7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.1. COMMINUTION

7.1.1.1. CRUSHING

This unit operation pertains to the reduction of run-of-mine ore to a size suitable for grinding and further beneficiation operations. The cost curves are applicable to crushing operations performed either in the mine or at a surface location. The curves include the costs associated with crushing, screening, and transfer of material and are valid for the primary, secondary, and, if necessary, tertiary stages of crushing. The curves are valid for secondary and tertiary crushing when the mobile crushing section (7.1.1.2.) is used. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a daily feed rate (X), in metric tons ore per day. The curves are valid for operations between 500 and 100,000 mtpd, operating three shifts per day.

BASE CURVE

The base curves were developed for the reduction of a medium hard ore (work index of 14.3 kW.h/mt) from run-of-mine size to 80% passing 1.27 cm (0.5 in). The process commences with the introduction of the ore into the primary crusher and terminates with the final crusher discharge conveyor.

(L) Labor Operating Cost $(Y_L) = 187.200(X)^{0.279}$
The operating labor costs consist of the following typical range of personnel:

Direct labor..............	50%
Maintenance labor.........	50%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Control room operator......	28%	$17.23
Mill operator..............	46%	16.78
Mill helper................	20%	13.66
Mill laborer...............	6%	11.68

The average wage for labor is $16.54 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.315(X)^{0.840}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 1.093(X)^{0.775}$
The equipment operation curve consists of 96% for wear materials and repair parts and 4% for lubrication.

ADJUSTMENT FACTORS

Ore Hardness Factor The base curves are premised on an ore hardness of 14.3 kW.h/mt. To adjust for a different work index, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = (14.3/I)^{-0.279}$

Supply factor $(F_S) = (14.3/I)^{-0.840}$

Equipment operation factor $(F_E) = (14.3/I)^{-0.756}$
where I = new work index, in kilowatt hours per metric ton.

Product Size Factor The particle size of the crushed product is ultimately dependent on the discharge opening setting of the final crusher(s) in the series. To adjust for a crusher discharge setting other than 1.27 cm, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = (S/1.27)^{-0.432}$

Supply factor $(F_S) = (S/1.27)^{-0.736}$

Equipment operation factor $(F_E) = (S/1.27)^{-0.714}$
where S = new crusher discharge setting, in centimeters.

Mobile Crushing Factor In the event that mobile crushers are to be used as the primary crushers, multiply the costs obtained from the curves by the following factors to determine the costs of secondary and tertiary crushing:

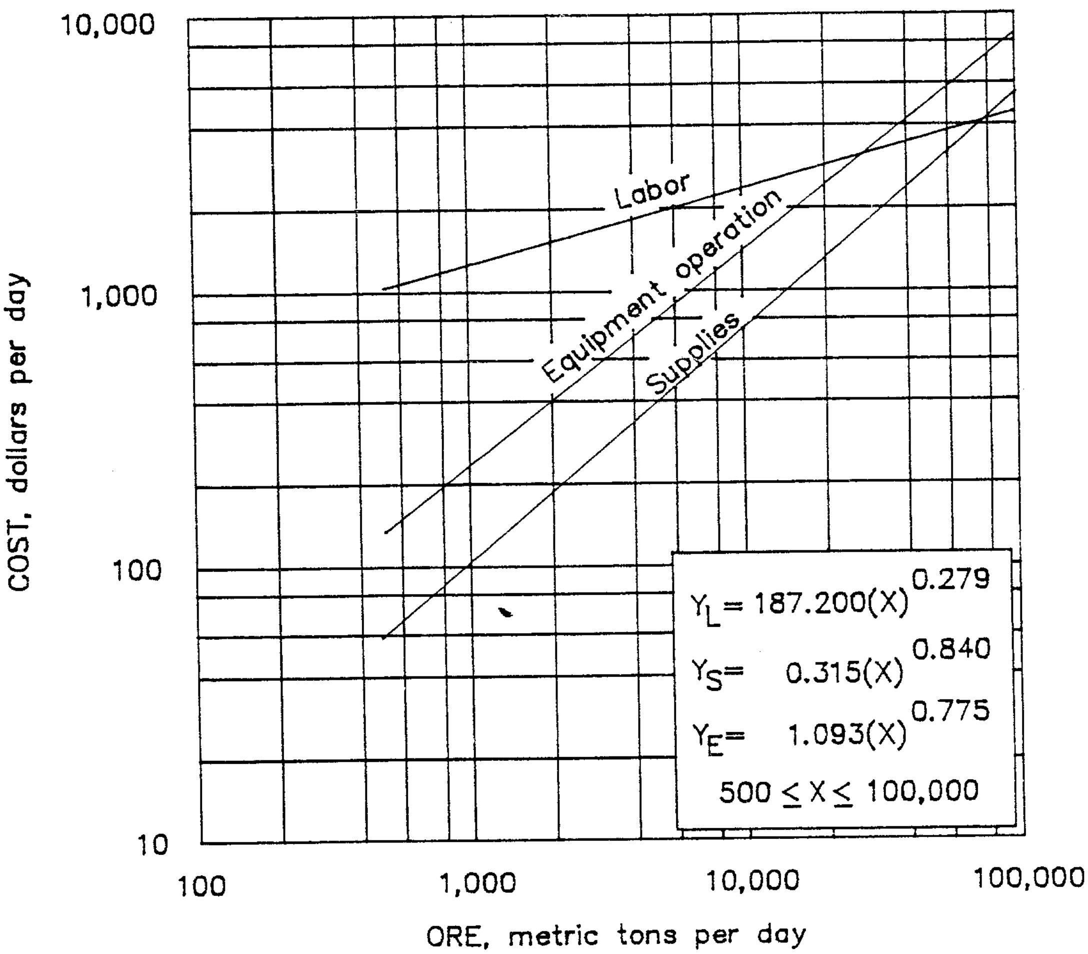
Labor factor $(F_L) = 0.776$

Supply factor $(F_S) = 0.764$

Equipment operation factor $(F_E) = 0.676$

Long Distance Conveyors The base curves are predicated on the assumption that the primary crusher(s) are reasonably proximate to the fine crushing facility. If the distance between primary and secondary crushing facilities exceeds 150 m, a long-distance conveyor should be included in the cost estimate (see section 7.1.7.5.).

Mineral Processing—Operating Costs



7.1.1.1. Crushing

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.1. COMMINUTION

7.1.1.2. MOBILE CRUSHING

The operating costs for mobile crushing are given on a metric ton per day basis. The costs include the operation of primary crusher, discharge conveyor, and feed hopper. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a production rate (X), in metric tons of ore per day. The curves are valid for operations between 17,600 and 79,000 mtpd, operating three shifts per day.

BASE CURVE

The base curve is predicated on the primary crushing of an ore at an open side setting of 7 in (17.78 cm) utilizing a mobile crusher. The ore has a work index of 14.3 kW.h/mt. The process commences with the direct dumping of the ore into the crusher and terminates with the crusher discharge conveyor.

(L) Labor Operating Cost $(Y_L) = 79.988(X)^{0.248}$
The operating labor costs consist of the following typical range of personnel:

Direct labor...............	36%
Maintenance labor..........	64%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Control room crusher operator...	97%	$17.56
Mill laborer....................	3%	11.68

The average wage for labor is $17.21 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.008(X)^{1.000}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 0.087(X)^{0.878}$
The equipment operation curve consists of 95.5% for wear materials and repair parts and 4.5% for lubrication.

ADJUSTMENT FACTORS

Ore Hardness Factor The base curves are premised on an ore hardness of 14.3 kW.h/mt. To adjust for a different work index, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.993(14.300/I)^{-0.251}$

Supply factor $(F_S) = 1.004(14.300/I)^{-0.244}$

Equipment operation factor $(F_E) = 1.002(14.300/I)^{-0.878}$
where: I = new work index, in kilowatt hours per metric ton.

Crusher Open-Side Setting Factor The base curves are premised on an open-side setting of 17.78 cm. To adjust for a different crusher open-side setting, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = (S/17.78)^{-0.174}$

Supply factor $(F_S) = (S/17.78)^{-0.230}$

Equipment operation factor $(F_E) = (S/17.78)^{-0.646}$
where: S = new crusher open-side setting, in centimeters.

Feeding the Crusher With a Fixed Angle Apron Feeder From the Bench Above Factor The base case assumes direct dumping of the ore into the primary crusher. If the option of utilizing a fixed angle apron from the bench above the crusher is adopted, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.22$

Supply factor $(F_S) = 0.003(X)^{0.583}$

Equipment operation factor $(F_E) = 0.0004(X)^{0.762}$
where X = ore feed, in metric tons per day.

Feeding the Crusher With a Fixed Angle Apron Feeder From the Same Bench Factor The crusher can also be fed from the same bench utilizing a fixed angle apron feeder. For this scenario, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.22$

Supply factor $(F_S) = 0.078(X)^{0.287}$

Equipment operation factor $(F_E) = 0.0004(X)^{0.762}$
where X = ore feed, in metric tons per day.

Feeding the Crusher With a Fixed Angle Apron Feeder From the Same Bench Factor The crusher can also feed from the same bench utilizing a fixed angle apron feeder. For this scenario, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.22$

Supply factor $(F_S) = 0.078(X)^{0.287}$

Equipment operation factor $(F_E) = 0.0004(X)^{0.762}$
where X = ore feed, in metric tons per day.

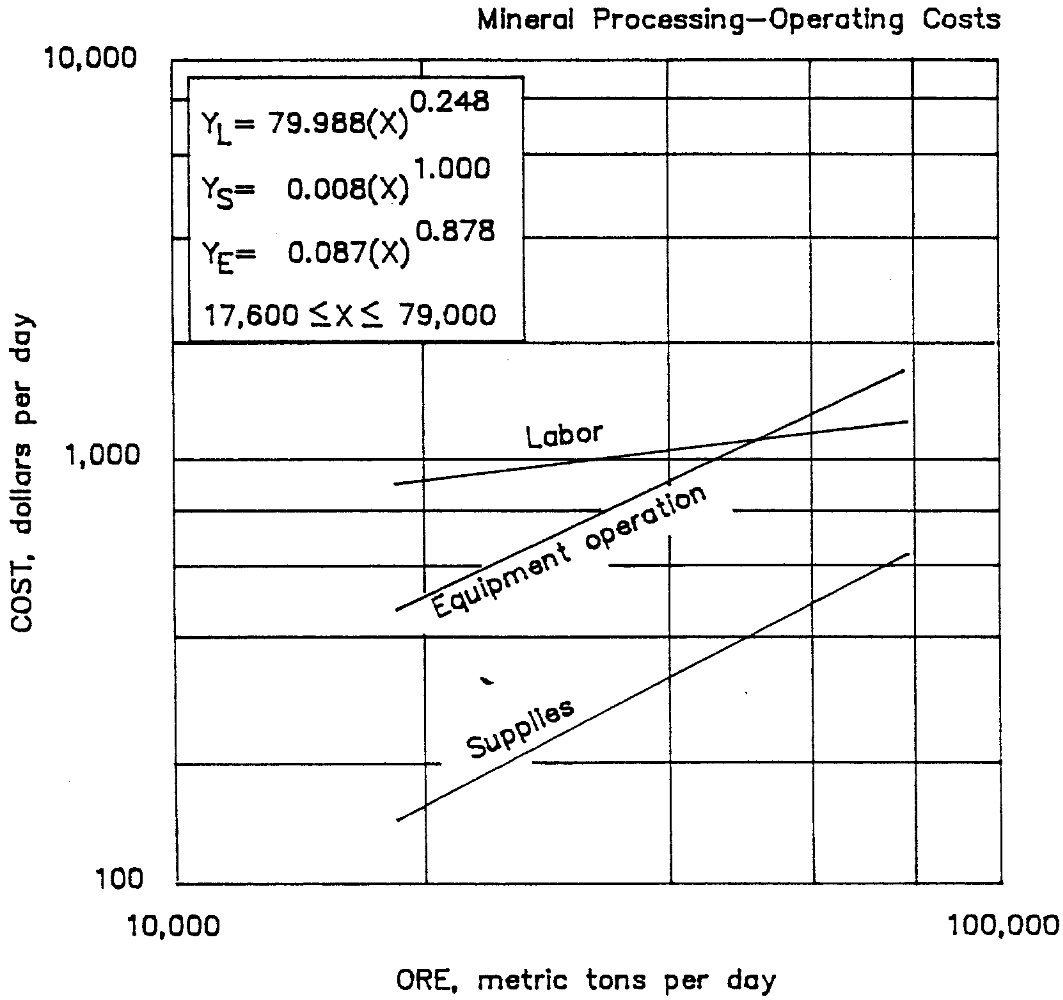
Feeding the Crusher With a Variable Angle Apron Feeder From Same Bench Factor
The most operating flexibility is obtained by feeding the crusher with an apron feeder that is capable of adjusting to different ground elevations. For this case, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.35$

Supply factor $(F_S) = 2.06$

Equipment operation factor $(F_E) = 0.0004(X)^{0.762}$
where X = ore feed, in metric tons per day.

Shift Factor The curve is based on a three-shift-per-day operation. The mobile crusher can also be operated one or two shifts per day. For a reduced shift operation, decrease the operating costs proportionately.



7.1.1.2. Mobile crushing

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.1. COMMINUTION

7.1.1.3. IMPACT CRUSHING

Impact crushing operating costs, as determined in this section, are based on metric tons of mine run ore reduced by impactors to a size suitable for further beneficiation. The costs are applicable for reduction of mine run ore, with an equivalent hardness and abrasiveness of medium hard limestone, to minus 0.95 cm (3/8 in).

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the production rate (X), in metric tons of ore crushed per day. The curves are valid for operations between 1,200 and 20,000 mtpd, operating two shifts per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 17.126(X)^{0.585}$
The operating labor costs consist of the following typical range of personnel:

Direct labor...............	55%
Maintenance labor..........	45%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Crusher operator...........	38%	$16.22
Screen operator............	18%	16.22
Conveyor operator..........	13%	14.89
Laborer....................	31%	13.26

The average wage for labor is $15.70 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.649(X)^{0.843}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 8.460(X)^{0.581}$
The equipment operation curve consists of 93 % for repair and maintenance parts and 7% for lubrication.

ADJUSTMENT FACTORS

Shift-Feed Rate Factor Because of high maintenance requirements, impact crushers are limited to not more than two shifts per day. If the crushing facility operates one shift per day, multiply the daily feed rate by two, then obtain a cost using the adjusted daily feed rate, then decrease this cost by 50% to arrive at the proper operating cost.

Alternative Impact Crushing If other than primary impact crushing facilities are required (see section 6.1.1.3., impact crushing capital cost), then use the following equations, based on the production rate (X), in metric tons of ore per day. The curves are valid for operations between 1,200 and 20,000 mt, operating two shifts per day.

(L) Labor Operating Cost $(Y_{L\ ALTERNATE}) = 7.884(X)^{0.607}$
The operating labor costs consist of the following typical range of personnel:

Direct labor..........	72%
Maintenance labor.....	28%

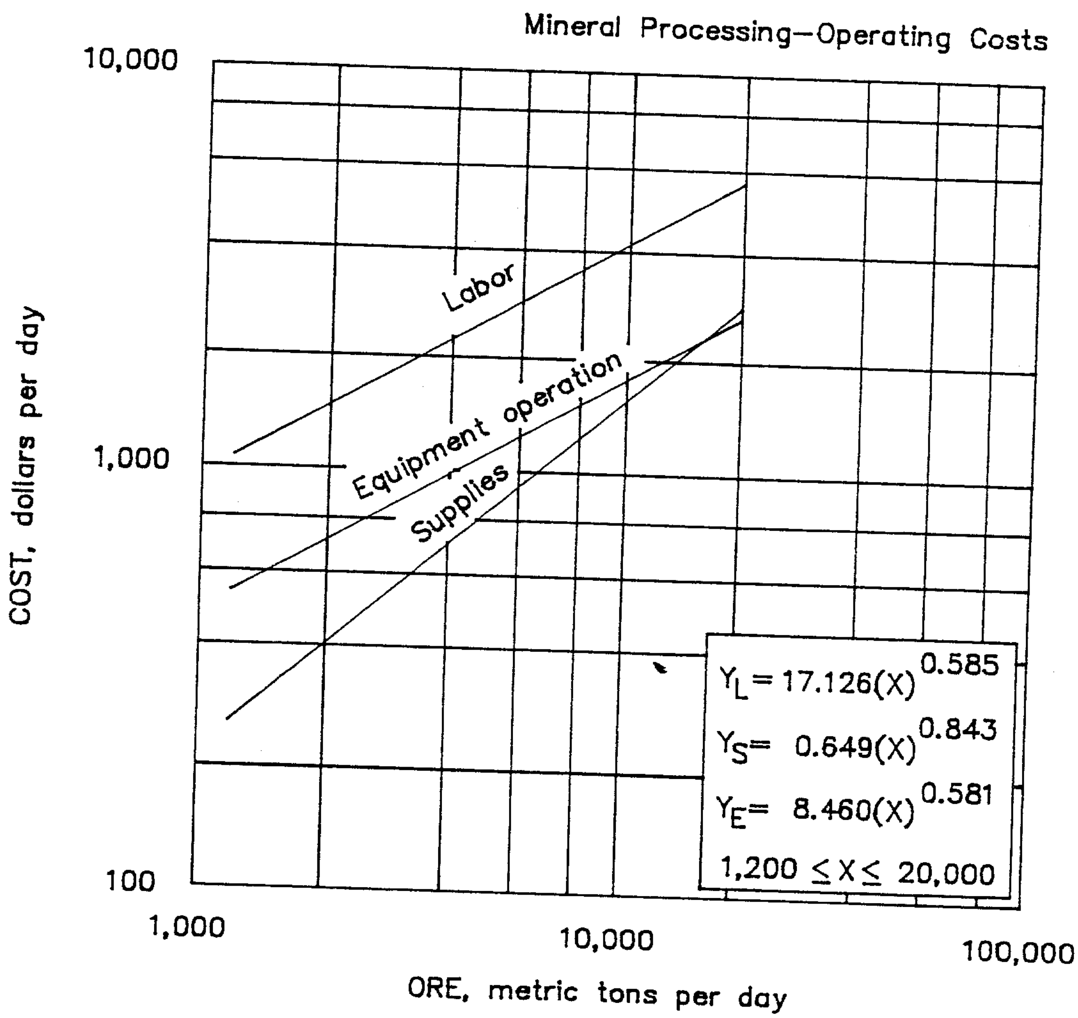
The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Crusher operator...........	38%	$16.22
Screen operator............	18%	16.22
Conveyor operator..........	13%	14.89
Laborer....................	31%	13.26

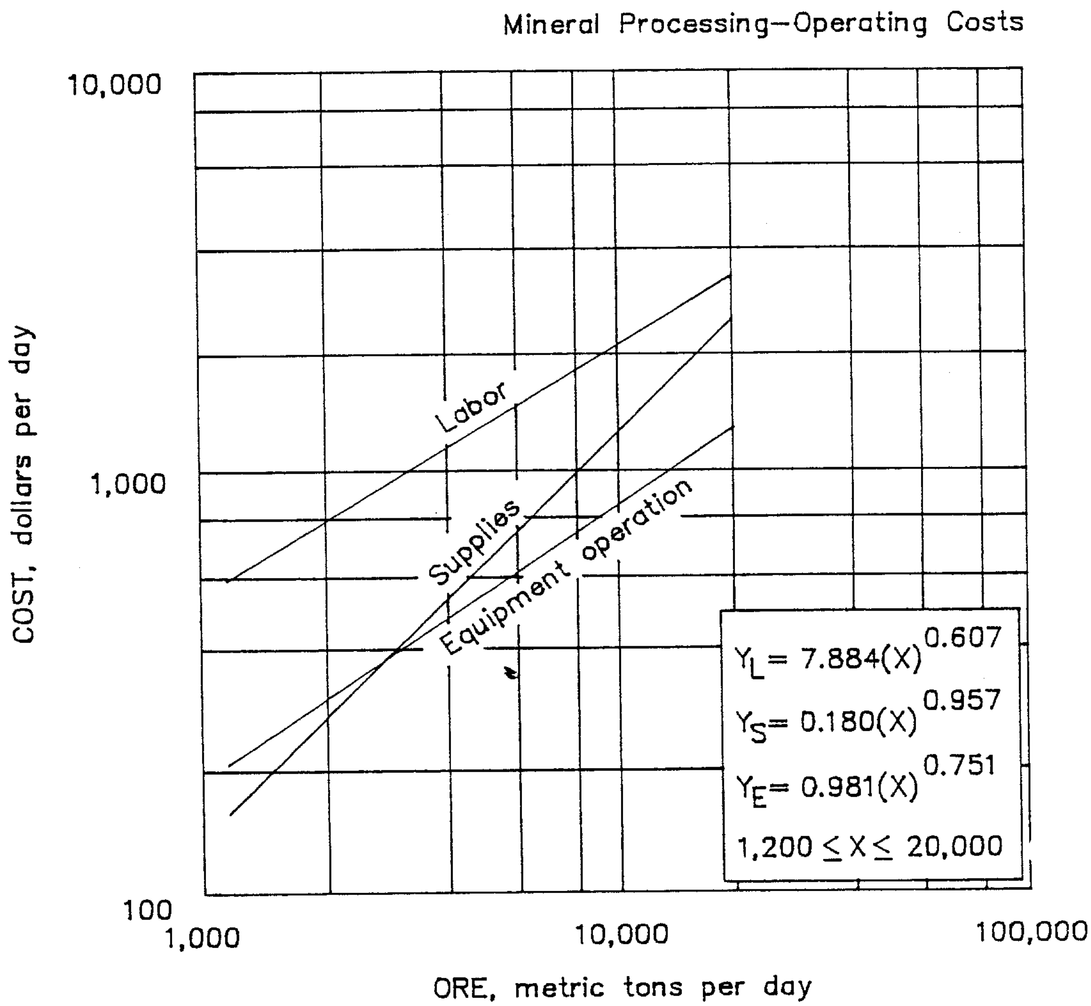
The average wage for labor is $15.70 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_{S\ ALTERNATE}) = 0.180(X)^{0.957}$
The supply costs consist of 100% electric power.

(E) Equipment Operating Cost $(Y_{E\ ALTERNATE}) = 0.981(X)^{0.751}$
The equipment operation curve consists of 93% for repair and maintenance parts and 7% for lubrication.



7.1.1.3.a Impact crushing



7.1.1.3.b Alternative impact crushing

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.2. COMMINUTION

7.1.2.1. GRINDING

This unit operation pertains to the wet grinding of crushed ore to a size suitable for further beneficiation operations. The curves are based on closed circuit operation with the mills running at normal load and percentage of critical speed and include the costs associated with grinding, classification, and pumping of the resultant slurry. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a feed rate X, in metric tons ore per day. The curves are valid for operations between 380 and 100,000 mtpd, operating three shifts per day.

BASE CURVE

The base curves were developed for the grinding of a medium hard ore (work index of 14.3 kW.h/mt) from 80% passing 1.27 cm to 80% passing 65 mesh. The process commences at the mill feed conveyors and terminates with the cyclone classifier overflow.

(L) Labor Operating Cost $(Y_L) = 144.500(X)^{0.301}$
The operating labor costs consist of the following typical range of personnel:

	Small (380 to 10,000 mtpd)	Large (10,000 to 100,000 mtpd)
Direct labor............	55%	45%
Maintenance labor.......	45%	55%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Control room operator......	23%	$17.23
Mill operator..............	36%	16.78
Mill helper................	18%	13.66
Mill laborer...............	23%	11.68

The average wage for labor is $15.33 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.689(X)^{0.977}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 0.308(X)^{1.000}$
The equipment operation curve consists of 96% for wear materials and repair parts and 4% for lubrication.

ADJUSTMENT FACTORS

Ore Hardness Factor The base curves are premised on an ore hardness of 14.3 kW.h/mt. To adjust for a different work index, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = (14.3/I)^{-0.301}$

Supply factor $(F_S) = (14.3/I)^{-0.977}$

Equipment operation factor $(F_E) = (14.3/I)^{-1.000}$
where I = new work index, in kilowatt hours per metric ton.

Size Factor The base curves are predicated on grinding crushed ore of 80% passing 1.27 cm to a final particle size of 80% passing 65 mesh. To allow for variation in either the particle size of the feed to the grinding circuit or of the ground ore, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = [((1/(P)^{0.5})-(1/(F)^{0.5}))/0.055]^{0.301}$

Supply factor $(F_S) = [((1/(P)^{0.5})-(1/(F)^{0.5}))/0.055]^{0.977}$

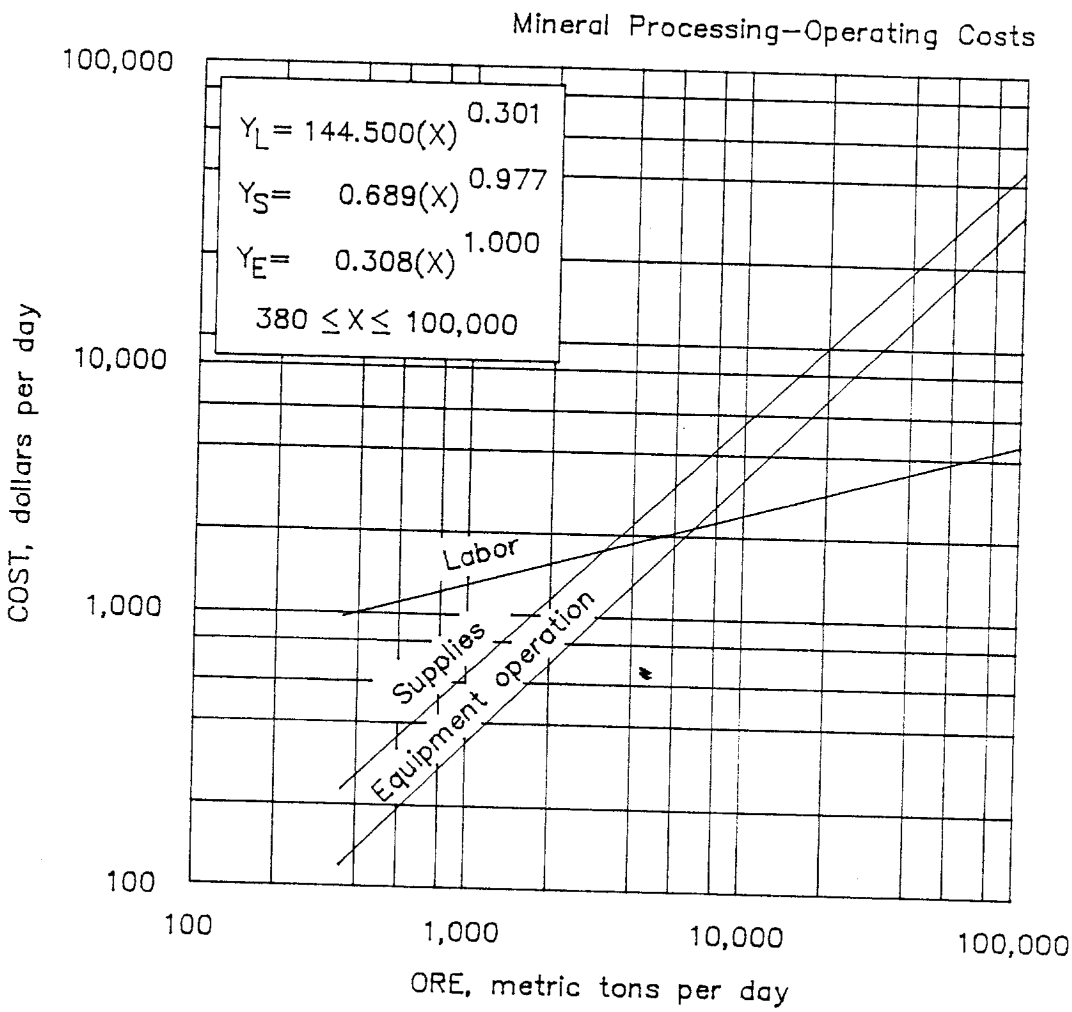
Equipment operation factor
$(F_E) = [((1/(P)^{0.5})-(1/(F)^{0.5}))/0.055]^{1.000}$
where F = particle size, in microns, passing 80% of the feed to the grinding circuit,
and P = particle size, in micron, passing 80% of the final product.

The following tabulation gives mesh sizes versus microns.

Mesh sizes versus microns

mesh[1]	microns[2]	mesh[1]	microns[2]	mesh[1]	microns[2]
2.....	11,058.183	45.....	371.368	200.....	73.061
5.....	4,073.138	50.....	331.077	230.....	62.737
10.....	1,913.403	60.....	271.407	270.....	52.677
15.....	1,229.892	70.....	229.430	300.....	46.961
20.....	898.843	80.....	198.353	325.....	43.038
25.....	704.777	100.....	155.527	400.....	34.321
30.....	577.756	120.....	127.497	600.....	22.061
35.....	488.396	140.....	107.777		
40.....	422.242	170.....	87.220		

[1] $2.354 \times (\text{mesh number})^{-1.090}$ = centimeters
[2] Centimeters X 10,000 = microns



7.1.2.1. Grinding

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.2. COMMINUTION

7.1.2.2. SEMIAUTOGENOUS GRINDING

The costs for semiautogenous grinding (SAG) are given on a metric ton per day basis. The costs include the operation of grinding mills, conveyors, pumps and classifier. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on feed rate (X), in metric tons of ore per day. The curves are valid for operations between 330 and 111,800 mtpd, operating one shift per day.

BASE CURVES

The base curves are for SAG mill grinding of sulfide ores.

(L) Labor Operating Cost $(Y_L) = 116.035(X)^{0.304}$
The operating labor costs consist of the following typical range of personnel:

	Small (330 to 40,000 mtpd)	Large (40,000 to 111,800 mtpd)
Direct labor...............	55%	45%
Maintenance labor..........	45%	55%

The average base salary including burden for labor is as follows:

	Small (330 to 40,000 mtpd)	Large (40,000 to 111,800 mtpd)	Av salary per hour (base rate)
Control room operator......	33%	23%	$17.23
Mill operator..............	24%	23%	16.78
Mill suboperator...........	-	20%	14.56
Mill helper................	33%	11%	13.66
Mill laborer...............	10%	23%	11.68

The average wage for labor is $15.13 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.614(X)^{0.986}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 0.312(X)^{0.998}$
The equipment operation curve consists of 94% for wear materials (balls and liner) and 6% for repair parts.

ADJUSTMENT FACTORS

Single-Stage SAG Grinding Factor The operating cost curves must be adjusted for single-stage grinding. Multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 2.047(X)^{-0.053}$

Supply factor $(F_S) = 1.137(X)^{-0.007}$

Equipment operation factor $(F_E) = 1.95$
where X = ore ground, in metric tons per day.

Uranium Factor The operating cost curves must be adjusted for uranium grinding. Multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 3.709(X)^{-0.201}$

Supply factor $(F_S) = 0.704(X)^{-0.102}$

Equipment operation factor $(F_E) = 0.088(X)^{0.214}$
where X = uranium ore ground, in metric tons per day.

Single-Stage (Sulfide) Autogenous Grinding Factor The operating cost curves must be adjusted for single-stage (sulfide) autogenous grinding. Multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.911$

Supply factor $(F_S) = 1.0$

Equipment operation factor $(F_E) = 0.270$

Iron Ore-SAG Factor For the grinding of taconite in a two-stage circuit, where the primary mill is a SAG mill, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.093$

Supply factor $(F_S) = 1.626$

Equipment operation factor $(F_E) = 4.473$

Hardness Factor The other operating cost curves can be adjusted by multiplying the base costs by the following factor:

Hardness factor $(F_H) = (N)/10.4$
where N = new power requirements, in kilowatt hours per metric ton.

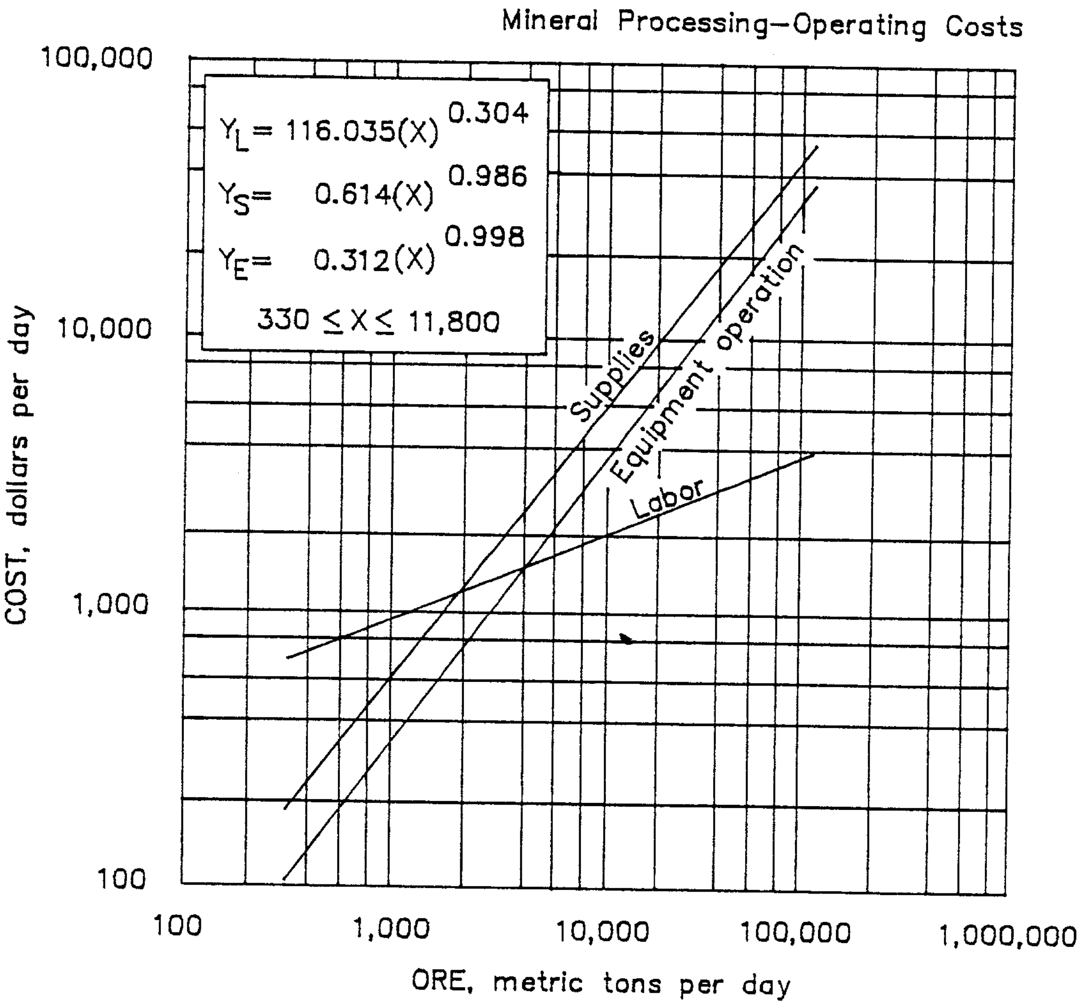
Iron Ore-Autogenous Grinding Factor To reflect the cost of grinding taconite in an autogenous mill (the autogenous mill is the primary mill), multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 1.352$

Supply factor $(F_S) = 2.086$

Equipment operation factor $(F_E) = 3.925$

Shift Factor The curve is based on a one-shift-per-day operation. Typically, semi-autogenous circuits are operated primarily on day shift only. For a two or three-shift operation, increase the operating costs proportionately.



7.1.2.2. Semiautogenous grinding

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.2. COMMINUTION

7.1.2.3. RAYMOND MILL GRINDING

The operating cost curves cover costs associated with dry grinding barite to 90% minus 325 mesh. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on feed rate (X), in metric tons of ore per day. The curves are valid for operations between 115 and 1,290 mtpd, operating two shifts per day.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 20.073(X)^{0.570}$
The operating labor costs consist of the following typical range of personnel:

Direct labor...............	42%
Maintenance labor..........	58%

The average base salary including burden for labor is as follows:

		Av salary per hour (base rate)
Mill operator..............	95%	$17.11
Mill laborer...............	5%	13.66

The average wage for labor is $16.92 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 1.001(X)^{0.952}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 1.999(X)^{0.800}$
The equipment operation curve consists of 100% for repair parts and materials.

ADJUSTMENT FACTORS

Ore Hardness Factor The base curves are premised on an ore hardness of 9.1 kW·h/mt. To adjust for a different work index, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.3308/(I)^{-0.501}$

Supply factor $(F_S) = 0.1709/(I)^{-0.800}$

Equipment operation factor $(F_E) = 0.1222/(I)^{-0.952}$
where I = new work index, in kilowatt hours per metric ton.

Flash Drying Factor If the barite is dried prior to grinding, the supply curve must be adjusted for natural gas consumed. Multiply the supply operating cost obtained from the curve by the following factor:

Labor factor $(F_L) = 1.04$

Supply factor $(F_S) = 13.32$

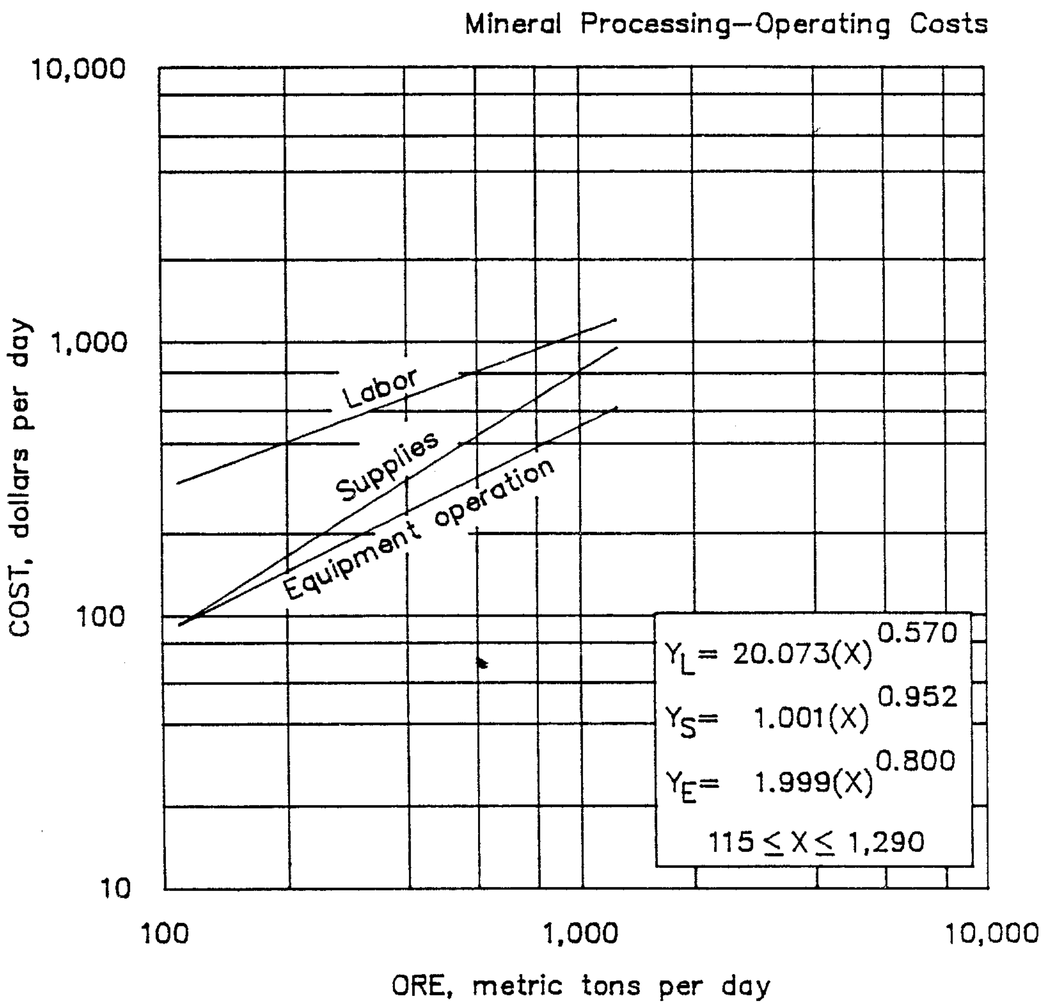
Equipment operation factor $(F_E) = 1.04$

Potash Factor The operating cost curves must be adjusted for grinding langbeinite. Multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.74$

Supply factor $(F_S) = 1.3$

Equipment operation factor $(F_E) = 0.38$



7.1.2.3. Raymond mill grinding