	0.20	38.80
					NONMAGNETIC							
-3 + 2-1/2.......	0.0	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	0.0	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	0.0	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	4.6	37.7	6.2	20.4	82.20	29.4	2.3	24.4	24.17	1.89	20.06	66.40
-5/8 + 1/2.......	5.8	34.9	6.8	21.2	79.13	24.4	2.3	27.0	19.31	1.82	21.37	57.25
-1/2 + 1/4.......	25.2	37.4	7.1	21.4	79.47	24.6	2.3	27.0	19.55	1.83	21.46	57.94
-1/4 + 0.........	64.4	33.3	6.8	21.6	82.60	25.6	3.4	26.0	21.15	2.81	21.48	63.59
Composite (calculated)..	100.0	34.7	6.7	21.5	-	-	-	-	20.78	2.46	21.40	61.94
Composite (analysis)....	-	35.6	7.3	21.9	81.40	25.1	3.4	26.5	20.43	2.77	21.57	61.20

[1]Value based on calculated Davis tube products.

TABLE B-7. - Sample identification 86-023 concentrate LC2-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.7	39.7	3.3	15.4	29.53	70.5	22.2	0.6	20.82	6.56	0.18	52.06
-5/8 + 1/2.......	8.4	38.5	12.0	17.2	29.67	70.2	23.2	0.74	20.83	6.88	0.22	53.84
-1/2 + 1/4.......	33.6	41.9	11.4	17.4	28.27	68.0	22.2	0.78	19.22	6.28	0.22	50.27
-1/4 + 0.........	52.3	32.2	2.2	20.5	17.80	70.2	22.5	0.75	12.50	4.01	0.13	37.91
Composite (calculated)..	100.0	36.4	6.2	18.9	-	-	-	-	15.93	5.16	0.17	44.72
Composite (analysis)....	-	34.5	6.6	19.5	23.33	69.6	12.5	0.72	16.24	2.89	0.17	47.09
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.7	39.7	3.3	15.4	70.47	27.2	9.1	19.2	19.17	6.41	13.53	47.94
-5/8 + 1/2.......	8.4	38.5	12.0	17.2	70.33	25.4	7.5	21.9	17.86	5.28	15.40	46.16
-1/2 + 1/4.......	33.6	41.9	11.4	17.4	71.73	26.5	6.8	22.5	19.01	4.88	16.14	49.73
-1/4 + 0.........	52.3	32.2	2.2	20.5	82.20	24.9	6.4	23.9	20.47	5.26	19.65	62.09
Composite (calculated)..	100.0	36.4	6.2	18.9	-	-	-	-	19.69	5.20	17.76	55.28
Composite (analysis)....	-	34.5	6.6	19.5	76.67	23.8	6.1	23.1	18.25	4.68	17.71	52.91

[1]Value based on calculated Davis tube products.

TABLE B-8. - Sample identification 86-023 tails LC2-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.8	27.2	7.5	23.2	4.73	70.2	-	-	3.32	-	-	11.62
-5/8 + 1/2.......	9.1	27.0	8.4	22.0	4.13	69.1	-	-	2.86	-	-	10.12
-1/2 + 1/4.......	32.9	27.2	0.8	21.1	4.47	68.2	-	-	3.05	-	-	10.82
-1/4 + 0.........	51.2	27.2	2.1	22.2	2.80	70.9	-	-	5.53	-	0.08	19.67
Composite (calculated)..	100.0	27.2	2.6	21.9	-	-	-	-	4.32	-	-	15.33
Composite (analysis)....	-	26.8	4.5	23.7	6.67	67.1	-	1.0	4.47	-	0.15	16.75
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.8	27.2	7.5	23.2	95.27	26.5	6.6	24.8	25.25	6.29	23.63	88.38
-5/8 + 1/2.......	9.1	27.0	8.4	22.0	95.87	26.5	7.5	24.1	25.40	7.19	23.10	89.88
-1/2 + 1/4.......	32.9	27.2	0.8	21.1	95.53	26.3	7.0	24.7	25.13	6.69	23.60	89.18
-1/4 + 0.........	51.2	27.2	2.1	22.2	92.20	24.5	5.9	21.2	22.59	5.44	19.55	80.33
Composite (calculated)..	100.0	27.2	2.6	21.9	-	-	-	-	23.86	6.07	21.48	84.67
Composite (analysis)....	-	26.8	4.5	23.7	93.33	23.8	6.6	26.7	22.21	6.16	24.92	83.25

[1]Value based on calculated Davis tube products.

TABLE B-9. - Sample identification 86-025 concentrate LC2-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.8	51.3	17.8	10.3	46.00	69.8	21.9	0.84	32.11	10.07	0.39	66.54
-5/8 + 1/2.......	8.2	50.7	17.1	12.5	44.33	69.8	22.4	0.78	30.94	9.93	0.35	66.98
-1/2 + 1/4.......	32.9	49.1	13.7	13.5	39.87	69.8	22.1	0.72	27.83	8.81	0.29	63.24
-1/4 + 0.........	53.1	37.2	10.3	20.2	20.93	70.2	22.9	1.2	14.70	4.79	0.25	44.60
Composite (calculated)..	100.0	43.0	12.4	16.8	-	-	-	-	21.36	6.84	0.28	55.38
Composite (analysis)....	-	40.8	14.7	17.1	31.47	70.5	22.9	1.4	22.18	7.21	0.44	57.84
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.8	51.3	17.8	10.3	54.00	29.9	9.6	18.4	16.15	5.18	9.94	33.46
-5/8 + 1/2.......	8.2	50.7	17.1	12.5	55.67	27.4	7.5	22.1	15.25	4.18	12.30	38.02
-1/2 + 1/4.......	32.9	49.1	13.7	13.5	60.13	26.9	8.0	22.1	16.18	4.81	13.29	36.76
-1/4 + 0.........	53.1	37.2	10.3	20.2	79.07	23.1	5.7	24.8	18.26	4.51	19.61	55.40
Composite (calculated)..	100.0	43.0	12.4	16.8	-	-	-	-	17.21	4.62	16.37	44.62
Composite (analysis)....	-	40.8	14.7	17.1	68.53	23.6	6.1	22.7	16.17	4.18	15.56	42.16

[1]Value based on calculated Davis tube products.

TABLE B-10. - Sample identification 86-025 tails LC2-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.7	27.2	9.1	25.5	10.53	68.9	22.3	1.5	7.26	2.35	0.16	28.46
-5/8 + 1/2.......	7.0	31.3	9.3	21.6	9.67	69.1	-	1.2	6.68	-	0.12	22.69
-1/2 + 1/4.......	27.8	28.3	9.1	22.3	11.00	69.1	23.3	1.3	7.60	2.56	0.14	25.54
-1/4 + 0.........	59.5	29.7	9.1	22.9	11.00	69.1	23.6	1.2	7.60	2.60	0.13	27.16
Composite (calculated)..	100.0	29.3	9.1	22.8	-	-	-	-	7.52	-	0.13	26.44
Composite (analysis)....	-	32.6	8.2	22.9	11.67	67.4	22.7	2.5	7.86	2.65	0.29	26.32
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.7	27.2	9.1	25.5	89.47	20.4	7.3	29.0	18.25	6.53	25.95	71.54
-5/8 + 1/2.......	7.0	31.3	9.3	21.6	90.33	25.2	9.1	24.2	22.76	8.22	21.86	77.31
-1/2 + 1/4.......	27.8	28.3	9.1	22.3	89.00	24.9	7.3	24.9	22.16	6.50	22.16	74.46
-1/4 + 0.........	59.5	29.7	9.1	22.9	89.00	22.9	5.7	26.0	20.38	5.07	23.14	72.84
Composite (calculated)..	100.0	29.3	9.1	22.8	-	-	-	-	20.92	5.77	22.94	73.56
Composite (analysis)....	-	32.6	8.2	22.9	88.33	24.9	6.1	23.8	22.00	5.39	21.02	73.68

[1]Value based on calculated Davis tube products.

TABLE B-11. - Sample identification 86-026 concentrate LC3/4-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	7.9	38.8	11.4	21.1	34.67	69.8	22.8	0.93	24.20	7.90	0.32	69.84
-5/8 + 1/2.......	16.6	34.5	11.4	21.7	32.33	69.8	23.3	0.94	22.57	7.53	0.30	67.31
-1/2 + 1/4.......	42.5	35.1	13.0	21.3	32.53	70.5	24.0	1.00	22.71	7.58	0.33	65.54
-1/4 + 0.........	33.0	33.3	12.1	21.8	30.07	70.9	23.1	1.00	21.32	6.95	0.30	63.93
Composite (calculated)..	100.0	34.7	12.3	21.5	-	-	-	-	22.35	7.39	0.31	65.66
Composite (analysis)....	-	37.4	11.8	21.5	33.80	69.1	22.9	1.7	23.36	7.74	0.57	62.14
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	7.9	38.8	11.4	21.1	65.33	16.0	5.0	32.1	10.45	3.27	20.97	30.16
-5/8 + 1/2.......	16.6	34.5	11.4	21.7	67.67	16.2	5.2	31.5	10.96	3.52	21.32	32.69
-1/2 + 1/4.......	42.5	35.1	13.0	21.3	67.47	17.7	5.0	30.6	11.94	3.37	20.64	34.46
-1/4 + 0.........	33.0	33.3	12.1	21.8	69.93	17.2	5.2	30.5	12.03	3.64	21.33	36.07
Composite (calculated)..	100.0	34.7	12.3	21.5	-	-	-	-	11.69	3.48	21.01	34.34
Composite (analysis)....	-	37.4	11.8	21.5	66.20	21.5	5.7	29.6	14.23	3.77	19.60	37.86

[1]Value based on calculated Davis tube products.

TABLE B-12. - Sample identification 86-026 tails LC3/4-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	11.0	23.8	8.8	27.1	7.33	69.1	23.6	1.7	8.80	3.01	0.22	35.77
-5/8 + 1/2.......	19.3	25.6	9.3	26.9	13.13	68.9	23.8	1.8	9.05	3.13	0.24	35.05
-1/2 + 1/4.......	45.3	22.7	7.9	27.3	12.60	69.3	24.0	1.5	8.73	3.02	0.19	36.62
-1/4 + 0.........	24.4	27.2	8.4	26.0	17.13	70.2	24.0	1.4	12.03	4.11	0.24	44.51
Composite (calculated)..	100.0	24.5	8.4	26.9	-	-	-	-	9.60	3.31	0.22	38.28
Composite (analysis)....	-	24.0	7.9	26.8	15.53	64.6	23.6	3.8	10.03	3.67	0.59	38.09
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	11.0	23.8	8.8	27.1	92.67	18.1	5.2	31.6	15.80	4.54	27.58	64.23
-5/8 + 1/2.......	19.3	25.6	9.3	26.9	86.67	19.3	5.2	31.1	16.77	4.52	27.02	64.95
-1/2 + 1/4.......	45.3	22.7	7.9	27.3	87.40	17.0	5.0	31.6	15.11	4.37	27.62	63.38
-1/4 + 0.........	24.4	27.2	8.4	26.0	82.87	18.1	5.7	31.4	15.00	4.72	26.02	55.49
Composite (calculated)..	100.0	24.5	8.4	26.9	-	-	-	-	15.48	4.50	27.11	61.72
Composite (analysis)....	-	24.0	7.9	26.8	84.47	19.3	5.7	29.8	16.30	4.81	25.17	61.91

[1]Value based on calculated Davis tube products.

TABLE B-13. - Sample identification 86-028 concentrate LC3/4-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.2	33.8	2.7	23.4	29.47	70.9	22.9	1.0	20.89	6.75	0.29	60.55
-5/8 + 1/2.......	11.8	32.9	2.7	23.8	29.20	68.2	23.4	0.93	19.91	6.83	0.27	60.19
-1/2 + 1/4.......	38.9	34.0	10.4	24.3	29.73	70.2	23.6	1.0	20.87	7.02	0.30	64.57
-1/4 + 0.........	44.1	33.6	10.2	23.6	29.20	70.5	23.8	0.74	20.59	6.95	0.22	64.08
Composite (calculated)..	100.0	33.7	9.0	23.9	-	-	-	-	20.63	6.95	0.26	63.61
Composite (analysis)....	-	32.2	5.5	23.9	30.20	68.9	12.0	1.4	20.81	3.62	0.42	63.41
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.2	33.8	2.7	23.4	70.53	19.3	5.5	29.6	13.61	3.88	20.88	39.45
-5/8 + 1/2.......	11.8	32.9	2.7	23.8	70.80	18.6	5.0	28.8	13.17	3.54	20.39	39.81
-1/2 + 1/4.......	38.9	34.0	10.4	24.3	70.27	16.3	5.2	30.0	11.45	3.65	21.08	35.43
-1/4 + 0.........	44.1	33.6	10.2	23.6	70.80	16.3	5.9	29.9	11.54	4.18	21.17	35.92
Composite (calculated)..	100.0	33.7	9.0	23.9	-	-	-	-	11.80	3.88	21.03	36.39
Composite (analysis)....	-	32.2	5.5	23.9	69.80	17.2	5.2	32.2	12.01	3.63	22.48	36.59

[1]Value based on calculated Davis tube products.

TABLE B-14. - Sample identification 86-028 tails LC3/4-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	23.1	21.5	1.8	29.2	6.67	68.2	-	1.3	4.55	-	0.09	21.22
-5/8 + 1/2.......	27.4	20.4	6.1	30.5	6.47	70.0	-	1.7	4.53	-	0.11	21.97
-1/2 + 1/4.......	42.2	21.5	6.3	30.8	5.80	71.4	-	-	4.14	-	-	19.54
-1/4 + 0.........	7.3	26.3	7.7	27.1	11.07	70.6	24.7	1.3	7.81	2.73	0.14	33.16
Composite (calculated)..	100.0	21.6	5.3	30.1	-	-	-	-	4.61	-	-	21.68
Composite (analysis)....	-	23.3	3.4	29.4	7.67	67.4	23.2	2.7	5.17	1.78	0.21	24.56
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	23.1	21.5	1.8	29.2	93.33	18.1	5.9	31.0	16.89	5.51	28.93	78.78
-5/8 + 1/2.......	27.4	20.4	6.1	30.5	93.53	17.2	6.1	31.6	16.09	5.71	29.56	78.03
-1/2 + 1/4.......	42.2	21.5	6.3	30.8	94.20	18.1	5.2	31.6	17.05	4.90	29.77	80.46
-1/4 + 0.........	7.3	26.3	7.7	27.1	88.93	17.7	5.7	30.3	15.74	5.07	26.95	66.84
Composite (calculated)..	100.0	21.6	5.3	30.1	-	-	-	-	16.65	5.28	28.23	78.32
Composite (analysis)....	-	23.3	3.4	29.4	92.33	17.2	6.8	30.1	15.88	6.28	27.79	75.44

[1]Value based on calculated Davis tube products.

TABLE B-15. - Sample identification 86-035 concentrate LC5-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.5	39.7	11.1	20.8	33.27	70.2	21.1	0.94	23.35	7.02	0.31	61.94
-5/8 + 1/2.......	8.5	39.7	9.3	22.0	29.93	70.2	22.7	0.66	21.01	6.79	0.20	56.91
-1/2 + 1/4.......	28.3	39.2	9.5	21.3	29.40	68.0	22.7	0.96	19.99	6.67	0.28	55.28
-1/4 + 0.........	57.7	34.0	5.0	23.9	14.33	69.8	22.2	0.66	10.00	3.18	0.09	29.50
Composite (calculated)..	100.0	36.3	7.0	22.8	-	-	-	-	14.50	4.69	0.17	41.42
Composite (analysis)....	-	34.1	4.1	23.9	20.93	69.1	11.8	0.89	14.46	2.47	0.19	41.67
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	5.5	39.7	11.1	20.8	66.73	21.5	4.1	27.0	14.35	2.74	18.02	38.06
-5/8 + 1/2.......	8.5	39.7	9.3	22.0	70.07	22.7	3.9	27.0	15.91	2.73	18.92	43.09
-1/2 + 1/4.......	28.3	39.2	9.5	21.3	70.60	22.9	3.6	26.3	16.17	2.54	18.57	44.72
-1/4 + 0.........	57.7	34.0	5.0	23.9	85.67	27.9	2.3	26.4	23.90	1.97	22.62	70.50
Composite (calculated)..	100.0	36.3	7.0	22.8	-	-	-	-	20.51	2.24	20.91	58.58
Composite (analysis)....	-	34.0	4.1	23.9	79.07	25.6	5.7	29.9	20.24	4.51	23.64	38.33

[1]Value based on calculated Davis tube products.

TABLE B-16. - Sample identification 86-035 tails LC5-fine ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	4.8	33.1	2.7	26.7	3.47	70.7	-	-	2.45	-	-	10.06
-5/8 + 1/2.......	7.0	31.3	2.3	26.4	3.60	71.6	-	-	2.58	-	-	8.64
-1/2 + 1/4.......	25.4	31.7	1.8	26.5	3.53	70.6	-	-	2.49	-	-	8.05
-1/4 + 0.........	62.8	32.0	3.2	24.7	6.33	69.3	-	0.90	4.39	-	0.06	14.21
Composite (calculated)..	100.0	31.9	2.8	25.4	-	-	-	-	3.69	-	-	12.09
Composite (analysis)....	-	33.3	5.0	24.7	5.33	67.2	-	2.4	3.58	-	0.13	11.75
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	4.8	33.1	2.7	26.7	96.53	22.7	0.91	27.6	21.91	0.88	26.64	89.94
-5/8 + 1/2.......	7.0	31.3	2.3	26.4	96.40	28.3	1.40	28.3	27.28	1.35	27.28	91.36
-1/2 + 1/4.......	25.4	31.7	1.8	26.5	96.47	29.5	4.5	28.3	28.46	4.34	27.30	91.95
-1/4 + 0.........	62.8	32.0	3.2	24.7	93.67	28.3	1.6	27.4	26.51	1.50	25.66	85.79
Composite (calculated)..	100.0	31.9	2.8	25.4	-	-	-	-	26.84	2.18	26.24	87.91
Composite (analysis)....	-	33.3	5.0	24.7	94.67	28.4	1.6	27.7	26.89	1.51	26.22	88.25

[1]Based on calculated Davis tube products.

TABLE B-17. - Sample identification 86-037 concentrate LC5-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	9.9	44.5	13.7	17.4	45.20	70.9	22.7	1.0	32.05	10.26	0.45	74.14
-5/8 + 1/2.......	12.9	43.6	13.0	16.1	50.07	70.2	22.0	0.9	35.15	11.01	0.45	79.54
-1/2 + 1/4.......	36.0	43.1	13.9	16.1	42.07	70.7	24.0	1.1	29.74	10.10	0.46	69.34
-1/4 + 0.........	41.2	38.3	9.1	20.2	22.13	70.2	22.0	1.0	15.54	4.87	0.22	45.61
Composite (calculated)..	100.0	41.3	11.8	17.9	-	-	-	-	24.82	8.08	0.36	62.90
Composite (analysis)....	-	39.7	11.5	18.0	37.80	69.1	23.1	1.9	26.12	8.73	0.72	64.91
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	9.9	44.5	13.7	17.4	54.80	20.4	5.7	27.4	11.18	3.12	15.02	25.86
-5/8 + 1/2.......	12.9	43.6	13.0	16.1	49.93	18.1	4.8	27.2	9.04	2.40	13.58	20.46
-1/2 + 1/4.......	36.0	43.1	13.9	16.1	57.93	22.7	4.8	26.2	13.15	2.78	15.18	30.66
-1/4 + 0.........	41.2	38.3	9.1	20.2	77.87	23.8	4.5	26.4	18.53	3.50	20.56	54.39
Composite (calculated)..	100.0	41.3	11.8	17.9	-	-	-	-	14.64	3.06	17.17	37.10
Composite (analysis)....	-	39.7	11.5	18.0	62.20	22.7	4.1	26.4	14.12	2.55	16.42	35.09

[1]Value based on calculated Davis tube products.

TABLE B-18. - Sample identification 86-037 tails LC5-fine ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.2	30.3	5.0	24.6	7.73	69.3	-	1.7	5.36	-	0.13	17.98
-5/8 + 1/2.......	8.5	29.5	4.5	24.6	8.67	69.1	-	1.7	5.99	-	0.15	20.08
-1/2 + 1/4.......	24.5	30.3	4.1	24.9	9.33	69.1	-	1.6	6.45	-	0.15	21.42
-1/4 + 0.........	60.8	29.9	4.5	23.4	9.67	69.1	22.9	1.3	6.68	2.21	0.13	21.82
Composite (calculated)..	100.0	30.0	4.4	23.9	-	-	-	-	6.48	-	0.14	21.34
Composite (analysis)....	-	31.7	7.9	25.5	10.53	68.4	-	3.5	7.20	-	0.37	24.42
					NONMAGNETIC							
-3 + 2-1/2.......	-	-	-	-	-	-	-	-	-	-	-	-
-2-1/2 + 1-3/4...	-	-	-	-	-	-	-	-	-	-	-	-
-1-3/4 + 1.......	-	-	-	-	-	-	-	-	-	-	-	-
-1 + 5/8.........	6.2	30.3	5.0	24.6	92.27	26.5	3.4	27.7	24.45	3.14	25.56	82.02
-5/8 + 1/2.......	8.5	29.5	4.5	24.6	91.33	26.1	3.4	27.5	23.84	3.11	25.12	79.92
-1/2 + 1/4.......	24.5	30.3	4.1	24.9	90.67	25.1	5.0	29.0	23.66	4.53	26.29	78.58
-1/4 + 0.........	60.8	29.9	4.5	23.4	90.33	26.5	3.2	29.3	23.94	2.89	26.47	78.18
Composite (calculated)..	100.0	30.0	4.4	23.9	-	-	-	-	23.89	3.33	26.25	78.66
Composite (analysis)....	-	31.7	7.9	25.5	89.47	24.9	4.8	26.9	22.28	4.29	24.07	75.58

[1]Value based on calculated Davis tube products.

TABLE B-19. - Sample identification 86-040 concentrate LC3/4-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	5.1	26.0	9.1	29.5	26.80	70.4	22.9	1.1	18.87	6.14	0.29	79.12
-2-1/2 + 1-3/4...	9.6	34.2	11.6	21.6	36.53	70.7	22.0	1.1	25.83	8.04	0.40	76.51
-1-3/4 + 1.......	42.0	33.3	11.4	21.7	34.67	70.2	22.9	0.92	24.34	7.94	0.32	72.27
-1 + 5/8.........	33.2	31.9	11.4	22.8	31.80	70.4	22.9	1.3	22.39	7.28	0.41	69.36
-5/8 + 1/2.......	6.1	30.1	10.7	22.9	30.33	71.0	22.7	1.0	21.54	6.89	0.30	68.84
-1/2 + 1/4.......	3.0	31.9	10.3	23.3	30.73	71.0	22.7	0.93	21.82	6.98	0.29	69.23
-1/4 + 0.........	1.0	31.5	10.3	22.1	26.67	71.1	24.0	0.73	18.96	6.40	0.19	58.83
Composite (calculated)..	100.0	32.3	11.2	22.6	-	-	-	-	23.26	7.53	0.35	71.57
Composite (analysis)....	-	24.2	11.3	24.2	36.07	68.2	23.8	2.3	24.60	8.58	0.83	68.49
					NONMAGNETIC							
-3 + 2-1/2.......	5.1	26.0	9.1	29.5	73.20	6.8	4.7	38.7	4.98	3.43	28.33	20.88
-2-1/2 + 1-3/4...	9.6	34.2	11.6	21.6	63.47	12.5	5.0	32.7	7.93	3.17	20.75	23.49
-1-3/4 + 1.......	42.0	33.3	11.4	21.7	65.33	14.3	4.8	31.9	9.34	3.14	20.84	27.73
-1 + 5/8.........	33.2	31.9	11.4	22.8	68.20	14.5	4.8	32.1	9.89	3.27	21.89	30.64
-5/8 + 1/2.......	6.1	30.1	10.7	22.9	69.67	14.0	4.8	32.0	9.75	3.34	22.29	31.16
-1/2 + 1/4.......	3.0	31.9	10.3	23.3	69.27	14.0	4.5	31.0	9.70	3.12	21.47	30.77
-1/4 + 0.........	1.0	31.5	10.3	22.1	73.33	18.1	5.2	29.2	13.27	3.81	21.41	41.17
Composite (calculated)..	100.0	32.3	11.2	22.6	-	-	-	-	9.24	3.22	21.68	28.43
Composite (analysis)....	-	24.2	11.3	24.2	63.93	17.7	6.3	31.9	11.32	4.03	20.39	31.51

[1]Value based on calculated Davis tube products.

TABLE B-20. - Sample identification 86-040 tails LC3/4-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	3.8	28.2	7.9	27.0	26.33	69.1	21.8	1.6	18.20	5.74	0.42	61.61
-2-1/2 + 1-3/4...	22.8	22.7	6.8	28.0	18.27	69.6	23.1	1.4	12.71	4.22	0.26	46.90
-1-3/4 + 1.......	46.2	21.7	6.8	29.3	7.27	69.6	-	1.5	5.06	-	0.11	23.17
-1 + 5/8.........	23.8	22.7	6.8	29.7	10.80	68.9	23.3	2.0	7.44	2.52	0.22	31.54
-5/8 + 1/2.......	2.5	21.7	5.0	31.1	8.73	69.1	-	1.3	6.03	-	0.11	27.52
-1/2 + 1/4.......	0.5	20.6	7.5	29.2	9.80	69.6	31.2	1.4	6.82	3.06	0.14	30.79
-1/4 + 0.........	0.4	29.2	6.8	24.0	19.33	69.6	31.5	1.3	13.46	6.09	0.25	40.32
Composite (calculated)..	100.0	22.4	6.8	29.0	-	-	-	-	7.94	-	0.18	31.86
Composite (analysis)....	-	26.5	7.9	27.4	16.87	64.4	22.7	4.6	10.86	3.83	0.78	42.47
					NONMAGNETIC							
-3 + 2-1/2.......	3.8	28.2	7.9	27.0	73.67	15.4	4.1	36.6	11.34	3.02	26.96	38.39
-2-1/2 + 1-3/4...	22.8	22.7	6.8	28.0	81.73	17.6	4.1	36.5	14.39	3.35	29.83	53.10
-1-3/4 + 1.......	46.2	21.7	6.8	29.3	92.73	18.1	4.3	34.8	16.78	3.99	32.27	76.83
-1 + 5/8.........	23.8	21.7	6.8	29.7	89.20	18.1	4.8	34.7	16.15	4.28	30.95	68.46
-5/8 + 1/2.......	2.5	21.7	5.0	31.1	91.27	17.4	4.2	36.4	15.88	3.83	33.22	72.48
-1/2 + 1/4.......	0.5	20.6	7.5	29.2	90.20	17.0	4.5	34.2	15.33	4.06	30.85	69.21
-1/4 + 0.........	0.4	29.2	6.8	24.0	80.67	24.7	4.8	29.9	19.92	3.87	24.12	59.68
Composite (calculated)..	100.0	22.4	6.8	29.0	-	-	-	-	16.98	3.87	31.18	68.14
Composite (analysis)....	-	26.5	7.9	27.4	83.13	17.7	4.3	31.6	14.71	3.57	26.27	57.53

[1]Value based on calculated Davis tube products.

TABLE B-21. - Sample identification 86-042 concentrate LC2-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	2.8	31.0	12.6	23.1	32.80	70.8	23.8	0.80	23.22	7.81	0.26	69.17
-2-1/2 + 1-3/4...	10.3	43.8	12.1	14.4	45.27	71.4	23.1	0.75	32.32	10.46	0.34	72.24
-1-3/4 + 1.......	33.3	37.5	12.6	18.4	37.87	71.4	23.6	0.85	27.04	8.94	0.32	68.84
-1 + 5/8.........	18.2	34.7	11.9	19.7	32.53	71.5	23.3	0.90	23.26	7.46	0.29	63.87
-5/8 + 1/2.......	10.3	34.7	12.6	20.4	33.27	70.9	23.1	1.0	23.59	7.68	0.33	66.13
-1/2 + 1/4.......	15.5	33.9	11.9	20.7	33.13	71.0	22.9	1.1	23.52	7.59	0.36	68.33
-1/4 + 0.........	9.6	32.7	11.4	21.2	28.27	71.0	22.7	1.1	20.07	6.42	0.31	56.55
Composite (calculated)..	100.0	36.2	12.2	19.2	-	-	-	-	25.22	8.21	0.32	66.95
Composite (analysis)....	-	35.3	12.2	20.4	35.13	68.4	23.6	2.4	24.03	8.29	0.84	66.57
					NONMAGNETIC							
-3 + 2-1/2.......	2.8	31.0	12.6	23.1	67.20	15.4	5.4	33.7	10.35	3.63	22.65	30.83
-2-1/2 + 1-3/4...	10.3	43.8	12.1	14.4	54.73	22.7	5.9	27.3	12.42	3.23	14.94	27.76
-1-3/4 + 1.......	33.3	37.5	12.6	18.4	62.13	19.7	6.3	28.8	12.24	3.91	17.89	31.16
-1 + 5/8.........	18.2	34.7	11.9	19.7	67.47	19.5	6.1	28.5	13.16	4.12	19.23	36.13
-5/8 + 1/2.......	10.3	34.7	12.6	20.4	66.73	18.1	5.0	29.7	12.08	3.34	19.82	33.87
-1/2 + 1/4.......	15.5	33.9	11.9	20.7	66.87	16.3	5.2	31.5	10.90	3.48	21.06	31.67
-1/4 + 0.........	9.6	32.7	11.4	21.2	71.73	21.5	5.2	30.0	15.42	3.73	21.52	43.45
Composite (calculated)..	100.0	36.2	12.2	19.2	-	-	-	-	12.45	3.73	19.00	33.05
Composite (analysis)....	-	35.3	12.2	20.4	64.87	18.6	5.9	28.3	12.07	3.83	18.36	33.43

[1]Value based on calculated Davis tube products.

TABLE B-22. - Sample identification 86-042 tails LC2-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^{t}	Fe^{+2}	Si	wt, pct	Fe^{t}, pct	Fe^{+2}, pct	Si, pct	Fe^{t}	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	9.1	26.4	6.3	27.8	12.40	69.3	24.5	1.6	8.59	3.04	0.20	33.69
-2-1/2 + 1-3/4...	21.5	22.7	7.5	28.6	14.80	69.1	23.1	1.7	10.23	3.42	0.25	35.31
-1-3/4 + 1.......	48.5	20.6	7.3	30.5	11.93	69.3	23.6	2.0	8.27	2.82	0.24	35.59
-1 + 5/8.........	10.5	22.1	7.3	28.8	10.67	69.3	24.5	1.8	7.39	2.61	0.19	28.16
-5/8 + 1/2.......	2.4	25.6	7.9	27.0	16.00	69.1	25.6	1.1	11.06	4.10	0.18	39.22
-1/2 + 1/4.......	4.2	23.8	7.9	27.4	15.60	69.6	23.8	1.6	10.86	3.71	0.25	42.09
-1/4 + 0.........	3.8	28.6	9.1	24.4	19.60	69.6	23.8	1.2	13.64	4.66	0.24	44.10
Composite (calculated)..	100.0	22.3	7.4	29.2	-	-	-	-	9.01	3.08	0.23	35.32
Composite (analysis)....	-	23.8	7.9	27.8	13.93	62.8	22.7	5.1	8.75	3.16	0.71	31.61
					NONMAGNETIC							
-3 + 2-1/2.......	9.1	26.4	6.3	27.8	87.60	19.3	4.2	31.8	16.91	3.68	27.86	66.31
-2-1/2 + 1-3/4...	21.5	22.7	7.5	28.6	85.20	22.0	5.2	33.5	18.74	4.43	28.54	64.49
-1-3/4 + 1.......	48.5	20.6	7.3	30.5	88.07	17.0	5.2	35.5	14.97	4.58	31.26	64.41
-1 + 5/8.........	10.5	22.1	7.3	28.8	89.30	21.1	5.7	32.4	18.85	5.09	28.94	71.84
-5/8 + 1/2.......	2.4	25.6	7.9	27.0	84.00	20.4	5.4	32.3	17.14	4.54	27.13	60.78
-1/2 + 1/4.......	4.2	23.8	7.9	27.4	84.40	17.7	5.4	31.7	14.94	4.56	26.75	57.91
-1/4 + 0.........	3.8	28.6	9.1	24.4	80.40	21.5	5.7	30.2	17.29	4.58	24.28	55.90
Composite (calculated)..	100.0	22.3	7.4	29.2	-	-	-	-	16.50	4.52	29.57	64.68
Composite (analysis)....	-	23.8	7.9	27.8	86.07	22.0	4.5	30.5	18.93	3.87	26.25	68.39

[1]Value based on calculated Davis tube products.

TABLE B-23. - Sample identification 86-044 concentrate LC2-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	4.0	34.2	10.7	24.1	31.80	70.2	23.1	0.75	22.32	7.35	0.24	66.49
-2-1/2 + 1-3/4...	10.4	33.5	10.9	25.0	25.53	68.2	23.6	0.94	17.41	6.03	0.24	58.62
-1-3/4 + 1.......	29.7	34.4	11.1	24.1	28.27	68.9	22.9	0.94	19.48	6.47	0.27	62.78
-1 + 5/8.........	21.2	34.0	11.6	23.0	30.40	69.1	23.3	0.85	21.01	7.08	0.26	62.51
-5/8 + 1/2.......	8.4	33.3	10.2	23.4	29.60	70.0	23.6	0.79	20.72	6.99	0.23	64.07
-1/2 + 1/4.......	15.1	34.0	10.4	23.2	30.33	70.0	23.3	0.88	21.23	7.07	0.27	63.66
-1/4 + 0.........	11.2	33.3	10.0	23.2	25.60	70.0	23.3	0.87	17.92	5.96	0.22	56.42
Composite (calculated)..	100.0	33.9	10.9	23.7	-	-	-	-	19.90	6.67	0.25	62.01
Composite (analysis)....	-	34.4	6.4	22.6	31.80	68.6	12.5	1.60	21.81	3.98	0.51	64.37
					NONMAGNETIC							
-3 + 2-1/2.......	4.0	34.2	10.7	24.1	68.20	16.5	4.5	32.0	11.25	3.07	21.82	33.51
-2-1/2 + 1-3/4...	10.4	33.5	10.9	25.0	74.47	16.5	6.2	29.6	12.29	4.62	22.04	41.38
-1-3/4 + 1.......	29.7	34.4	11.1	24.1	71.73	16.1	6.3	30.8	11.55	4.52	22.09	37.22
-1 + 5/8.........	21.2	34.0	11.6	23.0	69.60	18.1	6.8	27.8	12.60	4.73	19.35	37.49
-5/8 + 1/2.......	8.4	33.3	10.2	23.4	70.40	16.5	5.9	30.9	11.62	4.15	21.75	35.93
-1/2 + 1/4.......	15.1	34.0	10.4	23.2	69.67	17.4	4.8	29.4	12.12	3.34	20.48	36.34
-1/4 + 0.........	11.2	33.3	10.0	23.2	74.40	18.6	5.4	28.1	13.84	4.02	20.91	43.58
Composite (calculated)..	100.0	33.9	10.9	23.7	-	-	-	-	12.19	4.25	21.09	37.99
Composite (analysis)....	-	34.4	6.4	22.6	68.20	17.7	6.1	31.0	12.07	4.16	21.14	35.63

[1]Value based on calculated Davis tube products.

TABLE B-24. - Sample identification 86-044 tails LC2-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	8.5	20.2	5.7	33.4	12.40	68.0	26.1	1.3	8.43	3.24	0.16	40.74
-2-1/2 + 1-3/4...	19.2	20.4	6.3	31.6	6.00	68.9	-	-	4.13	-	-	22.19
-1-3/4 + 1.......	53.4	20.2	6.3	28.6	6.60	68.4	-	-	4.51	-	-	21.06
-1 + 5/8.........	15.6	20.6	6.8	28.9	3.33	68.0	-	-	4.31	-	-	20.63
-5/8 + 1/2.......	1.6	19.9	7.5	30.9	7.13	68.9	-	0.84	4.91	-	0.06	26.45
-1/2 + 1/4.......	1.2	20.8	7.7	28.3	7.07	71.2	-	0.98	5.03	-	0.07	23.42
-1/4 + 0.........	.5	29.5	11.1	22.0	17.47	70.0	30.6	0.91	12.23	5.34	0.16	43.19
Composite (calculated)..	100.0	20.4	6.4	29.6	-	-	-	-	4.80	-	-	23.15
Composite (analysis)....	-	19.1	4.3	29.4	7.67	64.9	26.8	2.70	4.98	2.05	0.21	25.09
					NONMAGNETIC							
-3 + 2-1/2.......	8.5	20.2	5.7	33.4	87.60	14.0	4.1	40.7	12.26	3.59	35.65	59.26
-2-1/2 + 1-3/4...	19.2	20.4	6.3	31.6	94.00	15.4	5.7	34.6	14.48	5.36	32.52	77.81
-1-3/4 + 1.......	53.4	20.2	6.3	28.6	93.40	18.1	6.1	32.0	16.91	5.70	29.89	78.94
-1 + 5/8.........	15.6	20.6	6.8	28.9	96.67	17.7	5.0	33.7	16.58	4.68	31.57	79.37
-5/8 + 1/2.......	1.6	19.9	7.5	30.9	92.87	14.7	4.3	33.4	13.65	3.99	31.02	73.55
-1/2 + 1/4.......	1.2	20.8	7.7	28.3	92.93	17.7	5.7	29.9	16.45	5.30	27.79	76.58
-1/4 + 0.........	.5	29.5	11.1	22.0	82.53	19.5	5.9	28.0	16.09	4.87	23.11	56.81
Composite (calculated)..	100.0	20.4	6.4	29.6	-	-	-	-	15.93	5.26	31.11	76.85
Composite (analysis)....	-	19.1	4.3	29.4	92.33	16.1	5.7	30.9	14.87	5.26	28.53	74.91

[1]Value based on calculated Davis tube products.

TABLE B-25. - Sample identification 86-045 concentrate LC5-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	10.6	40.3	11.3	15.4	31.93	70.7	23.6	0.86	22.58	7.54	0.27	56.25
-2-1/2 + 1-3/4...	22.5	34.2	10.4	23.2	32.07	70.0	23.7	1.00	22.45	7.60	0.32	67.24
-1-3/4 + 1.......	51.8	33.2	10.0	25.1	30.73	69.8	23.1	1.1	21.45	7.10	0.34	65.80
-1 + 5/8.........	12.6	33.5	9.3	24.5	26.80	70.0	23.4	1.2	18.76	6.27	0.32	60.83
-5/8 + 1/2.......	1.2	34.4	11.8	20.6	33.67	70.7	24.2	0.96	23.80	8.15	0.32	67.35
-1/2 + 1/4.......	.7	34.0	10.4	22.7	29.60	70.9	25.8	0.89	20.99	7.64	0.26	64.37
-1/4 + 0.........	.6	34.2	9.3	21.3	23.60	70.7	24.2	1.1	16.69	5.71	0.26	54.69
Composite (calculated)..	100.0	34.2	10.2	23.5	-	-	-	-	21.45	7.16	0.32	64.28
Composite (analysis)....	-	32.9	5.4	24.2	32.47	67.9	12.3	2.1	22.04	3.99	0.68	64.20
					NONMAGNETIC							
-3 + 2-1/2.......	10.6	40.3	11.3	15.4	68.07	25.8	6.2	19.3	17.56	4.22	13.14	43.75
-2-1/2 + 1-3/4...	22.5	34.2	10.4	23.2	67.93	16.1	5.2	31.1	10.94	3.53	21.13	32.76
-1-3/4 + 1.......	51.8	33.2	10.0	25.1	69.27	16.1	5.4	30.9	11.15	3.74	21.40	34.20
-1 + 5/8.........	12.6	33.5	9.3	24.5	73.20	16.5	5.7	31.2	12.08	4.17	22.84	39.17
-5/8 + 1/2.......	1.2	34.4	11.8	20.6	66.33	17.4	5.0	28.8	11.54	3.32	19.10	32.65
-1/2 + 1/4.......	.7	34.0	10.4	22.7	70.40	16.5	4.1	30.7	11.62	2.89	21.61	35.63
-1/4 + 0.........	.6	34.2	9.3	21.3	76.40	18.1	4.8	26.4	13.83	3.67	20.17	45.31
Composite (calculated)..	100.0	34.2	10.2	23.5	-	-	-	-	11.92	3.79	20.61	35.72
Composite (analysis)....	-	32.9	5.4	24.2	67.53	18.2	4.8	30.6	12.29	3.24	20.67	35.80

[1]Value based on calculated Davis tube products.

TABLE B-26. - Sample identification 86-045 tails LC5-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	4.4	39.7	3.4	19.0	4.67	70.9	-	-	3.31	-	-	8.54
-2-1/2 + 1-3/4...	29.1	26.2	2.8	29.8	3.20	70.2	-	-	2.25	-	-	8.83
-1-3/4 + 1.......	54.8	28.3	2.9	28.1	5.00	68.4	-	-	3.42	-	-	11.96
-1 + 5/8.........	10.4	27.2	2.7	28.9	4.33	66.8	-	-	2.89	-	-	10.00
-5/8 + 1/2.......	.7	32.9	4.3	22.0	6.33	71.8	-	-	4.55	-	-	14.06
-1/2 + 1/4.......	.3	33.5	6.6	19.9	8.20	71.8	-	1.3	5.89	-	0.11	17.15
-1/4 + 0.........	.3	34.4	7.3	18.1	12.73	70.9	38.1	1.0	9.03	4.85	0.13	25.03
Composite (calculated)..	100.0	28.1	2.9	28.2	-	-	-	-	3.05	-	-	10.80
Composite (analysis)....	-	29.0	2.7	28.8	5.87	64.9	-	1.8	3.81	-	0.11	14.74
					NONMAGNETIC							
-3 + 2-1/2.......	4.4	39.7	3.4	19.0	95.33	37.2	1.1	21.8	35.46	1.05	20.78	91.46
-2-1/2 + 1-3/4...	29.1	26.2	2.8	29.8	96.80	24.0	1.8	33.3	23.23	1.74	32.23	91.17
-1-3/4 + 1.......	54.8	28.3	2.9	28.1	95.00	26.5	1.1	30.9	25.18	1.05	29.36	88.04
-1 + 5/8.........	10.4	27.2	2.7	28.9	95.67	27.2	1.6	30.6	26.02	1.53	29.27	90.00
-5/8 + 1/2.......	.7	32.9	4.3	22.0	93.67	29.7	4.1	23.6	27.82	3.84	22.11	85.94
-1/2 + 1/4.......	.3	33.5	6.6	19.9	91.80	31.0	3.6	21.5	28.46	3.30	19.74	82.85
-1/4 + 0.........	.3	34.4	7.3	18.1	87.27	31.0	5.4	21.0	27.05	4.71	18.33	74.97
Composite (calculated)..	100.0	28.1	2.9	28.2	-	-	-	-	25.19	1.34	29.70	89.20
Composite (analysis)....	-	29.0	2.7	28.8	94.13	23.4	4.8	30.9	22.03	4.52	29.09	85.26

[1]Value based on calculated Davis tube products.

TABLE B-27. - Sample identification 86-047 concentrate LC5-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							Total Fe distribution,[1] pct
					Assay				Units			
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	3.3	30.5	11.0	23.1	22.73	71.0	23.6	0.93	16.14	5.37	0.21	50.60
-2-1/2 + 1-3/4...	19.3	34.2	11.4	20.2	39.27	71.0	22.7	1.2	27.88	8.91	0.47	81.52
-1-3/4 + 1.......	44.2	33.9	11.0	20.9	36.27	71.0	22.7	1.1	25.75	8.23	0.40	75.80
-1 + 5/8.........	20.9	35.7	11.2	19.9	35.07	70.9	22.4	1.1	24.86	7.85	0.39	68.39
-5/8 + 1/2.......	4.6	34.9	10.7	21.0	36.60	71.0	22.7	1.1	25.99	8.31	0.40	73.21
-1/2 + 1/4.......	4.6	33.2	10.3	21.5	31.67	70.5	22.7	1.0	22.33	7.19	0.32	66.44
-1/4 + 0.........	3.1	33.8	9.6	21.4	24.80	71.2	22.7	1.0	17.66	5.63	0.25	50.85
Composite (calculated)..	100.0	34.2	11.0	20.7	-	-	-	-	25.26	8.06	0.40	73.17
Composite (analysis)....	-	35.3	12.5	20.5	37.47	69.1	23.8	2.4	25.89	8.92	0.90	70.05
					NONMAGNETIC							
-3 + 2-1/2.......	3.3	30.5	11.0	23.1	77.27	20.4	4.3	30.5	15.76	3.32	23.57	49.40
-2-1/2 + 1-3/4...	19.3	34.2	11.4	20.2	60.73	10.4	4.8	33.9	6.32	2.92	20.59	18.48
-1-3/4 + 1.......	44.2	33.9	11.0	20.9	63.73	12.9	4.5	33.2	8.22	2.87	21.16	24.20
-1 + 5/8.........	20.9	35.7	11.2	19.9	64.93	17.7	4.5	31.2	11.49	2.92	20.26	31.61
-5/8 + 1/2.......	4.6	34.9	10.7	21.0	63.40	15.0	4.3	33.3	9.51	2.73	21.11	26.79
-1/2 + 1/4.......	4.6	33.2	10.3	21.5	68.33	16.5	4.8	32.3	11.28	3.28	22.07	33.56
-1/4 + 0.........	3.1	33.8	9.6	21.4	75.20	22.7	4.5	29.0	17.07	3.38	21.81	49.15
Composite (calculated)..	100.0	34.2	11.0	20.7	-	-	-	-	9.26	2.93	21.00	26.83
Composite (analysis)....	-	35.3	12.5	20.5	62.53	17.7	5.0	29.3	11.07	3.13	18.32	29.95

[1]Value based on calculated Davis tube products.

TABLE B-28. - Sample identification 86-047 tails LC5-coarse ore, 50 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	12.3	27.4	10.2	26.7	26.07	69.6	23.8	1.2	18.14	6.20	0.31	59.07
-2-1/2 + 1-3/4...	32.4	26.3	4.8	29.9	9.27	69.6	22.2	1.6	6.45	2.06	0.15	23.84
-1-3/4 + 1.......	45.1	27.2	4.1	30.2	7.60	70.0	-	1.8	5.32	-	0.14	20.24
-1 + 5/8.........	9.3	29.5	3.2	27.3	7.07	70.2	-	1.7	4.96	-	0.12	17.65
-5/8 + 1/2.......	0.4	29.7	4.8	25.7	6.13	70.0	-	1.5	4.29	-	0.09	14.07
-1/2 + 1/4.......	0.3	27.4	7.7	26.2	7.60	70.2	-	1.6	5.34	-	0.12	19.54
-1/4 + 0.........	0.2	31.0	6.8	20.3	13.73	70.2	30.3	1.3	9.64	4.16	0.18	27.47
Composite (calculated)..	100.0	27.2	5.0	29.4	-	-	-	-	7.23	-	0.16	26.50
Composite (analysis)....	-	28.1	5.0	28.7	10.00	66.0	-	4.0	6.60	-	0.40	24.42
					NONMAGNETIC							
-3 + 2-1/2.......	12.3	27.4	10.2	26.7	73.93	17.0	5.0	35.1	12.57	3.70	25.95	40.93
-2-1/2 + 1-3/4...	32.4	26.3	4.8	29.9	90.73	22.7	3.4	29.2	20.60	3.08	26.49	76.16
-1-3/4 + 1.......	45.1	27.2	4.1	30.2	92.40	22.7	5.9	32.1	20.97	5.45	29.66	79.76
-1 + 5/8.........	9.3	29.5	3.2	27.3	92.93	24.9	2.3	30.5	23.14	2.14	28.34	82.35
-5/8 + 1/2.......	0.4	29.7	4.8	25.7	93.87	27.9	2.3	26.1	26.19	2.16	24.50	85.93
-1/2 + 1/4.......	0.3	27.4	7.7	26.2	92.40	23.8	2.3	33.1	21.99	2.13	30.58	80.46
-1/4 + 0.........	0.2	31.0	6.8	20.3	86.27	29.5	4.1	22.3	25.45	3.54	19.24	72.53
Composite (calculated)..	100.0	27.2	5.0	29.4	-	-	-	-	20.05	4.13	28.02	73.50
Composite (analysis)....	-	28.1	5.0	28.7	90.00	22.7	2.3	29.4	20.43	2.07	26.46	75.58

[1]Value based on calculated Davis tube products.

TABLE B-29. - Sample identification 86-048 concentrate LC3/4-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	5.4	31.8	10.0	25.9	32.47	70.7	24.2	0.78	22.95	7.86	0.25	68.12
-2-1/2 + 1-3/4...	16.3	34.2	11.8	25.0	39.27	70.2	23.7	0.81	27.57	9.31	0.32	74.05
-1-3/4 + 1.......	37.9	33.3	10.7	24.2	30.00	70.2	23.3	0.52	21.06	6.99	0.16	65.85
-1 + 5/8.........	32.7	33.3	10.1	24.3	32.13	70.2	23.6	0.73	22.56	7.58	0.23	67.65
-5/8 + 1/2.......	5.1	33.5	10.2	24.5	28.20	70.5	23.1	0.87	19.88	6.51	0.25	62.95
-1/2 + 1/4.......	1.9	33.5	10.0	22.4	28.67	70.2	24.4	0.80	20.12	6.99	0.23	63.95
-1/4 + 0.........	.7	33.1	11.1	20.3	28.53	70.7	12.9	1.1	20.17	3.68	0.31	63.67
Composite (calculated)..	100.0	33.4	10.6	24.4	-	-	-	-	22.63	7.56	0.22	67.88
Composite (analysis)....	-	31.7	6.1	24.7	32.60	67.9	12.0	1.5	22.14	3.91	0.49	71.81
					NONMAGNETIC							
-3 + 2-1/2.......	5.4	31.8	10.0	25.9	67.53	15.9	4.3	35.3	10.74	2.90	23.84	31.88
-2-1/2 + 1-3/4...	16.3	34.2	11.8	25.0	60.73	15.9	5.2	33.3	9.66	3.16	20.22	25.95
-1-3/4 + 1.......	37.9	33.3	10.7	24.2	70.00	15.6	5.2	30.6	10.92	3.64	21.42	34.15
-1 + 5/8.........	32.7	33.3	10.1	24.3	67.87	15.9	5.4	31.3	10.79	3.66	21.24	32.35
-5/8 + 1/2.......	5.1	33.5	10.2	24.5	71.80	16.3	5.0	31.8	11.70	3.59	22.83	37.05
-1/2 + 1/4.......	1.9	33.5	10.0	22.4	71.33	15.9	4.3	30.2	11.34	3.07	21.54	36.05
-1/4 + 0.........	.7	33.1	11.1	20.3	71.47	16.1	5.7	29.7	11.51	4.07	21.23	36.33
Composite (calculated)..	100.0	33.4	10.6	24.4	-	-	-	-	10.71	3.52	21.37	32.12
Composite (analysis)....	-	31.7	6.1	24.7	67.40	12.9	5.0	31.3	8.69	3.37	21.10	28.19

[1]Value based on calculated Davis tube products.

TABLE B-30. - Sample identification 86-048 tails LC3/4-coarse ore, 100 pct splitter opening

Size distribution	Distribution, weight pct	Chemical analysis, pct			Davis magnetic tube test							
					Assay				Units			Total Fe distribution,[1] pct
		Fe^t	Fe^{+2}	Si	wt, pct	Fe^t, pct	Fe^{+2}, pct	Si, pct	Fe^t	Fe^{+2}	Si	
					MAGNETIC							
-3 + 2-1/2.......	14.4	26.7	8.4	26.4	17.47	69.1	25.1	1.0	12.07	4.38	0.17	45.24
-2-1/2 + 1-3/4...	21.1	21.5	7.3	32.2	10.40	68.2	25.1	1.2	7.09	2.61	0.12	32.42
-1-3/4 + 1.......	40.1	20.2	6.8	30.3	9.40	68.4	12.7	-	6.43	1.19	-	30.85
-1 + 5/8.........	21.0	20.4	6.8	30.0	10.20	68.2	24.2	1.1	6.96	2.47	0.11	29.99
-5/8 + 1/2.......	2.4	21.1	6.1	30.3	9.27	69.6	26.3	0.86	6.45	2.44	0.08	27.87
-1/2 + 1/4.......	.6	22.7	8.4	26.6	11.47	70.2	33.3	0.95	8.05	3.82	0.11	32.83
-1/4 + 0.........	.4	28.3	10.0	23.5	20.33	70.2	30.4	0.95	14.27	6.18	0.19	48.79
Composite (calculated)..	100.0	21.5	7.1	30.0	-	-	-	-	7.53	2.28	-	34.67
Composite (analysis)....	-	23.6	4.1	29.9	10.60	65.8	25.4	1.3	6.97	2.69	0.14	34.97
					NONMAGNETIC							
-3 + 2-1/2.......	14.4	26.7	8.4	26.4	82.53	17.7	5.7	30.9	14.61	4.70	25.50	54.76
-2-1/2 + 1-3/4...	21.1	21.5	7.3	32.2	89.60	16.5	4.8	33.6	14.78	4.30	30.11	67.58
-1-3/4 + 1.......	40.1	20.2	6.8	30.3	90.60	15.9	4.8	31.6	14.41	4.35	28.63	69.15
-1 + 5/8.........	21.0	20.4	6.8	30.0	89.80	18.1	5.0	31.6	16.25	4.49	28.38	70.01
-5/8 + 1/2.......	2.4	21.1	6.1	30.3	90.73	18.4	5.0	32.3	16.69	4.54	29.31	72.13
-1/2 + 1/4.......	.6	22.7	8.4	26.6	88.53	18.6	6.1	29.4	16.47	5.40	26.03	67.17
-1/4 + 0.........	.4	28.3	10.0	23.5	79.67	18.8	6.2	29.2	14.98	4.94	23.26	51.21
Composite (calculated)..	100.0	21.5	7.1	30.0	-	-	-	-	14.19	4.28	25.14	65.33
Composite (analysis)....	-	23.6	4.1	29.9	89.40	14.5	4.8	32.9	12.96	4.29	29.41	65.03

[1]Value based on calculated Davis tube products.

Appendix C.--Cobber Weight and Magnetic Iron Distribution by Particle Size

TABLE C-1. - 86-023 LC2-fine ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2											
-2-1/2 + 1-3/4											
-1-3/4 + 1											
-1 + 5/8	5.86	(18.00)	5.71	83.33	20.82	96.30	6.79	14.39	3.32	6.25	4.38
-5/8 + 1/2	8.49	(17.97)	8.41	84.79	20.83	97.44	8.97	13.41	2.86	6.25	4.11
-1/2 + 1/4	33.52	(16.92)	33.62	85.88	19.22	97.24	32.88	12.12	3.05	25.00	3.83
-1/4 + 0	52.13	(11.55)	52.26	85.82	12.50	93.51	51.36	7.39	5.53	62.50	2.74
Composite	100.00	(14.27)	85.61	85.61	15.93	95.62	14.39	14.39	4.32	4.38	4.38

TABLE C-2. - 86-025 LC2-fine ore, 50 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2											
-2-1/2 + 1-3/4											
-1-3/4 + 1											
-1 + 5/8	5.76	(17.36)	5.75	41.67	32.11	76.00	5.76	58.30	7.26	5.45	33.03
-5/8 + 1/2	7.52	(18.09)	8.25	45.74	30.94	79.41	7.00	54.98	6.68	6.36	31.23
-1/2 + 1/4	29.91	(16.84)	32.89	45.86	27.83	75.40	27.78	50.90	7.60	28.18	29.13
-1/4 + 0	56.81	(10.42)	53.11	38.99	14.70	55.41	59.46	34.71	7.60	60.01	19.82
Composite	100.00	(13.30)	41.70	41.70	21.36	66.76	15830	58.30	7.52	33.03	33.03

TABLE C-3. - 86-026 LC3/4-fine ore, 50 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2											
-2-1/2 + 1-3/4											
-1-3/4 + 1											
-1 + 5/8	8.28	(21.58)	7.91	83.68	24.20	92.68	10.92	12.37	8.80	11.11	5.67
-5/8 + 1/2	16.95	(20.57)	16.61	85.86	22.57	93.75	19.37	11.02	9.05	18.52	5.04
-1/2 + 1/4	42.88	(20.83)	9.66	86.89	22.71	94.63	45.42	8.63	8.73	40.74	3.99
-1/4 + 0	31.89	(20.49)	65.82	90.57	21.32	94.77	24.29	3.01	12.03	29.63	1.68
Composite	100.00	(20.74)	87.63	87.63	22.35	94.33	12.37	12.37	9.60	5.67	5.67

TABLE C-4. - 86-028 LC3/4-fine ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2											
-2-1/2 + 1-3/4											
-1-3/4 + 1											
-1 + 5/8	5.56	(19.62)	5.19	91.54	20.89	98.04	23.91	1.97	4.55	23.81	0.44
-5/8 + 1/2	12.10	(19.29)	11.78	95.41	19.91	98.90	28.26	1.37	4.53	28.57	0.34
-1/2 + 1/4	38.96	(20.50)	38.92	97.91	20.87	99.57	41.30	0.94	4.14	38.10	0.21
-1/4 + 0	43.38	(20.53)	44.11	99.90	20.59	99.90	6.53	0.13	7.81	9.52	0.04
Composite	100.00	(20.32)	98.03	98.03	20.63	99.56	1.97	1.97	4.61	0.44	0.44

TABLE C-5. - 86-035 LC5-fine ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2											
-2-1/2 + 1-3/4											
-1-3/4 + 1											
-1 + 5/8	5.12	(13.25)	5.49	50.60	23.35	90.91	4.79	52.81	2.45	3.17	22.11
-5/8 + 1/2	7.72	(12.00)	8.50	52.00	21.01	90.00	7.01	50.28	2.58	4.76	21.40
-1/2 + 1/4	26.79	(11.29)	28.32	49.88	19.99	88.78	25.42	46.57	2.49	17.46	20.35
-1/4 + 0	60.37	(6.90)	57.69	45.09	10.00	65.19	62.78	33.15	4.39	74.61	16.49
Composite	100.00	(8.80)	47.19	47.19	14.50	77.89	52.81	52.81	3.69	22.11	22.11

TABLE C-9. - 86-044 LC2-coarse ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2	5.15	(16.54)	4.01	57.89	22.32	77.27	8.48	25.57	8.43	15.77	7.66
-2-1/2 + 1-3/4	12.67	(12.23)	10.41	61.16	17.41	87.50	19.24	23.40	4.13	15.77	6.45
-1-3/4 + 1	35.76	(13.76)	29.72	61.86	19.48	87.40	53.33	18.48	4.51	50.47	5.25
-1 + 5/8	19.76	(17.65)	21.19	79.80	21.01	95.56	15.61	4.84	4.31	12.62	1.38
-5/8 + 1/2	6.66	(19.77)	8.38	93.60	20.72	97.06	1.67	0 85	4.91	3.15	0.41
-1/2 + 1/4	11.55	(20.94)	15.10	97.32	21.23	99.36	1.21	0.43	5.03	1.26	0.17
-1/4 + 0	8.45	(17.57)	11.19	98.62	17.92	99.22	0.46	0.12	12.23	0.96	0.07
Composite	100.00	(16.03)	74.43	74.43	19.90	92.34	25.57	25.57	4.80	7.66	7.66

TABLE C-10. - 86-045 LC5-coarse ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2	8.18	(18.76)	10.62	79.10	22.58	96.39	4.37	39.09	3.31	4.65	8.35
-2-1/2 + 1-3/4	25.09	(13.35)	22.53	54.70	22.45	92.41	29.08	37.38	2.25	21.32	7.97
-1-3/4 + 1	53.00	(14.12)	51.82	59.55	21.45	90.18	54.85	26.02	3.42	61.63	6.19
-1 + 5/8	11.74	(13.19)	12.59	65.35	18.76	92.54	10.40	4.57	2.89	9.69	1.04
-5/8 + 1/2	0.97	(20.00)	1.21	76.19	23.80	95.24	0.59	0.51	4.55	0.78	0.23
-1/2 + 1/4	0.55	(18.33)	0.68	75.00	20.99	90.91	0.35	0.28	5.89	0.78	0.16
-1/4 + 0	0.47	(13.00)	0.55	70.00	16.69	76.92	0.36	0.14	9.03	1.15	0.10
Composite	100.00	(14.27)	60.91	60.91	21.45	91.65	39.09	39.09	3.05	8.35	8.35

TABLE C-11. - 86-047 LC5--coarse ore, 50 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2	9.06	(17.86)	3.33	13.27	16.14	11.43	12.29	63.91	18.14	31.00	33.67
-2-1/2 + 1-3/4	27.68	(11.85)	19.33	25.21	27.88	59.15	32.39	56.05	6.45	29.00	23.23
-1-3/4 + 1	44.78	(12.59)	44.17	35.60	25.75	72.95	45.12	35.35	5.32	33.00	13.47
-1 + 5/8	13.49	(16.20)	20.87	55.82	24.86	86.68	9.33	6.52	4.96	6.30	2.36
-5/8 + 1/2	1.94	(22.14)	4.61	85.71	25.99	96.77	0.43	0.55	4.29	0.30	0.24
-1/2 + 1/4	1.85	(20.50)	4.61	90.00	22.33	97.56	0.29	0.28	5.34	0.20	0.13
-1/4 + 0	1.20	(16.15)	3.08	92.31	17.66	95.24	0.15	0.09	9.64	0.20	0.07
Composite	100.00	(13.72)	36.09	36.09	25.26	66.33	63.91	63.91	7.23	33.67	33.67

TABLE C-12. - 86-048 LC3/4-coarse ore, 100 pct splitter opening

Size fraction	Cobber feed, pct		Cobber concentrate, pct				Cobber tails, pct				
	Weight	Mag Fe	Weight	Weight recovery	Mag Fe	Mag Fe recovery	Weight		Mag Fe	Mag Fe distribution	
							Ind.	Cum.		Ind.	Cum.
-3 + 2-1/2	6.65	(19.47)	5.40	70.20	22.95	81.63	14.52	13.64	12.07	23.18	4.99
-2-1/2 + 1-3/4	16.95	(24.05)	16.31	83.12	27.57	95.03	20.97	11.66	1.09	19.74	3.83
-1-3/4 + 1	38.20	(19.01)	37.92	85.71	21.06	95.15	40.00	8.80	6.43	34.33	2.85
-1 + 5/8	31.12	(21.15)	32.72	90.81	22.56	96.99	20.97	3.35	6.96	19.31	1.13
-5/8 + 1/2	4.75	(18.98)	5.10	92.59	19.88	97.56	2.58	0.48	6.45	2.15	0.17
-1/2 + 1/4	1.72	(18.46)	1.89	94.87	20.12	97.22	0.65	0.13	8.05	0.86	0.06
-1/4 + 0	0.61	(22.14)	0.66	92.86	20.17	96.77	0.31	0.04	14.27	0.43	0.02
Composite	100.00	(20.57)	86.36	86.36	22.63	95.01	13.64	13.64	7.53	4.99	4.99

Appendix D.--Bond Grindability Data Sheets

TABLE D-1. - Work index LC-5 fine ore head sample

(Bond grindability data sheet)

Sample: Barrel #1 LC-5 (fine ore)

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 13.5

80% Passing Size: 2,770.7 µm = F

Mill Charge, M = 1,579.7 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 451.3 grams.

80% Passing Product Undersize = 128.0 µm = F

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,579.7	213.3	238	100	1,130.9	448.8	235.5	2.36
2	448.8	60.6	390.7	166	1,205.8	373.9	313.3	1.89
3	373.9	50.5	400.8	212	1,130.8	448.9	398.4	1.88
4	448.9	60.6	390.7	208	1,110.4	469.3	408.7	1.96
5	469.3	63.4	387.9	198	1,124.5	455.2	391.8	1.98
6	455.2	61.5	389.8	197	1,150.7	429.0	367.5	1.87

Average Grind Rate, last three periods: G_{BP} = 1.97 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\,G_{BP}^{0.82}\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{149^{0.23}\,1.97^{0.82}\left[\frac{1}{\sqrt{128}} - \frac{1}{\sqrt{2770.7}}\right]} = 11.63 \text{ kWh/ton}$$

TABLE D-2. - Work index LC-5 tertiary ore head sample

(Bond grindability data sheet)

Sample: Barrel #2 LC-5 (tertiary)

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 8.2

80% Passing Size: 3,592.4 μm = F

Mill Charge, M = 1,461.0 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 417.4 grams.

80% Passing Product Undersize = 105.0 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,461.0	119.8	297.6	53	1,210.5	250.5	130.1	2.47
2	250.5	20.5	396.9	159	1,182.0	279.0	258.5	1.63
3	279.0	22.9	394.5	242	1,054.5	406.5	383.6	1.59
4	406.5	33.3	384.1	242	1,021.3	439.7	406.4	1.68
5	439.7	36.1	381.3	227	1,019.7	441.3	405.2	1.79
6	441.3	36.2	381.2	213	1,078.0	383.0	346.8	1.63

Average Grind Rate, last three periods: G_{BP} = 1.70 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.70)^{0.82} \left[\frac{1}{\sqrt{105.0}} - \frac{1}{\sqrt{3{,}592.4}} \right]} = 11.26 \text{ kWh/ton}$$

TABLE D-3. - Work index LC-3/4 fine ore head sample

(Bond grindability data sheet)

Sample: Barrel #3 LC-3/4 (fine ore)

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 7.2

80% Passing Size: 4,180.9 µm = F

Mill Charge, M = 1,514.8 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 432.8 grams.

80% Passing Product Undersize = 121.9 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,514.8	109.1	323.7	50	1,227.3	237.5	128.4	2.57
2	237.5	17.1	415.7	110	1,225.4	289.4	272.3	1.70
3	289.4	20.8	412.0	242	1,097.6	417.2	396.4	1.64
4	417.2	30.0	402.8	252	1,079.6	435.2	405.2	1.61
5	435.2	31.3	401.5	251	1,063.7	451.1	419.8	1.67
6	451.1	32.5	400.3	235	1,077.8	437.0	404.5	1.72
7	437.0	31.5	401.3	236	1,083.3	431.5	400.0	1.69

Average Grind Rate, last three periods: G_{BP} = 1.69 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.69)^{0.82} \left[\frac{1}{\sqrt{121.9}} - \frac{1}{\sqrt{4{,}180.9}} \right]} = 12.19 \text{ kWh/ton}$$

TABLE D-4. - Work index LC-3/4 tertiary ore head sample

(Bond grindability data sheet)

Sample: Barrel #4 LC-3/4 (tertiary)

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 6.2

80% Passing Size: 3,819.8 µm = F

Mill Charge, M = 1,487.9 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 425.1 grams.

80% Passing Product Undersize = 126.1 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,487.9	92.2	332.9	100	1,191.7	296.2	204.0	2.04
2	296.2	18.4	406.7	199	1,138.9	349.0	330.6	1.66
3	349.0	21.6	403.5	243	1,044.0	443.9	422.3	1.74
4	443.9	27.5	397.6	229	1,046.8	441.1	413.6	1.81
5	441.1	27.3	397.8	220	1,078.5	409.4	382.1	1.74
6								

Average Grind Rate, last three periods: G_{BP} = 1.76 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82}\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.76)^{0.82}\left[\frac{1}{\sqrt{126.1}} - \frac{1}{\sqrt{3{,}819.8}}\right]} = 12.15 \text{ kWh/ton}$$

TABLE D-5. - Work index LC-2 tertiary ore head sample

(Bond grindability data sheet)

Sample: Barrel #5 LC-2 (tertiary)

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 6.5

80% Passing Size: 3,208.6 μm = F

Mill Charge, M = 1,448.4 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 413.8 grams.

80% Passing Product Undersize = 120.1 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,448.4	94.1	319.7	50	1,238.1	210.7	116.6	2.33
2	210.7	13.7	400.1	174	1,155.8	292.6	278.9	1.60
3	292.6	19.0	394.8	247	1,044.6	403.8	384.8	1.56
4	403.8	26.2	387.6	248	1,048.9	399.9	373.3	1.51
5	399.9	26.0	387.8	257	1,001.4	447.0	421.0	1.64
6	447.0	29.1	384.7	235	1,042.3	406.1	377.0	1.60

Average Grind Rate, last three periods: G_{BP} = 1.58 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.58)^{0.82} \left[\frac{1}{\sqrt{120.1}} - \frac{1}{\sqrt{3,208.6}} \right]} = 11.26 \text{ kWh/ton}$$

TABLE D-6. - Work index LC-2 fine ore head sample

(Bond grindability data sheet)

Sample: Barrel #6 LC-2 (fine ore)

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 6.2

80% Passing Size: 3,047.7 µm = F

Mill Charge, M = 1,520.2 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 434.3 grams.

80% Passing Product Undersize = 134.7 µm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,520.2	94.3	340.0	100	1,155.4	364.8	270.5	2.71
2	364.8	22.8	411.5	152	1,177.1	343.1	320.3	2.11
3	343.1	21.3	413.0	196	1,127.2	393.0	371.7	1.90
4	393.0	24.4	409.9	216	1,089.3	430.9	406.5	1.88
5	430.9	26.7	407.6	217	1,096.2	424.6	397.3	1.83
6	424.0	26.3	408.0	223	1,079.0	441.2	414.9	1.86
7	441.2	26.9	407.4	219	1,078.8	441.4	414.5	1.89

Average Grind Rate, last three periods: G_{BP} = 1.70 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.86)^{0.82} \left[\frac{1}{\sqrt{134.7}} - \frac{1}{\sqrt{3{,}047.7}} \right]} = 12.44 \text{ kWh/ton}$$

TABLE D-7. - Work index 86-023 concentrate

(Bond grindability data sheet)

Sample: 86-023 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 13.19

80% Passing Size: 2,545.19 µm = F

Mill Charge, M = 1,394.9 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 398.54 grams.

80% Passing Product Undersize = 112.03 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,394.9	183.99	214.55	100	1,013.6	381.3	197.31	1.97
2	381.3	50.29	348.25	177	1,034.1	360.8	310.51	1.75
3	360.8	47.59	350.95	201	1,006.0	388.9	341.31	1.70
4	388.9	51.30	347.24	204	992.2	402.7	351.40	1.72
5	402.7	53.12	345.42	201	991.7	403.2	350.08	1.74
6	403.2	53.18	345.36	198	999.0	395.9	342.72	1.73

Average Grind Rate, last three periods: G_{BP} = 1.73 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.73)^{0.82} \left[\frac{1}{\sqrt{112.03}} - \frac{1}{\sqrt{2,545.19}} \right]} = 12.03 \text{ kWh/ton}$$

TABLE D-8. - Work index 86-023 tail

(Bond grindability data sheet)

Sample: 86-023 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 14.25

80% Passing Size: 2,199.95 µm = F

Mill Charge, M = 1,294.3 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 369.80 grams.

80% Passing Product Undersize = 113.71 µm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,294.3	184.44	185.36	100	943.6	350.7	166.26	1.66
2	350.7	49.97	319.83	193	950.6	343.7	293.73	1.52
3	343.7	48.98	320.82	211	923.6	370.7	321.72	1.52
4	370.7	52.82	316.98	209	912.6	381.7	328.88	1.57
5	381.7	54.39	315.41	201	916.6	377.7	323.31	1.61
6	377.7	53.82	315.98	196	930.3	364.0	310.18	1.58

Average Grind Rate, last three periods: G_{BP} = 1.59 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\ G_{BP}^{0.82}\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\ (1.59)^{0.82}\left[\frac{1}{\sqrt{113.71}} - \frac{1}{\sqrt{2,199.95}}\right]} = 13.28 \text{ kWh/ton}$$

TABLE D-9. - Work index 86-025 concentrate

(Bond grindability data sheet)

Sample: 86-025 concentrate

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 13.79

80% Passing Size: 2,466.32 μm = F

Mill Charge, M = 1,533.0 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 438.0 grams.

80% Passing Product Undersize = 107.72 μm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,533.0	211.40	226.60	50	1,209.3	323.7	112.30	2.25
2	323.7	49.64	393.36	175	1,168.3	364.7	320.06	1.83
3	364.7	50.29	387.71	212	1,109.9	423.1	372.81	1.41
4	423.1	58.35	379.65	216	1,093.5	439.5	381.15	1.76
5	439.5	60.61	377.39	214	1,075.7	457.3	396.69	1.85
6								

Average Grind Rate, last three periods: G_{BP} = 1.80 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.80)^{0.82} \left[\frac{1}{\sqrt{107.72}} - \frac{1}{\sqrt{2{,}466.32}} \right]} = 11.41 \text{ kWh/ton}$$

TABLE D-10. - Work index 86-025 tail

(Bond grindability data sheet)

Sample: 86-025 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 14.12

80% Passing Size: 2,486.39 μm = F

Mill Charge, M = 1,373.3 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 392.37 grams.

80% Passing Product Undersize = 106.71 μm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,373.3	193.91	198.46	50	1,082.30	291.0	97.09	1.94
2	291.0	41.09	351.28	181	1,043.15	330.15	289.06	1.60
3	330.15	46.62	345.75	216	993.5	379.8	333.18	1.54
4	379.8	53.63	338.74	220	967.2	406.1	352.47	1.60
5	406.1	57.34	335.03	209	971.6	401.7	344.36	1.65
6								

Average Grind Rate, last three periods: G_{BP} = 1.58 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.58)^{0.82} \left[\frac{1}{\sqrt{106.71}} - \frac{1}{\sqrt{2,486.39}} \right]} = 11.26 \text{ kWh/ton}$$

TABLE D-11. - Work index 86-026 concentrate

(Bond grindability data sheet)

Sample: 86-026 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 13.84

80% Passing Size: 2,891.83 µm = F

Mill Charge, M = 1,448.7 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 413.91 grams.

80% Passing Product Undersize = 109.49 µm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,448.7	200.50	213.41	50	1,172.4	276.3	75.80	1.52
2	276.3	38.24	375.67	247	1,009.8	438.9	400.66	1.62
3	438.9	60.74	353.17	218	1,017.7	431.0	370.26	1.70
4	431.0	59.65	354.26	208	1,023.5	425.2	365.55	1.76
5	425.2	58.85	355.06	202	1,031.7	417.0	358.15	1.77
6	417.0	57.71	356.20	201	1,036.4	412.3	354.59	1.76

Average Grind Rate, last three periods: G_{BP} = 1.76 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.76)^{0.82} \left[\frac{1}{\sqrt{109.49}} - \frac{1}{\sqrt{2,891.83}} \right]} = 11.50 \text{ kWh/ton}$$

TABLE D-12. - Work index 86-026 tail

(Bond grindability data sheet)

Sample: 86-026 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 12.45

80% Passing Size: 2,805.51 μm = F

Mill Charge, M = 1,343.5 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 383.86 grams.

80% Passing Product Undersize = 113.44 μm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,343.5	167.27	216.59	50	1,102.4	241.1	73.83	1.45
2	241.1	30.02	353.84	244	965.3	378.2	348.18	1.43
3	378.2	47.09	336.77	236	949.0	394.5	347.41	1.44
4	394.5	49.12	334.74	228	947.5	396.0	346.88	1.52
5	396.0	49.30	334.56	220	948.2	395.3	346.0	1.57
6	395.3	49.21	334.65	213	959.1	384.4	335.17	1.57

Average Grind Rate, last three periods: G_{BP} = 1.55 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\ G_{BP}^{0.82}\left[\dfrac{1}{\sqrt{P}} - \dfrac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\ (1.55)^{0.82}\left[\dfrac{1}{\sqrt{113.44}} - \dfrac{1}{\sqrt{2,805.51}}\right]} = 13.10 \text{ kWh/ton}$$

TABLE D-13. - Work index 86-028 concentrate

(Bond grindability data sheet)

Sample: 86-028 concentrate

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 15.02

80% Passing Size: 2,563.93 μm = F

Mill Charge, M = 1,426.5 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 407.57 grams.

80% Passing Product Undersize = 113.94 μm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,426.5	214.26	193.31	100	1,046.6	379.9	165.64	1.66
2	379.9	57.06	350.51	211	1,024.2	402.3	345.24	1.64
3	402.3	60.43	347.14	212	1,003.9	422.6	362.17	1.71
4	422.6	63.47	344.10	201	1,022.6	403.9	340.48	1.69
5								
6								

Average Grind Rate, last three periods: G_{BP} = 1.68 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.68)^{0.82} \left[\frac{1}{\sqrt{113.94}} - \frac{1}{\sqrt{2,563.93}} \right]} = 12.44 \text{ kWh/ton}$$

TABLE D-14. - Work index 86-028 tail

(Bond grindability data sheet)

Sample: 86-028 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 13.47

80% Passing Size: 2,378.94 μm = F

Mill Charge, M = 1,270.6 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 363.08 grams.

80% Passing Product Undersize = 119.76 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,270.6	171.15	191.89	100	970.9	299.7	128.55	1.29
2	299.7	40.37	322.66	250	898.2	372.4	332.03	1.33
3	372.4	50.16	312.87	235	894.5	376.1	325.94	1.39
4	376.1	50.66	312.37	225	897.8	372.8	322.14	1.43
5	372.8	50.22	312.81	219	898.7	371.9	321.68	1.47
6	371.9	50.09	312.94	213	913.9	356.7	306.61	1.44

Average Grind Rate, last three periods: G_{BP} = 1.45 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]}$$ kWh/net ton, to -100 μm

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.45)^{0.82} \left[\frac{1}{\sqrt{119.76}} - \frac{1}{\sqrt{2,378.94}} \right]} = 14.65 \text{ kWh/ton}$$

TABLE D-15. - Work index 86-035 concentrate

(Bond grindability data sheet)

Sample: 86-035 concentrate

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 16.75

80% Passing Size: 2,148.07 μm = F

Mill Charge, M = 1,481.6 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 423.31 grams.

80% Passing Product Undersize = 116.13 μm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,481.6	248.17	175.14	100	1,075.7	405.9	157.73	1.58
2	405.9	67.99	355.32	225	1,038.0	443.6	375.61	1.67
3	443.6	74.30	349.01	209	1,050.5	431.1	356.80	1.71
4	431.1	72.21	351.1	205	1,052.9	428.7	356.49	1.74
5	424.7	71.81	351.5	202	1,055.0	426.6	354.79	1.76
6								

Average Grind Rate, last three periods: G_{BP} = 1.74 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\; G_{BP}^{0.82}\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\;(1.74)^{0.82}\left[\frac{1}{\sqrt{116.13}} - \frac{1}{\sqrt{2,148.07}}\right]} = 12.55 \text{ kWh/ton}$$

TABLE D-16. - Work index 86-035 tail

(Bond grindability data sheet)

Sample: 86-035 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 17.81

80% Passing Size: 2,045.39 μm = F

Mill Charge, M = 1,444.4 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 412.69 grams.

80% Passing Product Undersize = 117.69 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,444.4	257.25	155.44	100	1,042.5	401.9	144.65	1.45
2	401.9	71.58	341.11	235	1,014.4	430.0	358.42	1.53
3	430.0	76.58	336.11	220	1,019.4	425.0	348.42	1.58
4	425.0	75.69	337.0	213	1,021.0	423.4	347.71	1.63
5	423.4	75.41	337.28	207	1,011.1	433.3	357.89	1.73
6								

Average Grind Rate, last three periods: G_{BP} = 1.65 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.65)^{0.82} \left[\frac{1}{\sqrt{117.69}} - \frac{1}{\sqrt{2{,}045.39}} \right]} = 13.33 \text{ kWh/ton}$$

TABLE D-17. - Work index 86-037 concentrate

(Bond grindability data sheet)

Sample: 86-037 concentrate

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 14.68

80% Passing Size: 2,490.78 μm = F

Mill Charge, M = 1,578.5 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 451.0 grams.

80% Passing Product Undersize = 107.76 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,578.5	231.72	219.28	50	1,244.0	334.5	102.78	2.06
2	334.5	49.10	401.9	195	1,178.2	400.3	351.20	1.80
3	400.3	58.76	392.24	218	1,132.2	441.3	387.54	1.78
4	446.3	65.52	385.48	217	1,115.0	463.5	397.98	1.83
5	463.5	68.04	382.96	209	1,123.1	455.4	387.36	1.85
6	455.4	66.85	384.15	208	1,126.4	452.1	385.25	1.85

Average Grind Rate, last three periods: G_{BP} = 1.84 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.84)^{0.82} \left[\frac{1}{\sqrt{109.76}} - \frac{1}{\sqrt{2,490.78}} \right]} = 11.19 \text{ kWh/ton}$$

TABLE D-18. - Work index 86-037 tail

(Bond grindability data sheet)

Sample: 86-037 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 16.13

80% Passing Size: 2,378.96 µm = F

Mill Charge, M = 1,418.4 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 405.26 grams.

80% Passing Product Undersize = 96.47 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,418.4	228.65	176.61	50	1,102.7	315.7	87.05	1.74
2	315.7	50.92	354.34	204	1,058.0	360.4	309.48	1.52
3	360.4	58.13	347.13	228	1,003.6	414.8	356.67	1.56
4	414.8	66.91	338.35	217	1,008.6	409.8	342.89	1.58
5	409.8	66.10	339.16	215	1,004.6	413.8	347.70	1.62
6	413.8	66.75	338.51	209	1,062.9	355.5	288.75	1.38

Average Grind Rate, last three periods: G_{BP} = 1.53 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.53)^{0.82} \left[\frac{1}{\sqrt{96.47}} - \frac{1}{\sqrt{2,378.96}} \right]} = 11.19 \text{ kWh/ton}$$

TABLE D-20. - Work index 86-040 tail

(Bond grindability data sheet)

Sample: 86-040 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 11.22

80% Passing Size: 2,769.66 µm = F

Mill Charge, M = 1,297.40 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 370.69 grams.

80% Passing Product Undersize = 107.05 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,297.40	145.57	225.12	50	1,027.8	269.6	124.03	2.48
2	296.6	30.25	340.44	137	1,080.3	217.1	186.85	1.36
3	217.1	24.36	346.33	255	889.5	407.9	383.54	1.50
4	407.9	45.77	324.92	217	960.1	337.3	291.53	1.34
5	337.3	37.85	332.84	248	906.3	391.1	353.25	1.42
6								

Average Grind Rate, last three periods: G_{BP} = 1.42 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.42)^{0.82} \left[\frac{1}{\sqrt{107.05}} - \frac{1}{\sqrt{2,769.66}} \right]} = 13.60 \text{ kWh/ton}$$

TABLE D-19. - Work index 86-040 concentrate

(Bond grindability data sheet)

Sample: 86-040 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 11.45

80% Passing Size: 2,954.60 µm = F

Mill Charge, M = 1,352.6 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 386.46 grams.

80% Passing Product Undersize = 105.37 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,352.6	154.87	231.59	50	1,068.9	283.7	128.83	2.58
2	283.7	32.48	353.98	137	1,050.8	301.8	269.32	1.97
3	301.8	34.56	351.90	179	999.9	352.7	318.14	1.78
4	352.7	40.38	346.08	194	1,013.9	338.7	298.32	1.54
5	338.7	38.78	347.68	226	954.8	397.8	359.02	1.59
6	397.8	45.55	340.91	214	958.8	393.8	348.25	1.63
7	393.8	45.09	341.37	209	966.4	386.2	341.11	1.63

Average Grind Rate, last three periods: G_{BP} = 1.62 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.62)^{0.82} \left[\frac{1}{\sqrt{105.37}} - \frac{1}{\sqrt{2,954.60}} \right]} = 11.99 \text{ kWh/ton}$$

TABLE D-21. - Work index 86-042 concentrate

(Bond grindability data sheet)

Sample: 86-042 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 12.81

80% Passing Size: 3,099.05 µm = F

Mill Charge, M = 1,392.7 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 397.91 grams.

80% Passing Product Undersize = 106.64 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,392.70	178.40	219.51	50	1,118.1	274.6	96.20	1.92
2	274.6	35.18	362.73	189	1,044.6	348.1	312.92	1.66
3	348.1	44.59	353.32	213	994.4	398.3	353.71	1.66
4	398.3	51.02	346.89	209	996.2	396.5	345.48	1.65
5	396.5	50.79	347.12	210	1,003.7	389.0	338.21	1.61
6	389.0	49.83	348.08	216	982.1	410.6	360.77	1.67

Average Grind Rate, last three periods: G_{BP} = 1.64 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.64)^{0.82} \left[\frac{1}{\sqrt{106.64}} - \frac{1}{\sqrt{3{,}099.05}} \right]} = 11.90 \text{ kWh/ton}$$

TABLE D-22. - Work index 86-042 tail

(Bond grindability data sheet)

Sample: 86-042 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 11.63

80% Passing Size: 2,648.88 μm = F

Mill Charge, M = 1,339.8 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 382.8 grams.

80% Passing Product Undersize = 107.12 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,339.8	155.82	226.98	50	1,103.5	236.3	80.48	1.61
2	236.3	27.48	355.32	221	995.1	344.7	317.22	1.44
3	344.7	40.09	342.71	238	962.2	377.6	337.51	1.42
4	377.6	43.91	338.89	239	941.2	398.6	354.19	1.48
5	398.6	46.36	336.44	227	950.5	389.3	342.94	1.51
6								

Average Grind Rate, last three periods: G_{BP} = 1.47 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.47)^{0.82} \left[\frac{1}{\sqrt{107.12}} - \frac{1}{\sqrt{2,648.88}} \right]} = 13.30 \text{ kWh/ton}$$

TABLE D-23. - Work index 86-044 concentrate

(Bond grindability data sheet)

Sample: 86-044 concentrate

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 11.68

80% Passing Size: 2,914.07 μm = F

Mill Charge, M = 1,481.9 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 423.4 grams.

80% Passing Product Undersize = 114.38 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,481.9	173.23	250.17	100	1,116.5	365.4	192.17	1.92
2	365.4	42.72	380.68	198	1,109.0	372.9	330.18	1.67
3	372.9	43.59	379.81	227	1,060.9	421.0	377.41	1.66
4	421.0	49.21	374.19	225	1,053.3	428.6	379.39	1.69
5	428.6	50.10	373.3	221	1,060.9	421.0	370.9	1.68
6								

Average Grind Rate, last three periods: G_{BP} = 1.68 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82}\left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}}\right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.68)^{0.82}\left[\frac{1}{\sqrt{114.38}} - \frac{1}{\sqrt{2,914.07}}\right]} = 12.27 \text{ kWh/ton}$$

TABLE D-24. - Work index 86-044 tail

(Bond grindability data sheet)

Sample: 86-044 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 8.86

80% Passing Size: 3,220.94 µm = F

Mill Charge, M = 1,261.4 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 360.4 grams.

80% Passing Product Undersize = 118.15 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,266.4	111.89	248.51	100	997.0	204.4	152.51	1.53
2	204.4	23.45	336.95	220	957.0	304.4	280.95	1.28
3	304.4	27.00	333.40	260	904.7	356.7	329.7	1.27
4	356.7	31.64	328.76	259	888.6	372.8	341.16	1.32
5	372.8	33.07	327.33	248	894.6	366.8	333.73	1.35
6	366.8	32.54	327.86	243	903.1	358.3	325.76	1.34

Average Grind Rate, last three periods: G_{BP} = 1.34 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.34)^{0.82} \left[\frac{1}{\sqrt{118.15}} - \frac{1}{\sqrt{3{,}220.94}} \right]} = 14.89 \text{ kWh/ton}$$

TABLE D-25. - Work index 86-045 concentrate

(Bond grindability data sheet)

Sample: 86-045 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 11.30

80% Passing Size: 2,900.26 µm = F

Mill Charge, M = 1,434.0 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 409.71 grams.

80% Passing Product Undersize = 114.37 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,434.0	162.04	247.67	100	1,105.0	329.0	166.96	1.67
2	329.0	37.18	372.53	223	1,036.0	398.0	360.82	1.62
3	398.0	44.97	364.74	225	1,006.2	427.8	382.83	1.70
4	427.8	48.34	361.37	213	1,007.9	426.1	377.76	1.77
5	426.1	48.15	361.56	204	1,034.3	399.7	351.55	1.72
6								

Average Grind Rate, last three periods: G_{BP} = 1.73 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.73)^{0.82} \left[\frac{1}{\sqrt{114.37}} - \frac{1}{\sqrt{2{,}900.26}} \right]} = 11.98 \text{ kWh/ton}$$

TABLE D-26. - Work index 86-045 tail

(Bond grindability data sheet)

Sample: 86-045 tail

Grindability Test Size: 100 mesh, 149 μm.

Feed Sample Crushed through: 6 mesh, 3,360 μm.

% Passing Test Size: 11.38

80% Passing Size: 2,721.33 μm = F

Mill Charge, M = 1,340.8 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 383.09 grams.

80% Passing Product Undersize = 114.39 μm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,340.8	152.58	230.51	100	1,044.7	296.1	143.52	1.44
2	296.1	33.70	349.39	243	954.3	386.5	352.8	1.45
3	386.5	43.98	339.11	234	941.2	399.0	355.62	1.52
4	399.0	45.47	337.62	222	947.4	393.4	347.93	1.57
5	393.4	44.77	338.32	215	959.8	381.0	336.23	1.56
6								

Average Grind Rate, last three periods: G_{BP} = 1.55 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 μm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.55)^{0.82} \left[\frac{1}{\sqrt{114.39}} - \frac{1}{\sqrt{2,721.33}} \right]} = 13.22 \text{ kWh/ton}$$

TABLE D-27. - Work index 86-047 concentrate

(Bond grindability data sheet)

Sample: 86-047 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 9.67

80% Passing Size: 3,916.5 µm = F

Mill Charge, M = 1,500.6 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 428.74 grams.

80% Passing Product Undersize = 106.9 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	1,500.6	145.11	283.63	50	1,265.5	235.1	89.99	1.80
2	235.1	22.73	406.01	226	1,114.2	386.4	363.67	1.61
3	386.4	37.36	391.38	243	1,061.6	439.0	401.64	1.65
4	459.0	42.45	386.29	234	1,052.7	447.9	405.45	1.72
5	447.9	43.31	385.43	224	1,064.9	435.7	392.39	1.75
6	435.7	42.13	386.11	221	1,075.3	425.3	383.72	1.74

Average Grind Rate, last three periods: G_{BP} = 1.74 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.75)^{0.82} \left[\frac{1}{\sqrt{106.9}} - \frac{1}{\sqrt{3,916.5}} \right]} = 11.02 \text{ kWh/ton}$$

TABLE D-28. - Work index 86-047 tail

(Bond grindability data sheet)

Sample: 86-047 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 10.57

80% Passing Size: 3,043.56 µm = F

Mill Charge, M = 1,343.6 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 383.89 grams.

80% Passing Product Undersize = 108.70 µm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,343.6	142.02	241.87	50	1,117.0	226.6	89.58	1.69
2	226.1	23.95	359.94	213	1,002.4	341.2	317.25	1.49
3	341.2	36.06	347.83	233	954.0	389.6	353.54	1.52
4	389.6	41.18	342.70	225	942.1	401.5	360.32	1.60
5	401.5	42.44	341.45	213	961.5	382.2	339.76	1.60
6								

Average Grind Rate, last three periods: G_{BP} = 1.57 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.57)^{0.82} \left[\frac{1}{\sqrt{108.7}} - \frac{1}{\sqrt{3{,}043.56}} \right]} = 12.50 \text{ kWh/ton}$$

TABLE D-29. - Work index 86-048 concentrate

(Bond grindability data sheet)

Sample: 86-048 concentrate

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 11.97

80% Passing Size: 3,344.59 µm = F

Mill Charge, M = 1,398.9 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 399.69 grams.

80% Passing Product Undersize = 108.77 µm = P

Mill Operations:

Period	FEED, g		GRIND		PRODUCT, g			Rate,
	New Feed	U'size	U'size Need, g	R revs	O'size	Total U'size	New U'size	G g/rev
1	1,398.9	167.73	231.96	50	1,133.3	265.6	97.87	1.96
2	265.6	31.85	367.84	188	1,044.4	354.5	322.65	1.72
3	354.5	42.50	357.19	208	1,002.9	396.0	353.5	1.70
4	396.0	47.48	352.21	207	995.5	403.4	355.92	1.72
5	403.4	48.37	351.32	204	992.2	406.7	358.33	1.76
6	406.7	48.76	350.93	199	998.2	400.7	351.94	1.77

Average Grind Rate, last three periods: G_{BP} = 1.75 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\, (1.75)^{0.82} \left[\frac{1}{\sqrt{108.77}} - \frac{1}{\sqrt{3{,}344.59}} \right]} = 11.32 \text{ kWh/ton}$$

TABLE D-30. - Work index 86-048 tail

(Bond grindability data sheet)

Sample: 86-048 tail

Grindability Test Size: 100 mesh, 149 µm.

Feed Sample Crushed through: 6 mesh, 3,360 µm.

% Passing Test Size: 11.00

80% Passing Size: 2,914.01 µm = F

Mill Charge, M = 1,245.8 grams, mass of 700 cc bulk volume.

Test Goal: Mill Product Undersize = 0.286M = 355.94 grams.

80% Passing Product Undersize = 111.11 µm = P

Mill Operations:

Period	FEED, g New Feed	FEED, g U'size	GRIND U'size Need, g	GRIND R revs	PRODUCT, g O'size	PRODUCT, g Total U'size	PRODUCT, g New U'size	Rate, G g/rev
1	2,914.01	137.16	218.78	50	1,024.8	221.0	83.84	1.68
2	221.0	24.33	331.61	197	960.1	285.7	261.37	1.33
3	285.7	31.46	324.48	249	884.1	261.7	330.24	1.33
4	361.7	29.82	326.12	238	877.2	268.6	328.78	1.38
5	368.6	40.58	315.36	229	877.5	368.3	327.72	1.43
6	368.3	40.55	315.39	221	902.8	343.0	302.45	1.37

Average Grind Rate, last three periods: G_{BP} = 1.39 g/rev

Work Index:

$$W_i = \frac{4.45}{P^{0.23}\, G_{BP}^{0.82} \left[\frac{1}{\sqrt{P}} - \frac{1}{\sqrt{F}} \right]} \text{ kWh/net ton, to -100 µm}$$

$$W_i = \frac{4.45}{(149)^{0.23}\,(1.39)^{0.82} \left[\frac{1}{\sqrt{111.11}} - \frac{1}{\sqrt{2,914.01}} \right]} = 14.03 \text{ kWh/ton}$$