7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.1.1. SEDIMENTATION
CONCENTRATE THICKENING

Concentrate thickening is the partial dewatering of the concentrate pulp in preparation for effective filtration and, in some cases, drying.

The curves include all daily operating and maintenance costs associated with continuous concentrate thickening, but apply only to the operation of conventional concentrate thickeners and do not make allowances for the use of high-capacity, tray, deep-cone, or middling thickeners. In addition, the curves do not apply to the operation of clarifiers or countercurrent decantation arrangements.

1. Costs are based on current industry preference for installation of a single large thickener, rather than several smaller thickeners of the same or different sizes, whenever possible. Large-capacity operations may use several thickeners because of maximum design-size limitations.

2. The curves cannot be directly applied to thickeners processing light (river or lake water clarification, metallic oxides, and brine clarification), some standard (magnesium oxide and lime or brine softening), or extra-heavy (uranium countercurrent decantation, iron ore concentrate, iron pellet feed, and titanium ilmenite) pulps. Size of solids is approximately 68% smaller than 200 mesh and 10% larger than 65 mesh.

3. Cost are applicable to the following thickener operating parameters:

Solids loading........................	0.77 m^2/mtpd[1]
Specific gravity of solution...........	1.00
Specific gravity of underflow slurry...	1.46
Inflow slurry solid percent............	25% by weight
Underflow slurry solid percent.........	50% by weight

[1]The cost curves are actually based on 0.93m^2/mtpd, an increase of approximately 25% for safety and temporary storage. See table A-1 for unit areas.

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 concentrate per day, on a dry basis. The curves are valid for operations between 5 and 100,000 mtpd, operating three shifts per day. If more than one concentrate is being produced and thickened, the curves should be entered as often as necessary using the appropriate daily tonnage rates and unit area settling rates.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 0.005(X)+33.289$

The operating labor costs consist of the following typical range of personnel:

Direct labor...............	19%
Maintenance labor..........	81%

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

		Av salary per hour (base rate)
Utility person.............	100%	$14.89

The average wage for labor is $14.89 per worker-hour (including burden and average shift differential).

No operating personnel are specifically assigned full time for thickener operation. Annual maintenance labor, prorated to a daily basis for this curve, is required for overhaul and/or lubrication.

(S) Supply Operating Cost $(Y_S) = 1.614(X)^{0.547}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 0.991(X)^{0.496}$
The equipment operation cost generally consists of only annual maintenance, which includes 92% for overhaul and repair parts and 8 % for lubrication.

ADJUSTMENT FACTORS

Amorphous or Colloidal Tailings The thickener area should be approximately doubled for amorphous or colloidal tailings. Costs should be increased accordingly.

Flocculation Factor Flocculants are high-molecular weight polyelectrolytes of chemically modified natural organic materials used to promote settling. A wide range of unit area reductions is possible in designing a thickener, depending upon which flocculant is added to the feed. In an existing thickener, throughputs can be markedly increased, sometimes by a factor of 10 or more. For the basis of this section, the following costs should be added to the operating curves given above if flocculants are added:

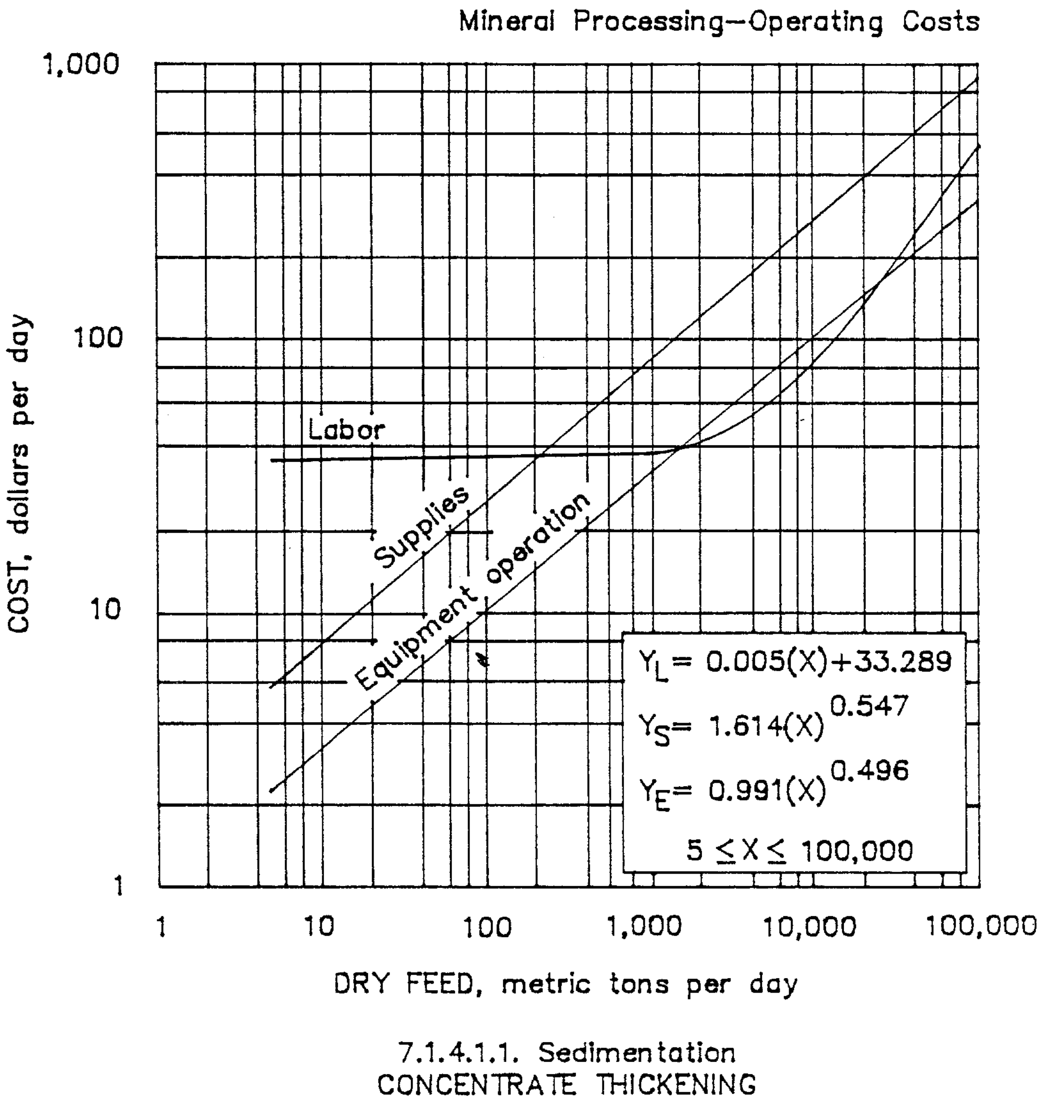
Labor factor $(F_L) = 0.110(X)^{0.722}$

Flocculation polymer cost
Supply factor $(F_{S\ POLYMER}) = 0.028(X)^{1.000}$

Flocculation power cost
Supply factor $(F_{S\ POWER}) = 0.011(X)^{0.745}$

where X = dry concentrate, in metric tons per day.

These curves are based on a polymer costing $2.76 per kilogram in emulsion form being added at the rate of 3 mg/L of thickener slurry feed and on a slurry volume of 3,392 L of slurry per metric ton of dry solids.



7.1.4.1.1. Sedimentation
CONCENTRATE THICKENING

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.1.2. SEDIMENTATION TAILINGS THICKENING

Dewatering of tailings slurries through sedimentation and decantation in ponds and basins is usually preceded by preliminary dewatering with thickeners to reduce the slurry volume prior to transportation to the pond and to facilitate water reuse.

The cost curves in this section are applicable to operation of tailingsthickener systems but cannot be used to obtain costs for dewatering directly from the pond or for dewatering by alternative systems necessary for problem slurries, such as red mud resulting from bauxite processing or slimes from phosphate processing, both of which may contain as much as 85% to 90% water. The cost curves cannot be applied to high-rate tray, deep-cone, lamella, or middlings thickeners. In addition, the curves do not apply to the operation of clarifiers or countercurrent decantation arrangements.

The following operational conditions apply for correct usage of the cost curves:

1. Costs are based on current industry preference for installation of a single large thickener, rather than several smaller thickeners of the same or different sizes, whenever possible. Large capacity operations may use several thickeners because of maximum design-size limitations.

2. Thus, as defined, the curves cannot be directly applied to thickeners processing light (river or lake water clarification, metallic oxides, and brine clarification), some standard (magnesium oxide and lime or brine softening), or extra-heavy (uranium countercurrent decantation, iron ore concentrate, iron pellet feed, and titanium ilmenite) pulps. Size of solids is approximately 68% smaller than 200 mesh and 10% larger than 65 mesh.

3. Costs are applicable to the following thickener operating parameters:

Solids loading........................	0.77 m^2/mtpd[1]
Specific gravity of solution...........	1.00
Specific gravity of underflow slurry...	1.46
Inflow slurry solid percent............	25 percent by weight
Underflow slurry solid percent.........	50 percent by weight

[1]The cost curves are actually based on 0.93 m^2/mtpd, an increase of approximately 25% for safety and temporary storage. See table A-1 for unit areas.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the feed rate (X), in metric tons of tailings per day determined on a dry basis. The curves are valid for operations between 5 and 100,000 mtpd, operating three shifts per day.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 0.005(X)+33.289$
The operating labor costs consist of the following typical range of personnel:

Direct labor..............	19%
Maintenance labor..........	81%

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

		Av salary per hour (base rate)
Utility person............	100%	$14.56

The average wage for labor is $14.89 per worker-hour (including burden and average shift differential).

No operating personnel are specifically assigned full time for thickener operation. Annual maintenance labor, prorated to a daily basis for this curve, is required for overhaul and/or lubrication.

(S) Supply Operating Cost $(Y_S) = 1.614(X)^{0.547}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 0.991(X)^{0.496}$
The equipment operation cost consists only of annual maintenance, which includes 92% for overhaul and repair parts and 8% for lubrication.

ADJUSTMENT FACTORS

Amorphous or Colloidal Tailings The thickener area should be approximately doubled for amorphous or colloidal tailings. Costs should be increased accordingly.

Flocculation Factor Flocculants are high-molecular weight polyelectrolytes of chemically modified natural organic materials used to promote settling. A wide range of unit area reductions is possible in designing a thickener, depending upon which flocculant is added to the feed. In an existing thickener, throughputs can be markedly increased in many cases, depending upon the nature of the input slurry. For the basis of this section, add the costs obtained from the curves to the following factors if flocculants are added:

Labor factor $(F_L) = 0.110(X)^{0.722}$

Flocculation polymer cost

Supply factor $(F_{S\ POLYMER}) = 0.028(X)^{1.000}$

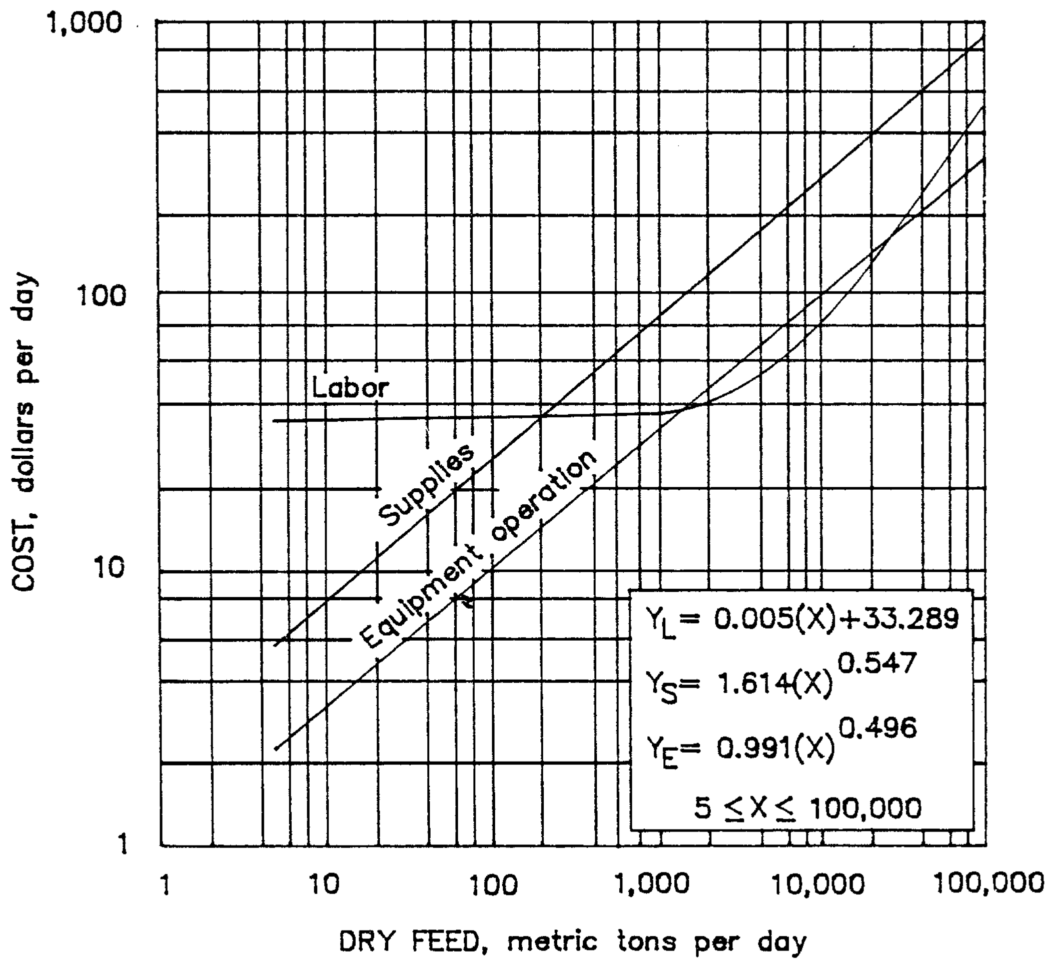
Flocculation power cost

Supply factor $(F_{S\ POWER}) = 0.011(X)^{0.745}$

where X = dry tailings, in metric tons per day.

These curves are based on a polymer costing $2.76 per kilogram in emulsion form being added at the rate of 3 mg/L of thickener slurry feed and on a slurry volume of 3,392 L of slurry per metric ton of dry solids.

Mineral Processing—Operating Costs



7.1.4.1.2. Sedimentation
TAILINGS THICKENING

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.1.3. SEDIMENTATION
COUNTERCURRENT DECANTATION

The operating cost curves for countercurrent decantation cover the operation of a 4-stage circuit at a settling area of 0.06 m^2/mtpd. The circuit includes the operation of thickeners and pumps. 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 concentrate per day. The curves are valid for operations between 175 and 5,500 mtpd, operating three shifts per day.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 30.193(X)^{0.380}$
The operating labor costs consist of the following typical range of personnel:

	Small (175 to 2,000 mtpd)	Large (2,000 to 5,500 mtpd)
Operations.................	88%	88%
Maintenance................	12%	12%

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

	Small (175 to 2,000 mtpd)	Large (2,000 to 5,500 mtpd)	Av salary per hour (base rate)
Mill operator..............	100%	68%	$17.11
Mill helper................	-	32%	13.99

The average wage for labor is $16.42 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 1.181(X)^{0.849}$
Supplies consist of 74% flocculant and 26% electric power.

(E) Equipment Operating Cost $(Y_E) = 1.808(X)^{0.544}$
The equipment operating cost consists of 100% for repair parts and materials for the operation of the thickeners and pumps.

ADJUSTMENT FACTORS

Number of Thickener Units The cost curves are based on the operation of a four-stage circuit. To adjust for each additional thickener unit, multiply the costs obtained from the curves by the following factors:

Supply factor $(F_{S\ EXTRA}) = 1.06$

Equipment operation factor $(F_{E\ EXTRA}) = 1.11$

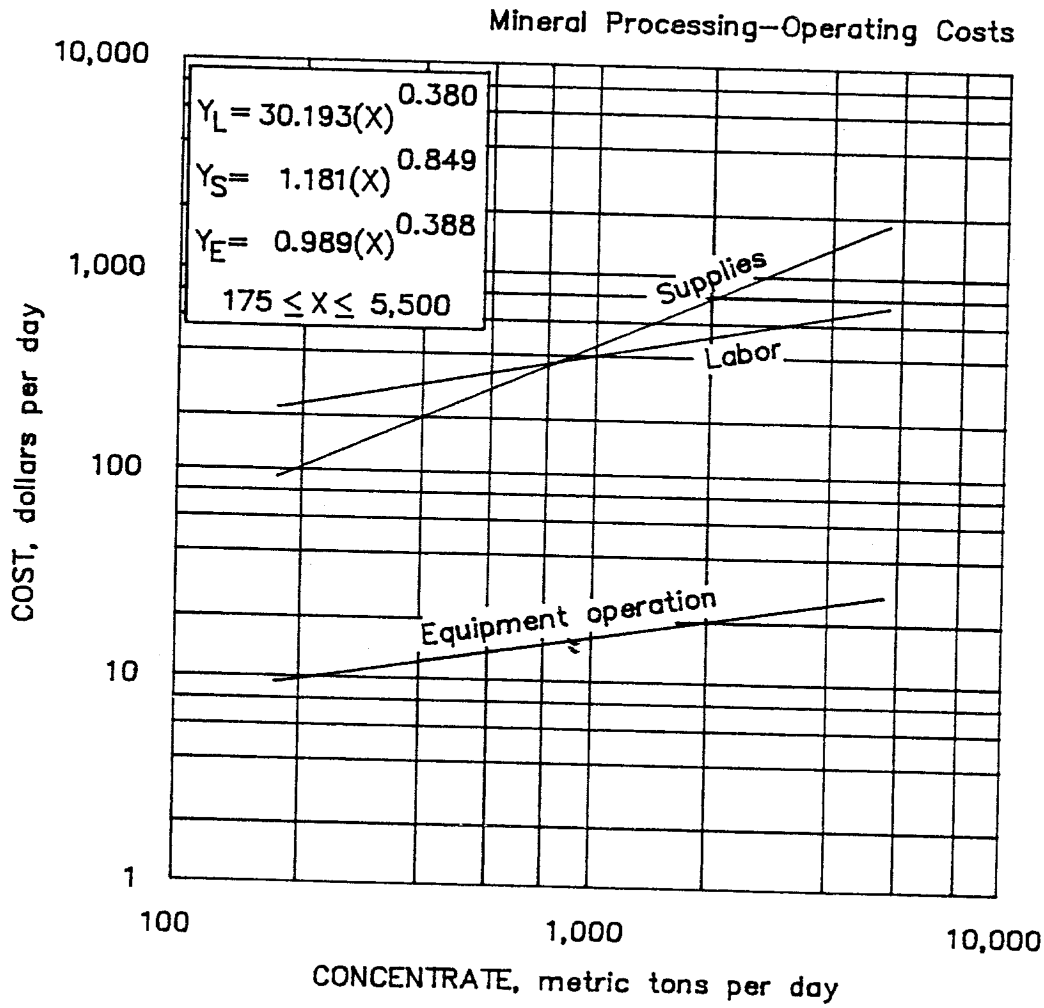
Conversely, to adjust for less than four thickener units, multiply the costs obtained from the curves by the following factors for each unit:

Supply factor ($F_{S\ FEWER}$) = 0.94

Equipment operation factor ($F_{E\ FEWER}$) = 0.89

Shift Factor The curve is based on a three-shift-per-day operation. Typically, counter-current decantation circuits are operated on a continuous basis to maintain steady flow rates between the individual thickener units. No adjustment factor for a oneor two-shift operation is recommended for this unit process.

Feed Rate Adjustment Accordingly, no adjustment factor for feed rate is recommended based on the above discussion for shift factor.



7.1.4.1.3. Sedimantation
COUNTER CURRENT DECANTATION

7.1. MINERAL PROCESSING--OPERATING COST

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.2.1. CONCENTRATE FILTRATION
VACUUM, DISK, AND DRUM FILTRATION

During filtration, the water content of the thickened concentrate pulp is reduced from approximately 50% to 12%. Unless subsequent drying is required, the filtration process is the final step used in producing a concentrate product.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the output rate (X), in metric tons dry concentrate per day. The curves are valid for operations between 5 and 60,000 mtpd, operating three shifts per day. The curves include all daily operating and maintenance costs associated with continuous-vacuum filtration, but do not include costs related to the auxiliary use of steam hoods or dewatering reagents. In particular, the curves apply to the operation of rotary-disc filter equipment; however, for the operation of drum-type or horizontal filter equipment, the curves still provide approximations of costs.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 18.964(X)^{0.470}$
The labor costs consist of the following typical range of personnel:

Direct labor..............	62%
Maintenance labor..........	38%

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

	%	Av Salary per hour (base rate)
Filter-dryer operators.....	100%	$16.22

The average wage for labor is $16.22 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.792(X)^{0.843}$
The supply costs consist of 91% electric power and 9% filter media (the filter medium is polyethylene cloth). If flocculants, filter aids, or other reagents (for improving dewatering performance) are used in the filtration process, their cost(s) should be added to the base supplies cost.

(E) Equipment Operating Cost $(Y_E) = 4.642(X)^{0.528}$
The equipment operating cost consists of 93% for overhaul and repair parts and 7% for lubrication.

ADJUSTMENT FACTORS

Filtration Rate Factor The operating cost curves are predicated on a filtration rate of 490 $(kg/m^2)/hr$ (approximately 100 $(lb/ft^2)/hr$). To allow for different filtration rates, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = (F/490)^{0.470}$

Supply factor $(F_S) = (F/490)^{0.843}$

Equipment operation factor $(F_E) = (F/490)^{0.528}$
where F = actual filtration rate, in kilograms per square meter per hour.

Pressure Filter Factor To account for the use of automatic pressure filters (e.g., Larox or Lasta-type filter presses) in place of the rotary-disk filters, multiply the costs obtained from the curves by the following factors:

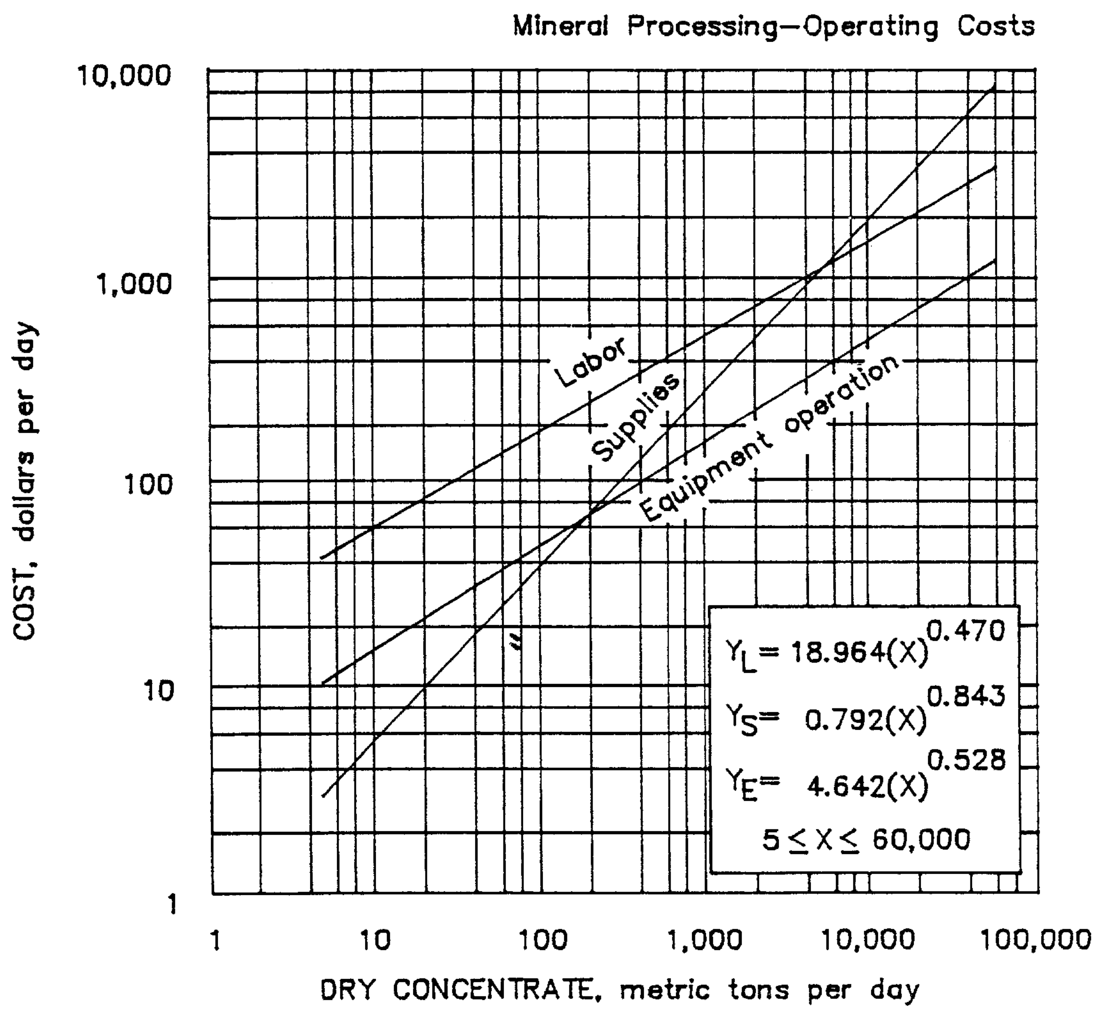
Supply factor $(F_S) = 0.56$

Equipment operation factor $(F_E) = 4.5$

The water content of the pressure-filtered concentrate will also be less than that obtained from rotary-disc filtration (approximately 8% instead of 12%).

Filter Medium Factor If the filter medium is not polyethylene cloth, the filter media cost should also be adjusted to reflect the material being used.

Steam Drying Factor If the filtration machines use auxiliary steam drying, the extra operating costs (labor, electric power, overhaul and repair parts, and lubrication) should be added to the applicable base curve costs.



7.1.4.2.1. Concentrate filtration
VACUUM, DISK, AND DRUM FILTRATION

7.1. MINERAL PROCESSING--OPERATING COST

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.2.2. CONCENTRATE FILTRATION
PRESSURE FILTRATION--SAND

The operating costs for pressure filtration are given on a metric ton per day of clarified solution basis. The costs include the operation of the feed pumps, filters, and ancillary equipment. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having an adjusted feed rate (X), in metric tons of solution per day. The curves are valid for operations between 1,900 and 31,900 mtpd, operating three shifts per day.

BASE CURVE

The base curve for sand filtration is predicated on processing an unclarified solution containing up to 200 ppm of suspended solids. the specific flowrate for the sand filters is 12 gallons per minute (gpm) per square foot of filter area. The filters are constructed of mild steel and are suitable for noncorrosive service.

(L) Labor Operating Cost $(Y_{L\ SAND}) = 0.422(X)^{0.590}$
The labor costs consist of the following typical range of personnel:

Direct labor...............	65%
Maintenance labor..........	35%

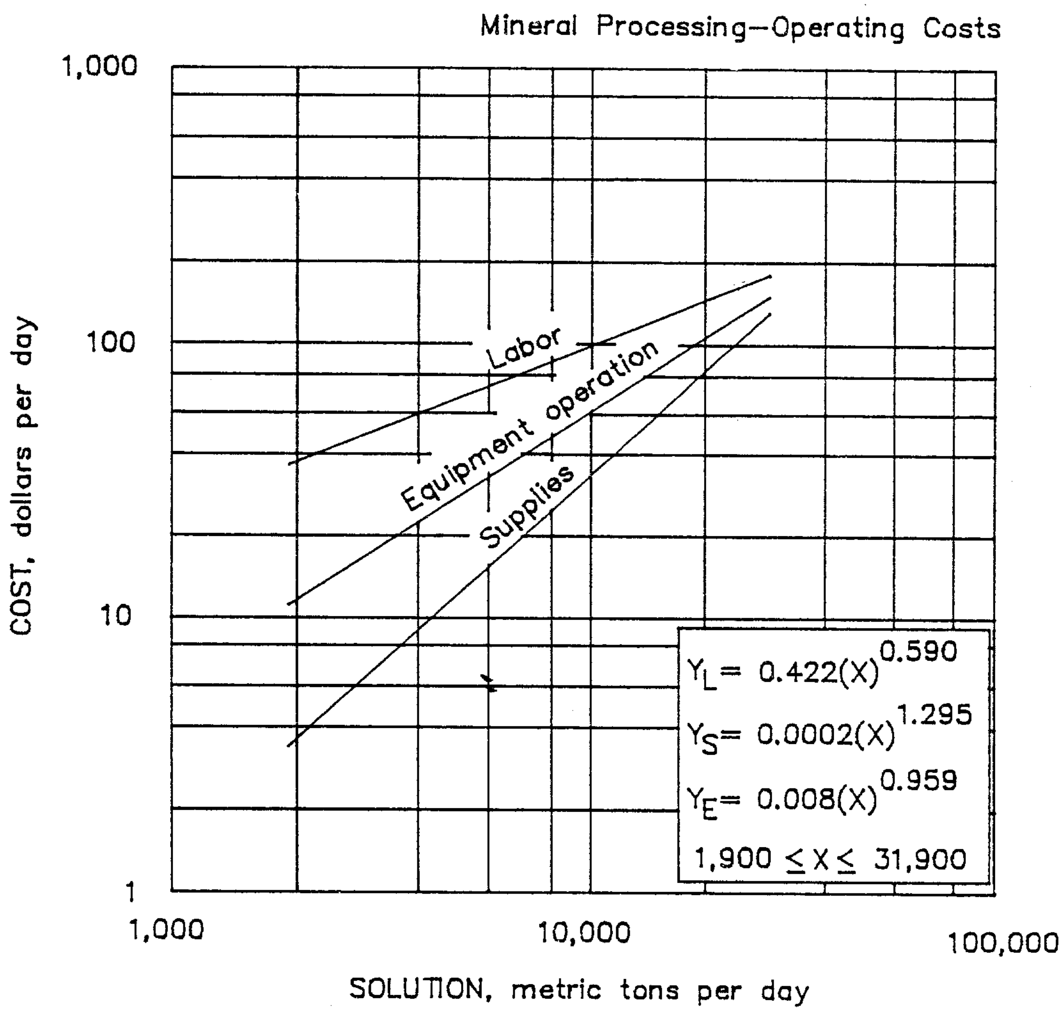
The average base salary including burden for labor is as follows:

		Av Salary per hour (base rate)
Mill operator..............	72%	$16.78
Mill laborer...............	28%	11.68

The average wage for labor is $15.86 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_{S\ SAND}) = 0.0002(X)^{1.295}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_{E\ SAND}) = 0.008(X)^{0.959}$
The equipment operation curve consists of 47% for repair parts and 53% for replacement sand.



7.1.4.2.2. Concentrate filtration
PRESSURE FILTRATION—SAND

7.1. MINERAL PROCESSING--OPERATING COST

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.2.3. CONCENTRATE FILTRATION
PRESSURE FILTRATION - PRECOAT

The operating costs for pressure filtration are given on a metric ton per day of clarified solution basis. The costs include the operation of the feed pumps, filters, and ancillary equipment. The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having an adjusted feed rate (X), in metric tons of solution per day. The curves are valid for operations between 2,100 and 16,100 mtpd, operating three shifts per day.

BASE CURVE

The base curve for precoat filtration is predicated on utilizing vertical leaf pressure precoat filters. The solution to be processed can contain up to 200 ppm of suspended solids. The specific flow rate for the precoat filter was 0.6 gpm/m^2 of filter area. The filters are constructed of mild steel.

(L) Labor Operating Cost $(Y_{L\ PRECOAT}) = 0.052(X)^{0.817}$
The labor costs consist of the following typical range of personnel:

Direct labor...............	70%
Maintenance labor..........	30%

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

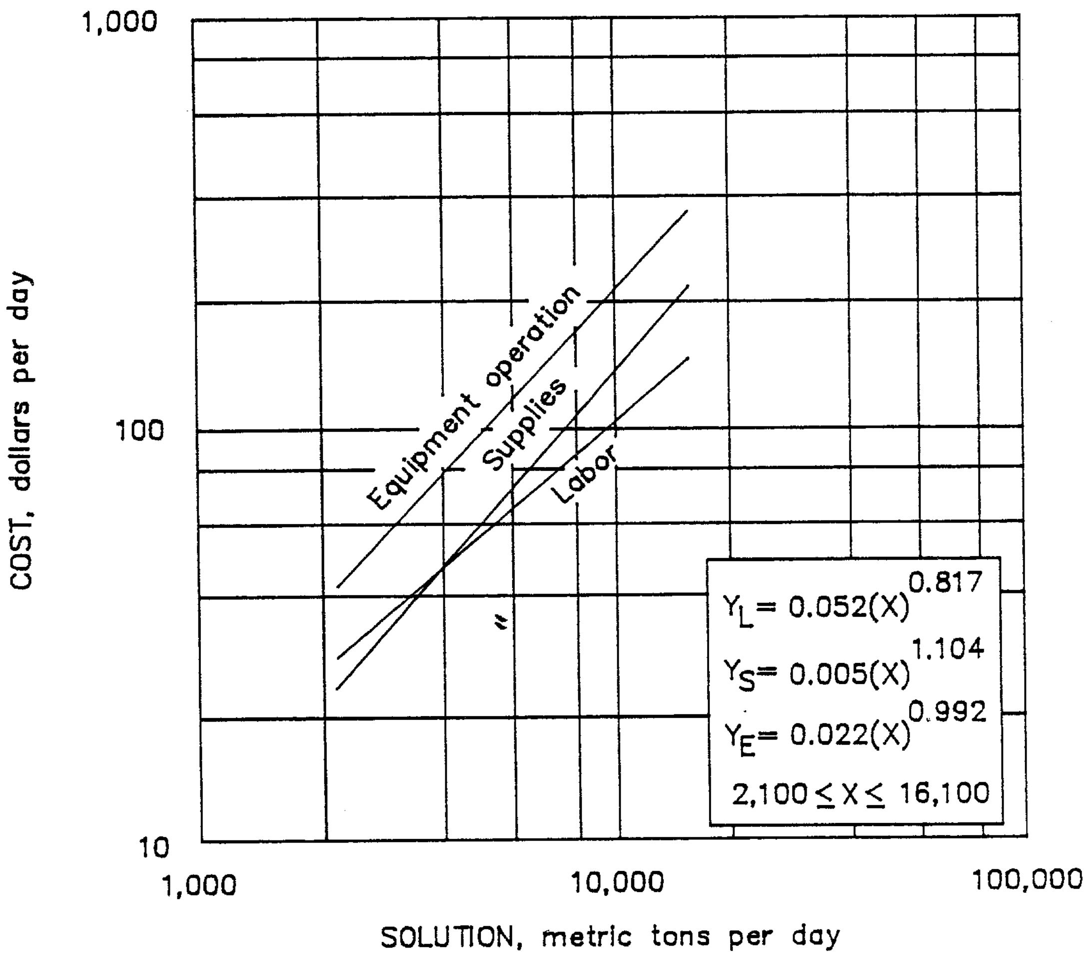
		Av Salary per hour (base rate)
Mill operator.............	100%	$16.78

The average wage for labor is $16.78 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_{S\ PRECOAT}) = 0.005(X)^{1.104}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_{E\ PRECOAT}) = 0.022(X)^{0.992}$
The equipment operation curve consists of 85% for precoat and 15% for repair parts.

Mineral Processing—Operating Costs



7.1.4.2.3. Concentrate filtration
PRESSURE FILTRATION—PRECOAT

7.1. MINERAL PROCESSING--OPERATING COST

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.2.4. CONCENTRATE FILTRATION
CENTRIFUGAL FILTRATION

The centrifuge filtration curves are based on the use of screen bowl centrifuges for concentrate filtration or tailings dewatering. Screen bowl centrifuges are normally used for feeds without an excess of minus 325-mesh fines. They are considered high-output units noted for their ability to produce a drier product than an equivalent capacity vacuum filter, and have the added advantage of being able to wash the filter cake. During centrifuging, the water content of a concentrate may be reduced to less than 8%, often eliminating the need for thermal drying. Centrifuges can also used for liquid clarification, slurry dewatering, and desliming.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on a production rate (X), in metric tons of dry solids handled per day. The curves are valid for operations between 5 and 30,000 mtpd, operating three shifts per day. Cost per metric ton is calculated by dividing the total cost per day by the metric tons of solids processed per day. Costs are based on the operation of screen bowl centrifuges utilizing gravity feed (feed pumps are not included in the cost).

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 3.728(X)^{0.543}$
The operation labor needs for a centrifuge are minimal and consist of only a fraction of a mill workers daily responsibility.

The labor costs consist of the following typical range of personnel:

Direct labor...............	54%
Maintenance labor..........	46%

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

		Av salary per hour (base rate)
Mill floorwalker...........	100%	$16.22

The average wage for labor is $16.45 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.216(X)^{1.010}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 1.366(X)^{0.807}$
The equipment operation curve consists of 83% for maintenance and repair parts (including ceramic hardfacing for scrolls and screens) and 17% for lubrication.

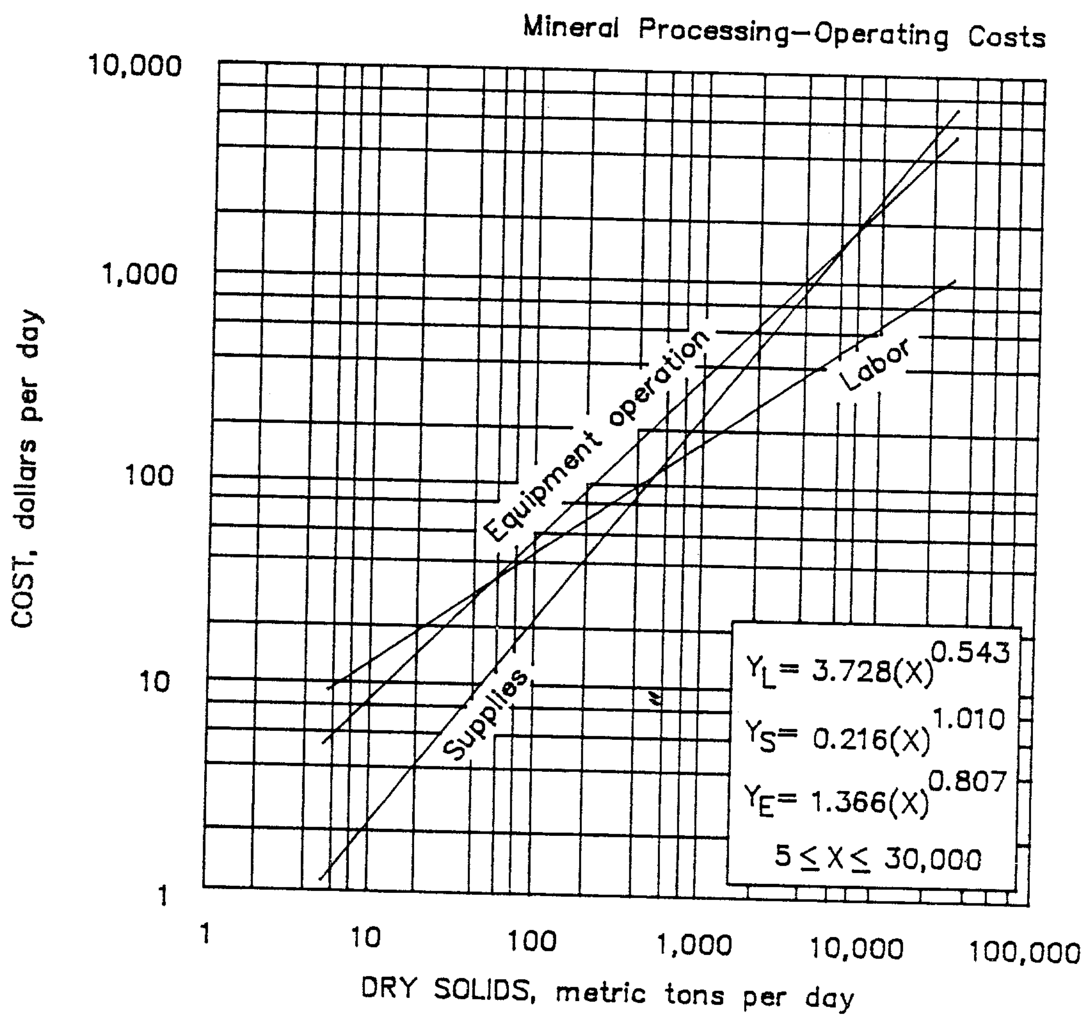
ADJUSTMENT FACTORS

Solid Bowl Centrifuge Factor In situations where water clarification is required, or excessive fines must be dewatered, solid bowl centrifuges are often called for. If solid bowl centrifuges are to be used, multiply the total daily operating costs by the following factor:

Solid bowl centrifuge factor $(F_S) = 0.778$

It must be remembered that solid bowl units are used mostly for clarification and desliming, and that in order to maintain throughput, flocculation of the feed may be required.

Flocculant Factor If flocculants are to be used to enhance sedimentation, the cost per day of the required flocculant must be added to the daily supply cost.



7.1.4.2.4. Concentrate filtration
CENTRIFUGAL FILTRATION

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.3. CONCENTRATE DRYING

Drying operations generally use natural gas when and if available; otherwise, fuel oil is used. A hypothetical product was used for the cost determinations; it contained 12% moisture (from the filtration section) and was dried to 2% moisture.

The curves are based on an operation using rotary dryers equipped with dust collectors and scrubbers and include conveyors in and out of the dryer. 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 of dry concentrate per day. The curves are valid for operations between 4 and 8,000 mtpd, operating three shifts per day.

BASE CURVES

(L) Labor Operating Cost $(Y_{L\ SMALL}) = 141.199(X)^{0.063}$
$(Y_{L\ LARGE}) = 48.296(X)^{0.237}$

The operating labor costs consist of the following typical range of personnel:

	Small (4 to 400 mtpd)	Large (400 to 8,000 mtpd)
Direct labor...............	36%	33%
Maintenance labor..........	64%	67%

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

	Small (4 to 400 mtpd)	Large (400 to 8,000 mtpd)	Av salary per hour (base rate)
Dryer operator.............	73%	65%	$15.89
Helper.....................	27%	35%	13.66

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

(S) Supply Operating Cost $(Y_{S\ SMALL}) = 17.691(X)^{0.634}$
The supply cost consists of 73% natural gas and 27% electric power.

(S) Supply Operating Cost $(Y_{S\ LARGE}) = 3.084(X)^{0.933}$
The supply cost consists of 95% natural gas and 5% electric power.

(E) Equipment Operating Cost $(Y_{E\ SMALL}) = 101.404(X)^{0.065}$
$(Y_{E\ LARGE}) = 28.501(X)^{0.265}$

Equipment operation consists of 94% for repair parts and 6% for lubrication for the dryer drum, drives, fans, conveyors, and dustcollection system for both the small and large operations.

ADJUSTMENT FACTORS

Fuel Oil Factor If fuel oil is used instead of natural gas, multiply the natural gas portion by the following factor:

Fuel oil factor $(F_F) = 2.3$

Moisture Factor The cost of gas is a direct function of the amount of moisture to be removed. If the reduction in moisture is different than drying from 12% to 2%, the cost of natural gas should be multiplied by the following factor:

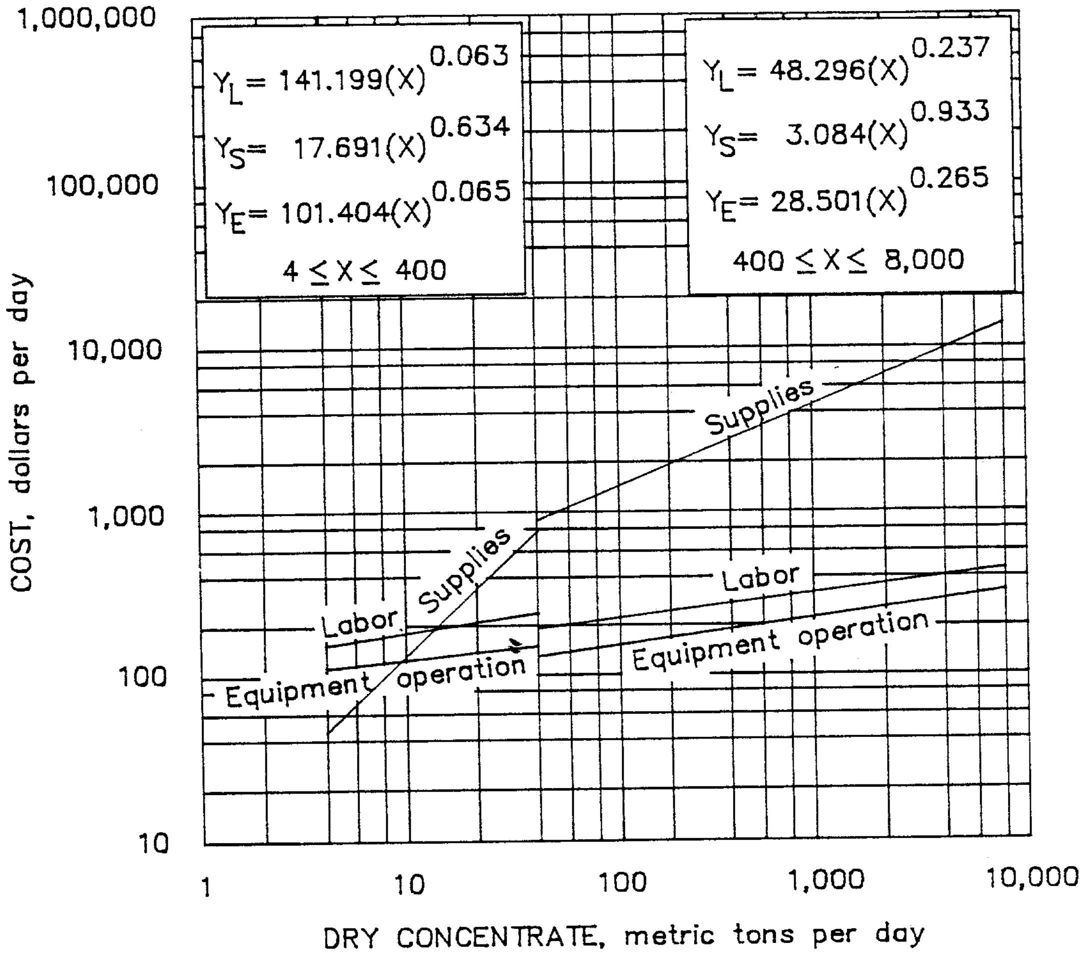
Moisture Factor $(F_M) = 8.624[(C-M)/((1-C)(1-M))]$

where C = input moisture content, expressed as a fraction of the total weight of dryer feed material (including moisture),

and M = output moisture content, expressed as a fraction of the total weight of dryer product material.

Actual costs, unit prices, wages, or cost breakdowns, if known, may be substituted for values given in the above descriptions in order to adjust the labor, supplies, and equipment curves.

Mineral Processing—Operating Costs



7.1.4.3. Concentrate drying

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.4. TRANSPORT AND PLACE TAILINGS

These curves cover the cost of transporting the partially dewatered tailings to a tailings pond. The tailings dam is raised by the constant addition of new material through the use of cyclones (for mineral processing plants over 1,000 mtpd). The curves are based on the following data:

Percent solids in slurry......	50%
Specific gravity of slurry....	1.46
Total average head...........	30 m (including 15 m of static head)
Average pump efficiency.......	65%
Pumping distance.............	1 km

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a disposal rate (X), in metric tons tailings per day (dry weight equivalent). The curves are valid for operations between 100 and 100,000 mtpd, operating three shifts per day. The curves include all daily operating and maintenance costs associated with the pumping, transporting through pipe, and disposing of the tailings in the pond. Backup pumps and motors allow the system to operate 100% of the time.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 0.728(X)^{0.682}$
The operating labor costs consist of the following typical range of personnel:

	Without cyclones (100 to 1,000 mtpd)	With cyclones (1,000 to 100,000 mtpd)
Direct labor...............	45%	80%
Maintenance labor..........	55%	20%

The operating labor costs consist of the following typical range of personnel.

	Without cyclones (100 to 1,000 mtpd)	With cyclones (1,000 to 15,000 mtpd)	(15,000 to 50,000 mtpd)	(50,000 to 100,000 mtpd)	Av salary per hour (base rate)
Operator..........	-	53%	14%	-	$16.25
Laborer...........	100%	47%	67%	50%	13.97
Crane operator....	-	-	10%	19%	15.89
Truck driver......	-	-	9%	19%	15.89
Dozer operator....	-	-	-	12%	16.33

Operating costs average $15.05 per hour (including shift differential and burden). Changes in pumping rate, slurry composition (percent solids), or distance do not materially affect the daily average labor wage.

(S) Supply Operating Cost $(Y_S) = 0.110(X)^{0.803}$
The supply cost consists of electric power and steel pipe.

	Without cyclones	With cyclones		
	(100 to 1,000 mtpd)	(1,000 to 15,000 mtpd)	(15,000 to 50,000 mtpd)	(50,000 to 100,000 mtpd)
Power...............	81%	78%	91%	84%
Pipe (steel)........	19%	21%	9%	16%

(E) Equipment Operating Cost $(Y_E) = 0.00261(X)^{1.052}$
The equipment operation curve covers the daily operating cost for pumping, cycloning, and redistributing waste in a tailings pond, and includes allowances for replacement of pumps and cyclones and for mobile equipment operating costs.

	Without cyclones	With cyclones		
	(100 to 1,000 mtpd)	(1,000 to 15,000 mtpd)	(15,000 to 50,000 mtpd)	(50,000 to 100,000 mtpd)
Equipment operation....	100%	46%	67%	88%
(Repair parts)....	(95%)	(95%)	(45%)	(45%)
(Fuel and lube)...	(5%)	(5%)	(52%)	(52%)
(Tires)...........	(-)	(-)	(3%)	(3%)
Repair parts...........	-	54%	33%	12%

ADJUSTMENT FACTORS

Operating Conditions Factor The user can factor the costs obtained from the supply and equipment operation curves to any set of conditions by multiplying the total daily operating costs by the following factor:

Operating conditions factor $(F_C) = (S/1.46)(H/30)(65/E)$
where S = actual specific gravity of slurry,
H = actual total head, in meters,
and E = actual pump efficiency, in percent.

Pumping Distance For pumping distances other than the 1-km base, multiply the supply operating cost by the following factor:

Supply factor $(F_S) = (D)+0.900$
where D = actual pumping distance, in kilometers.

NOTE--Apply this cost before applying the following gravity flow power cost adjustment factors.

Gravity Flow If the tailings flow by gravity to a ponding area, eliminate the power portion of the supply curve and multiply the equipment operating cost by one of the the following factors:

For operations greater than or equal to 100 mtpd and less than or equal to 1,000 mtpd

Equipment operation factor $(F_{E\ 100-1,000}) = 0.0$
This will eliminate the equipment portion of the curve.

For operations larger than 1,000 mtpd and less than or equal to 100,000 mtpd

Equipment operation factor $(F_{E\ 1,000-100,000}) = 0.8$

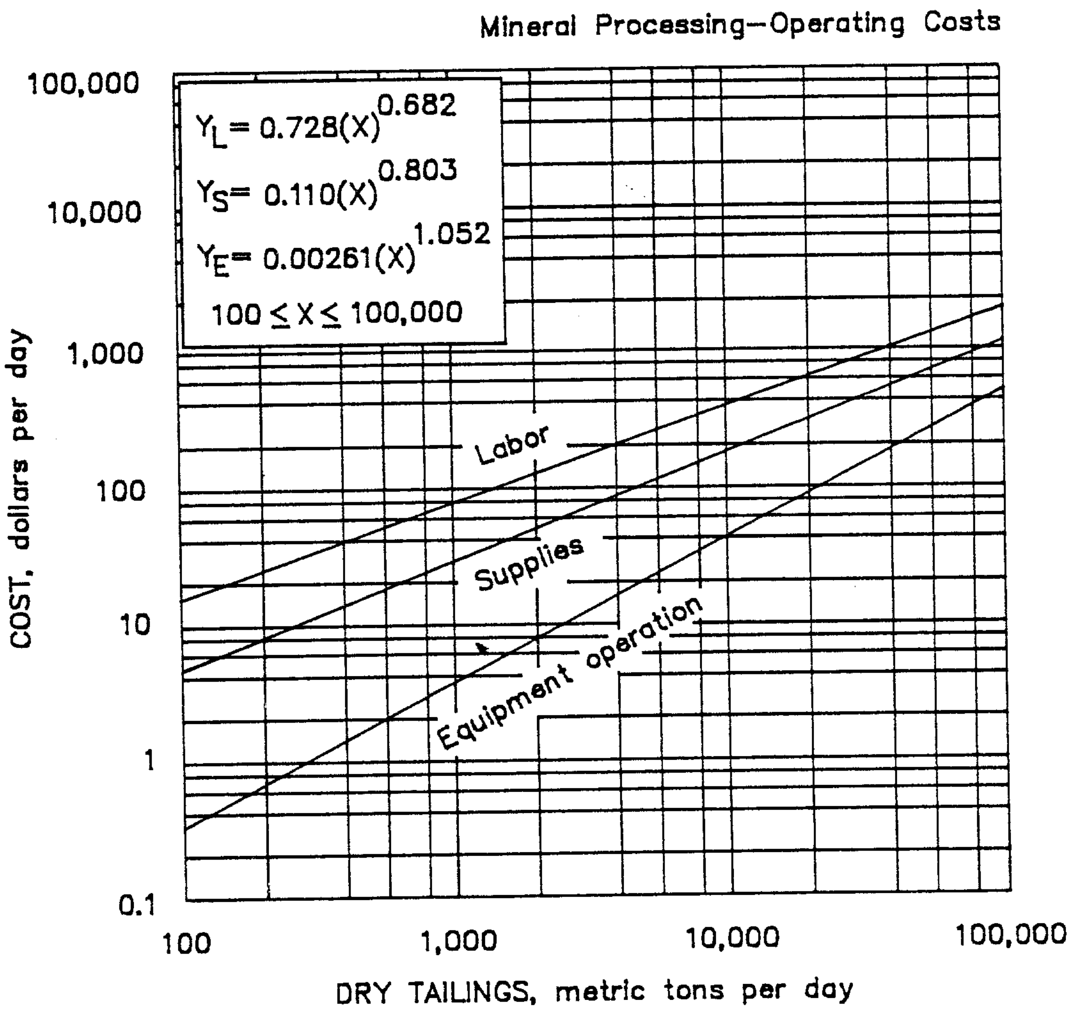
<u>Cyclones</u> If cyclones are not used (applies only to operations greater than 1,000 mtpd), multiply the costs obtained from the curves by the following factors:

Labor factor $(F_{L\ 1,000-100,000}) = 0.6$

Supply factor $(F_{S\ 1,000-100,000}) = 0.95$

Equipment operation factor $(F_{E\ 1,000-100,000}) = 0.6$

<u>Dry Tailings</u> If dry tailings are being transported, use front-end loaders and trucks or surface conveyors for loading and transporting the tailings (see section 3.2.2.6., (IC 9142), or 7.1.7.5.).



7.1.4.4. Transport and place tailings

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.4. SOLID-LIQUID SEPARATION

7.1.4.5. WATER RECLAMATION

These curves cover the cost of returning decanted water from the tailings ponds to the mill. In many cases lime, flocculants, or both may be added to the ponds to settle the colloidal particles. The curves are based on the following data:

Specific gravity of fluid...	1.0
Total head..................	16.5 m
Pump efficiency.............	80%
Pump operating time.........	100%
Pumping distance............	1.0 km

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) having a water pumping volume (X), in cubic meters per day. The curves are valid for pumping rates between 100 and 325,000 m^3/d, operating three shifts per day. These curves include all daily operating and maintenance costs associated with pumping and pipeline maintenance.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 0.073(X)^{0.587}$
The operating labor costs consist of the following typical range of personnel:

Direct labor...............	0%
Maintenance labor..........	100%

The maintenance labor costs consist of the following typical range of personnel:

	Small (100 to 10,000 m^3/day)	Large (10,000 to 325,000 m^3/day)	Av salary per hour (base rate)
Mechanic 2d class..........	55%	28%	$16.78
Mechanic 3d class..........	-	26%	15.89
Helper.....................	45%	46%	13.66

The average wage for maintenance labor is $15.44 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.017(X)^{0.910}$
The supply curve consists of 50% electric power, 29% flocculants, 12% pipe, and 9% miscellaneous items.

(E) Equipment Operation Cost $(Y_E) = 0.073(X)^{0.586}$
The equipment operation curve covers the daily cost related to pumping and minor pipeline maintenance, consisting of 96% for parts and 4% for lubrication.

ADJUSTMENT FACTORS

Pumping Head Adjustment Factor The operating cost curves are predicated on a pumping head of 16.5 m. To adjust for actual pumping heads, multiply the costs obtained from the curves by the following factors:

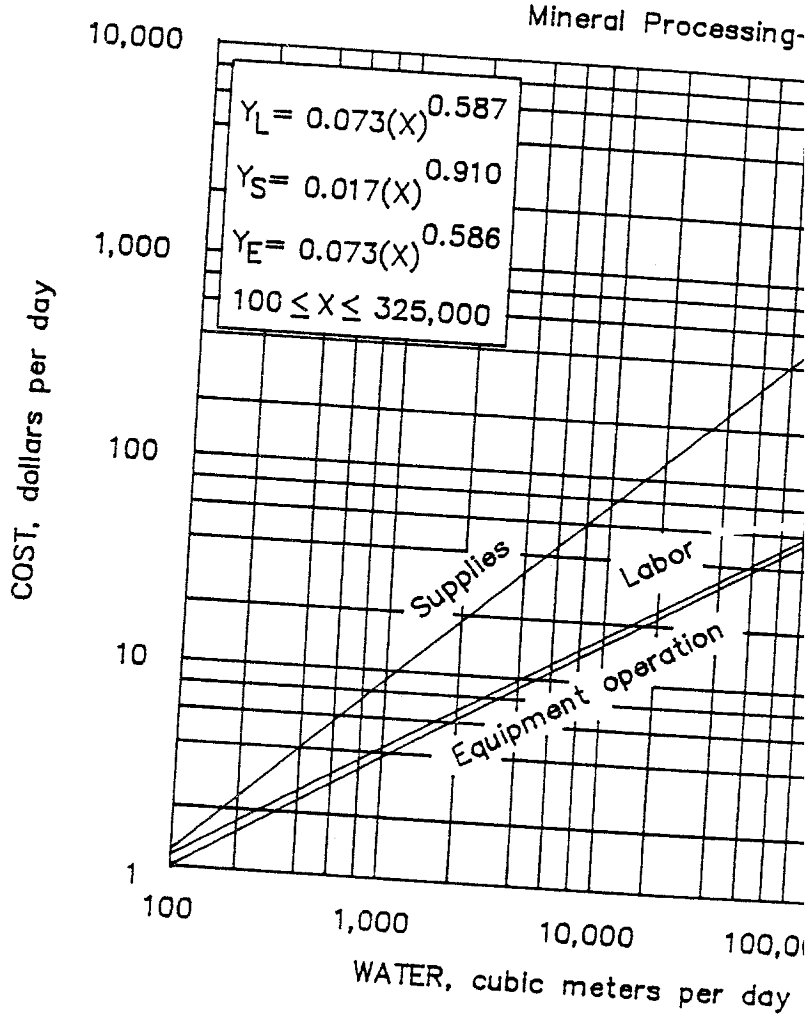
Supply factor $(F_S) = 0.450+0.042(H)(S)(E)(T)$

Equipment operation factor $(F_E) = 0.120+0.067(H)(S)(E)(T)$
where H = actual total head (static, friction, velocity, and fittings), in meters,
S = actual specific gravity,
E = actual pump efficiency, expressed as a decimal,
and T = actual pump operating time percentage, expressed as a decimal.

For preliminary estimates of H, add to the actual static head (lift) 1 to 2 m for each kilometer of new steel pipeline through which water is pumped. For accurate determinations of H, add to the actual static head the sum of the friction, velocity, and fitting heads obtained from hydraulics handbooks according to pipe quality, pipe diameter, and pipeline pumping distance.

Pumping Distance Adjustment Factor The operating cost curves are predicated on a pumping distance of 1 km. To adjust for actual pumping distances, multiply the costs obtained from the curves by the following factor:

Supply factor $(F_S) = 0.870+0.130(D)$
where D = actual pumping distance, in kilometers.



7.1.4.5. Water reclamation