7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.2. COMPRESSED AIR FACILITIES

These curves cover the use of compressed air in mineral processing plants. Low-pressure air is used in flotation, and high-pressure air is used for controls and general use.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the capacity (X), in metric tons processing plant feed per day. 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 producing compressed air.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 6.093(X)^{0.284}$
The air compressor has no operator assigned to it.

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

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

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

		Av salary per hour (base rate)
Mechanic.....	100%	$17.11

The average wage for labor is $17.11 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 9.591(X)^{0.232}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Cost $(Y_E) = 15.894(X)^{0.269}$
The equipment operating curve covers the daily operating cost for all compressor equipment and consists of 92% for repair parts and 8% for lubricants.

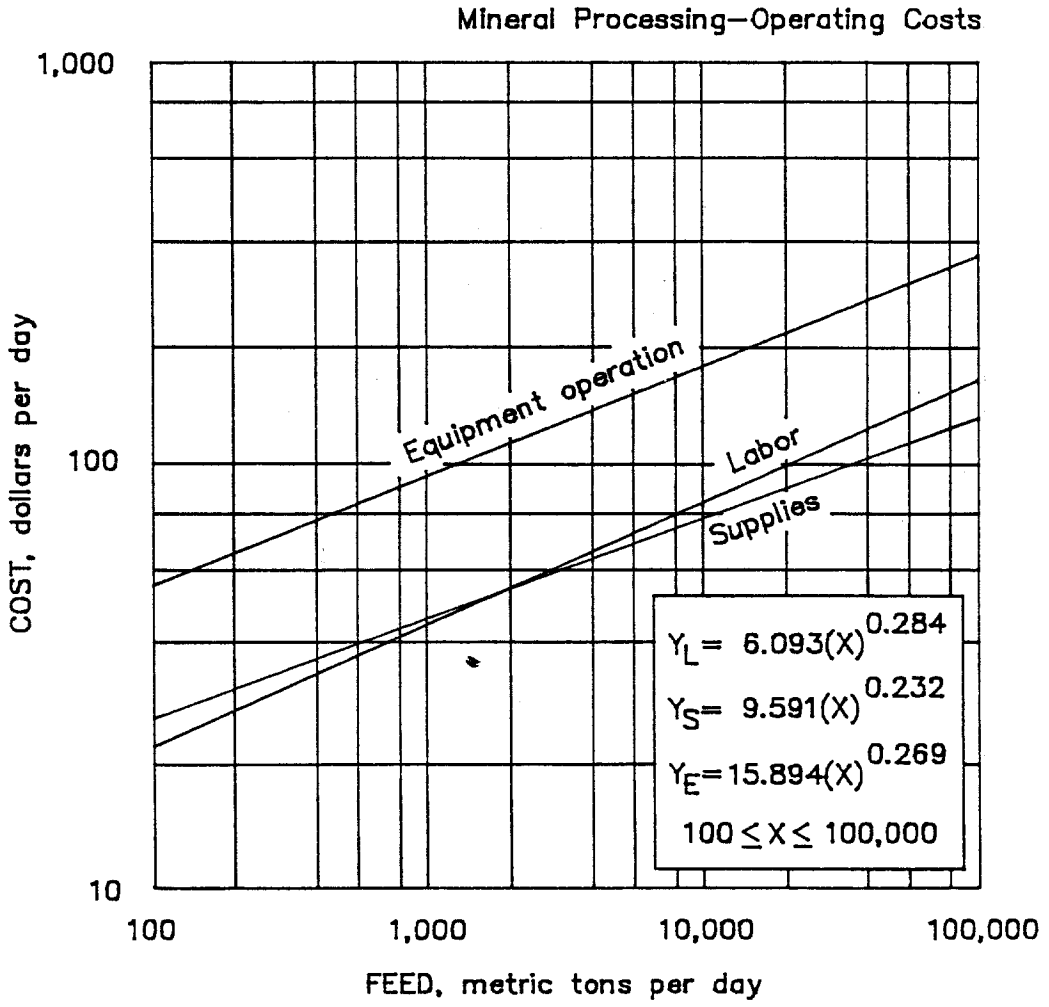
ADJUSTMENT FACTOR

Elevation Factor If elevation of the compressor plant varies from 1,600 m, a correction for altitude must be applied to the air requirements. To adjust air volume requirements if the plant is not at 1,600 m elevation, multiply the costs obtained from the curves by the following factor:

Elevation,			Elevation,		
ft	m	Factor	ft	m	Factor
0	0	0.85	6,000	1,831	1.03
1,000	305	0.87	7,000	2,136	1.07
2,000	610	0.90	8,000	2,441	1.11
3,000	915	0.93	9,000	2,746	1.15
4,000	1,220	0.96	10,000	3,050	1.19
5,000	1,526	0.99	12,500	3,813	1.31
5,249	1,600	1.00			

The factors can be generated from the following equation:

Elevation factor $(F_E) = 0.823+0.0001(G)$
where G = elevation, in meters.



7.1.8.2. Compressed air facilities

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.5. GENERAL ITEMS--COMMUNICATIONS, SANITATION, HOUSEKEEPING, FIRE PROTECTION, AND ELECTRICAL

This set of curves covers the cost of general yard work, carpentry repair, janitorial services, plumbing, road grading, ditch cleaning, general mechanical repairs, handling incoming supplies and materials, electrical maintenance and repair, and general housekeeping.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the capacity rate (X), in metric tons of processing plant feed per day. The curves are valid for operations between 100 and 100,000 mt, operating three shifts per day. The curves include daily operating and maintenance costs associated with utility trucks, mobile cranes, motor patrols, various cleaning materials, and electrical-plumbing supplies.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 4.041(X)^{0.692}$

The size of the work force required for this work will vary from a small crew of one or two workers working a fractional day to possibly three shifts of 50 to 60 workers per day.

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

Direct labor	0%
Maintenance labor	100%

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

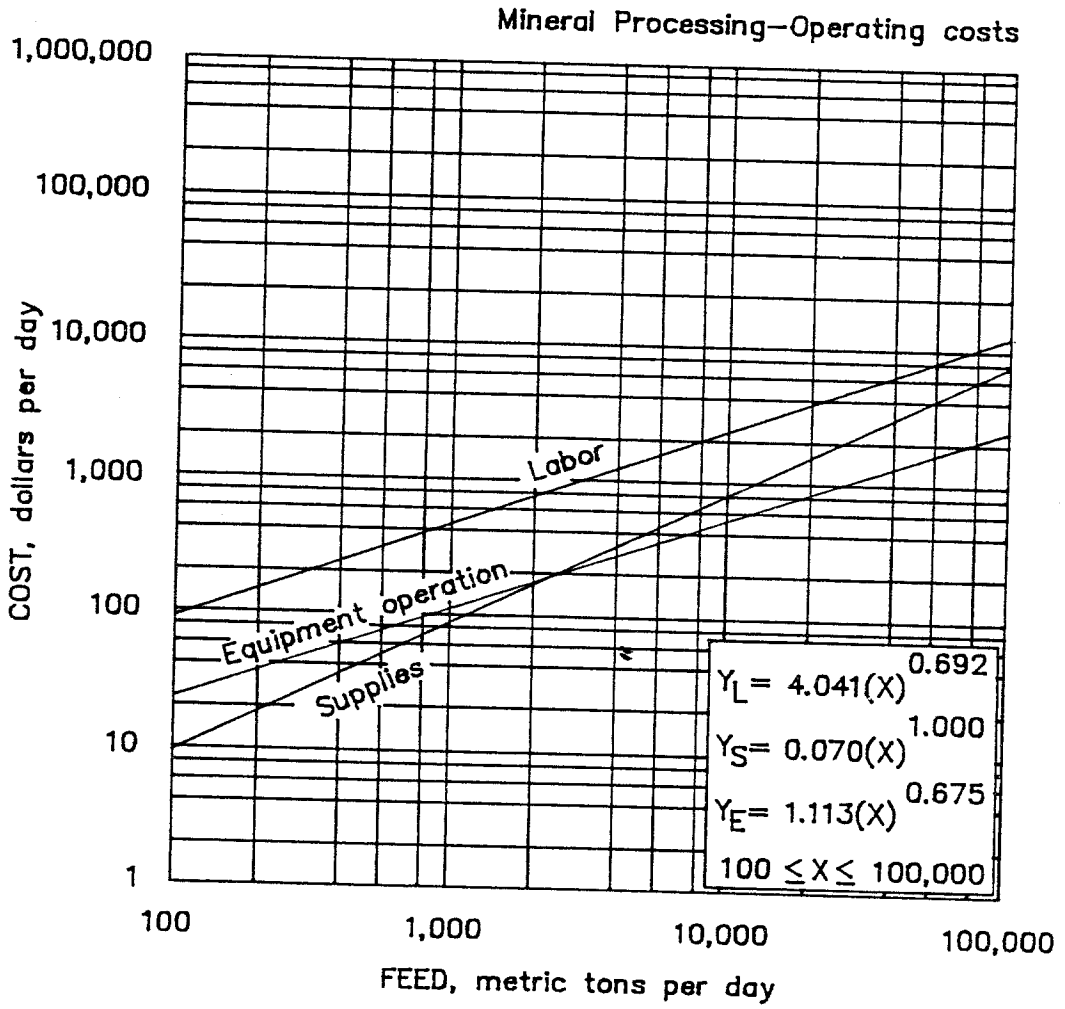
	Small (340 to 5,000 mtpd)	Large (5,000 to 100,000 mtpd)	Av salary per hour (base rate)
Crane operator	15%	11%	$16.33
Truck driver	15%	13%	16.33
Carpenter, 1st class	-	6%	17.23
Carpenter, rough	-	4%	16.33
Operator, motor-grader	-	3%	18.11
General laborer	40%	19%	13.86
Plant utility man	-	5%	14.56
Garage mechanic	-	13%	16.89
Plumber, licensed	-	5%	18.11
Welder, 1st class	15%	10%	16.78
Electrician	15%	11%	16.78

The average wage for labor is $16.13 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.070(X)^{1.000}$

The supply cost consists of 100% miscellaneous supplies priced at $0.070 per metric ton of mineral processing plant feed.

(E) Equipment Operating Cost $(Y_E) = 1.113(X)^{0.675}$
The equipment operating cost consists of 32% for repair parts and 62% for fuel and lubricants, and 6% for tires.



7.1.8.5. General items
COMMUNICATIONS, SANITATION, HOUSEKEEPING, FIRE PROTECTION, AND ELECTRICAL

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.6.1. LOADING FACILITIES
LOAD-OUT FACILITIES

The load-out operating costs represented are only applicable for concentrates stored using a conveyor, bucket elevator, and elevated storage bin system. The storage bins are capable of holding a 2-day supply of mill concentrate output, and are emptied every other day into 45-mt trucks or 90 mt railcars for delivery to the smelter. An example of the type of materials stored would be copper or molybdenum concentrates.

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) having on a production rate (X), in metric tons of concentrate transferred from a mill to storage bins in a 24-h period. The curves are valid for operations between 150 and 1,500 mtpd, operating one shift per day.

BASE CURVES

(L) Labor Operating Costs $(Y_L) = 71.565(X)^{0.145}$
The operating labor costs are distributed as follows:

Direct labor.....	84%
Maintenance labor.....	16%

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

		Av salary per hour (base rate)
Mechanic.....	42.9%	$17.99
Conveyor operator.....	30.2%	14.89
Laborer.....	26.9%	13.26

The average wage for labor is $15.78 per worker-hour (including burden and average shift differential).

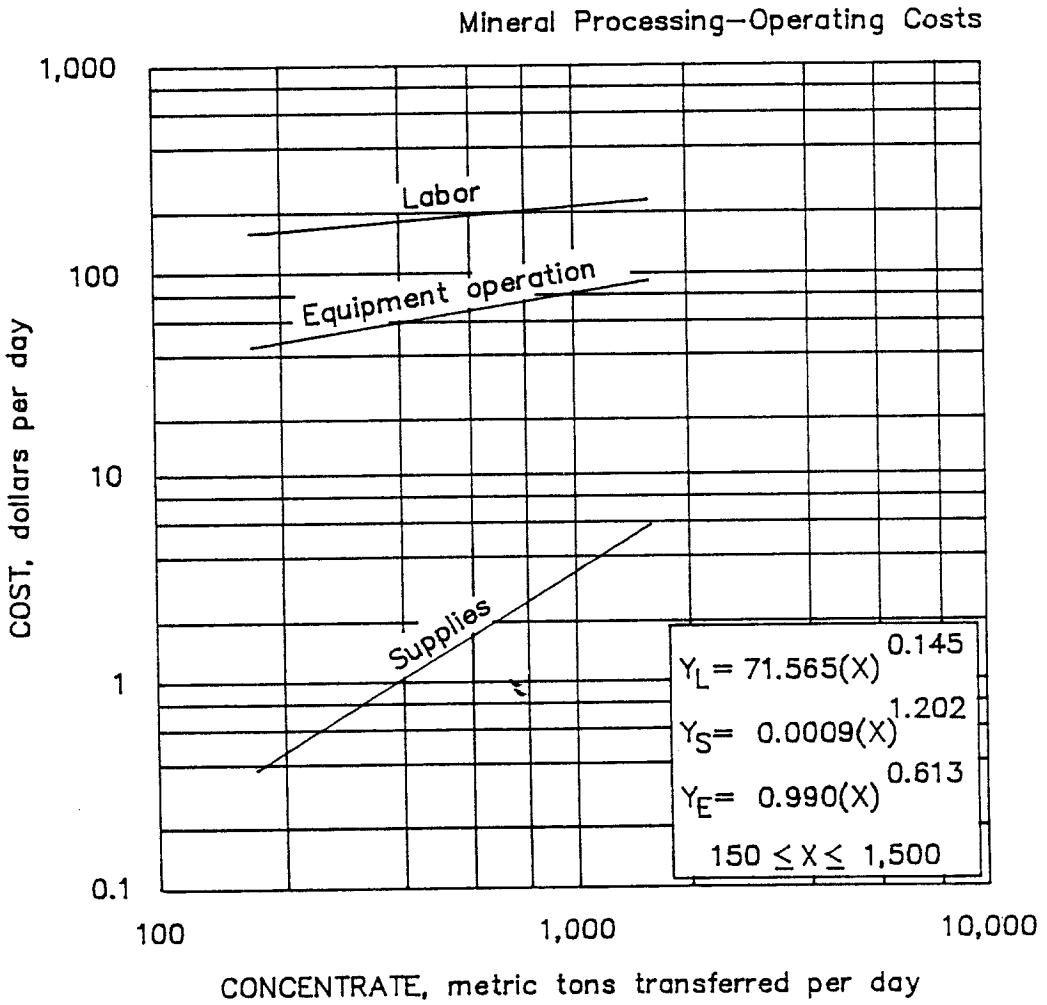
(S) Supply Operating Costs $(Y_S) = 0.0009(X)^{1.202}$
The supply curve consists of 100% electric power.

(E) Equipment Operating Costs $(Y_E) = 0.990(X)^{0.613}$
The equipment operating cost consists of 94% for repair and maintenance parts and 6% for lubrication.

ADJUSTMENT FACTORS

Secondary Mineral Recovery Operating costs for the recovery of secondary minerals are not included in this section. If such operations are considered, appropriate adjustments should be made to the cost curves.

Shift Factor Planned use of offloading equipment is considered to occur intermittently throughout the 24-h work day as concentrates in adequate quantities are made available from the mill for transportation to the storage bins. If the operations occur for periods of time 110% greater than or 70% less than 9 h/d, suitable adjustments must be made to the cost curves.



7.1.8.6.1. Loading facilities
LOAD—OUT FACILITIES

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.6.2. LOADING FACILITIES
OFF-LOADING FACILITIES

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) having on a production rate (X), in metric tons of ore off-loaded and stored in bins for use by the mill per day. The curves are valid for operations between 800 and 12,000 mtpd, operating two shifts per day.

BASE CURVES

(L) Labor Operating Costs $(Y_L) = 241.612(X)^{0.161}$
The operating labor costs are distributed as follows:

Direct labor.....	57%
Maintenance labor.....	43%

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

		Av salary per hour (base rate)
Mechanic.....	42.9%	$17.99
Conveyor operator.....	30.2%	14.89
Laborer.....	26.9%	13.26

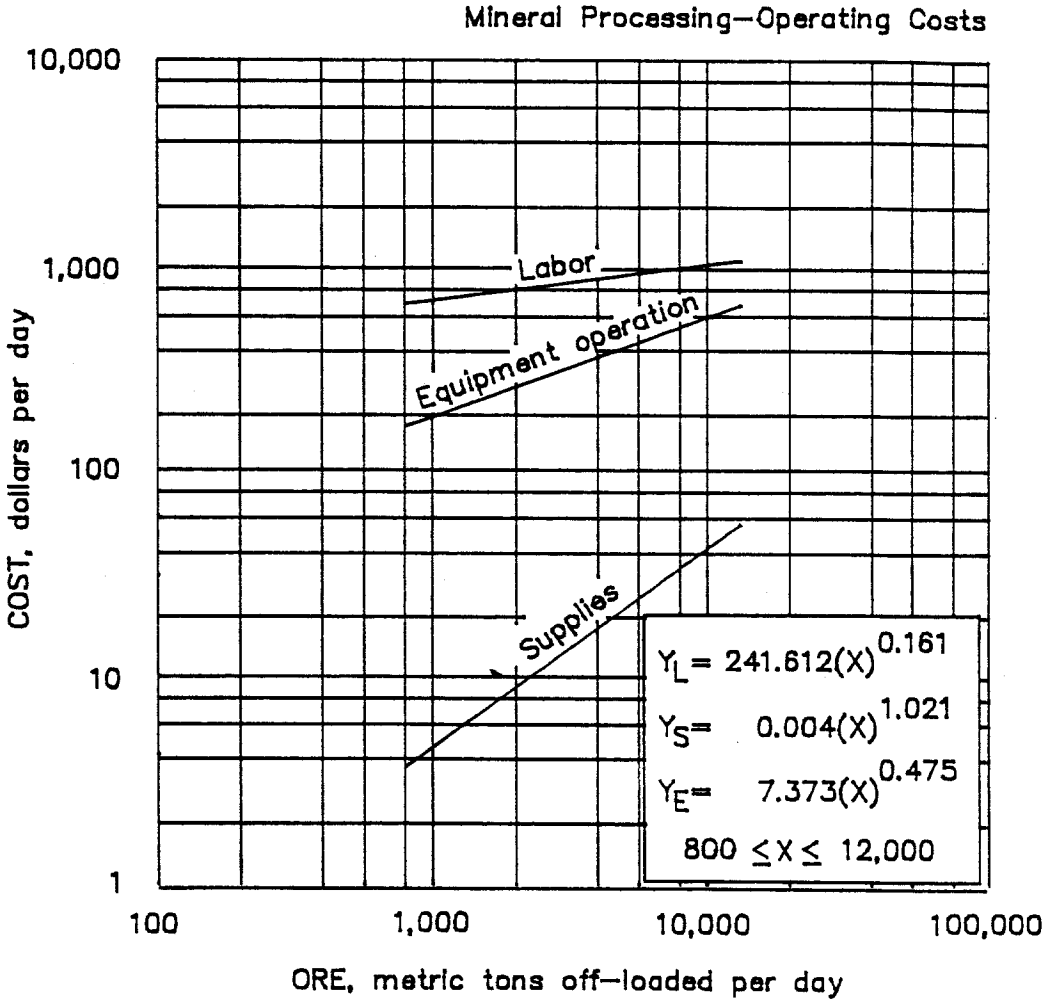
The average wage for labor is $15.38 per worker-hour (including burden and average shift differential).

(S) Supply Operating Costs $(Y_S) = 0.0\overline{0}4(X)^{1.021}$
The supply curve consists of 100% electric power.

(E) Equipment Operating Costs $(Y_E) = 7.373(X)^{0.475}$
The equipment operating cost consists of 94% for repair and maintenance parts and 6% for lubrication.

ADJUSTMENT FACTOR

Variable Shift Rate If the offloading facility is to be operated one shift per day, multiply the daily off-loading rate by two; calculate the operating costs from the base curves using the adjusted rate, then decrease the calculated cost by 50% to arrive at the adjusted cost. If the facility is operating three shifts per day, multiply the daily off-loading rate by 0.67; calculate the operating costs from the base curves using the adjusted off-loading rate, then increase the calculated cost by 50% to arrive at the adjusted cost.



7.1.8.6.2. Loading facilities
OFF—LOADING FACILITIES

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.11. PORTABLE POWER GENERATION

This section is to be used in conjunction with section 6.1.8.11. when electrical power is unavailable through a commercial power utility company or when it would be uneconomical to run power distribution facilities to the user. The total cost per kilowatt hour replaces the commercial Denver, CO, power rate used in other sections of this manual.

These curves cover the cost of power production from a single portable power unit (see adjustment factor for multiple units) ranging from a small diesel generator with less than 100 kW output to a large gas turbine producing more than 20,000 kW of power.

Total cost is expressed in terms of dollars per kilowatt hour for a specific power output. The curves cover the cost of labor for overhauls and normal repairs, parts for overhauls and normal repairs, and fuel and lubrication costs. The curves have been divided into three parts: the first part covering horizontal diesel generators from 18-to 400-kW output, the second part covering horizontal diesel generators from 400 to 2,900-kW output, and the last part covering gas turbine generators from 2,900-W to 23,600-kW output.

Total cost is the sum of two separate cost curves (labor and equipment operation) based on a specific power output rating (X), in kilowatts. The curves are valid for generators between 18 to 23,600 kW. The curves include all daily operating and maintenance costs associated with power production per generator unit.

BASE CURVE

To convert from kilovolt ampere (kV·A) demand to kilowatt power output estimate the power factor (PF). This may vary from 0.80 for electric motor circuits to 1.00 for electric light circuits. The kilowatt output is then determined by kV·A X PF = kW. [Power Output Determination - for surface mine power output (kW), see section 2.2.4.2 (IC 9142). For underground mine and mineral processing plant power demand (kV·A), see sections 4.2.5.3. (IC 9142) and 6.1.8.4.]

(L) Labor Operating Cost

$$(Y_{L\ 18\text{-}400\ kW}) = 0.169(X)^{-0.466}$$
$$(Y_{L\ 400\text{-}2,900\ kW}) = 0.409(X)^{-0.480}$$
$$(Y_{L\ 2,900\text{-}23,600\ kW}) = 0.008(X)^{-0.445}$$

The operating labor costs are distributed as follows:

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

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

		Av salary per hour (base rate)
Mechanics.....	100%	$18.11

The average wage for labor is $18.11 per worker-hour (including burden and average shift differential).

The labor curves do not contain any operating labor costs since all units operate unattended in an automatic mode (some smaller units may not have automatic starting systems and would require a manual start). The only labor necessary is that which is required for maintenance and scheduled overhauls by mechanics.

(E) Equipment Operation Costs

$$(Y_{E\ 18\text{-}400\ kW}) = 0.145(X)^{-0.075}$$
$$(Y_{E\ 400\text{-}2,900\ kW}) = 0.158(X)^{-0.070}$$
$$(Y_{E\ 2,900\text{-}23,600\ kW}) = 0.131(X)^{-0.122}$$

The general equipment operating cost component distribution is as follows:

	Repair parts	Fuel and lube	Tires
Horizontal diesel:			
18-400 kW.....	18.0%	73%	9%
400-2,900 kW.....	12.0%	79%	9%
Gas turbine:			
2,900-23,600 kW.....	11%	75%	14%

The parts category includes normal maintenance parts such as belts and pumps, and major overhaul items such as valves, injectors, brushes, and commutators. The natural gas has a Btu rating of 1,050 Btu/ft^3.

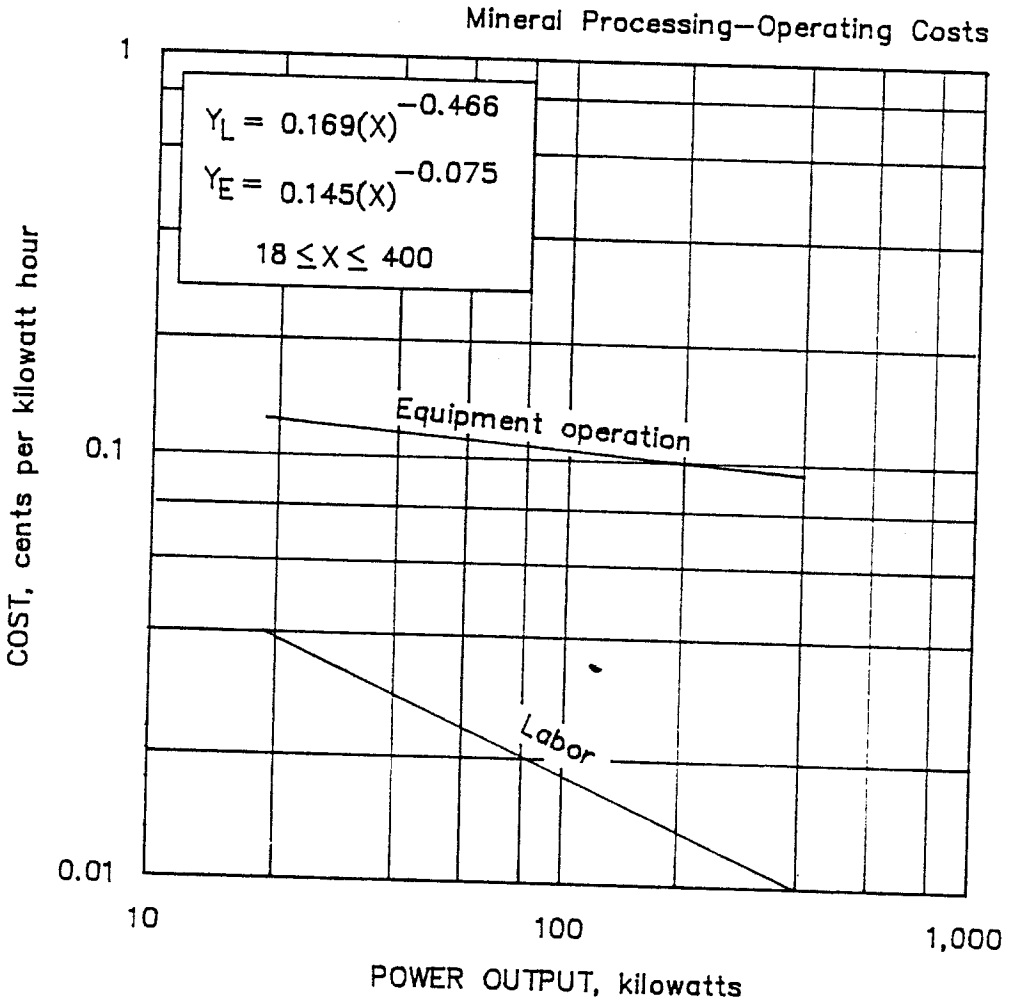
ADJUSTMENT FACTORS

Sulfur Fuels Factor If high-sulfur fuels are used, multiply the labor and equipment parts costs by the following factor:

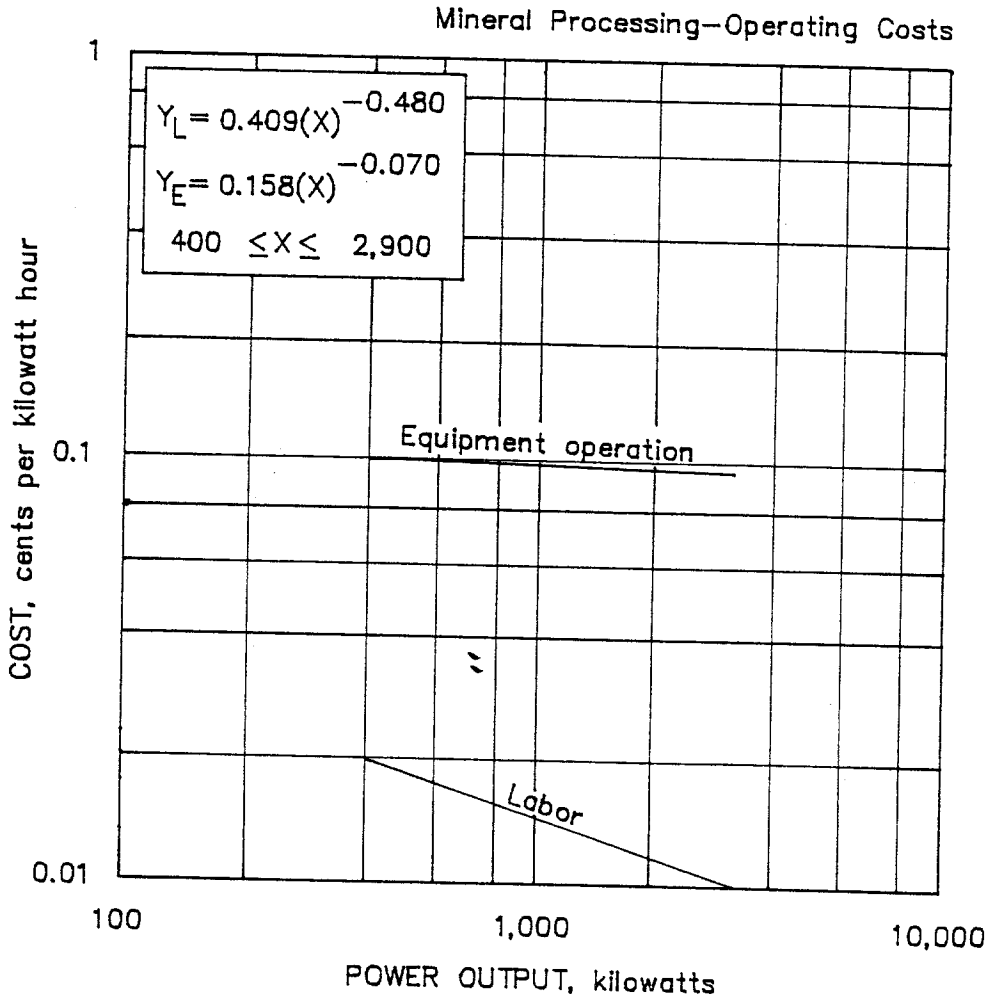
Sulfur fuels factor $(F_L) = 1.333$

Power Rate If power is to be supplied by more than one unit, then the total power output should be divided by the number of required units to obtain the power output per unit (X) needed for entering the curves.

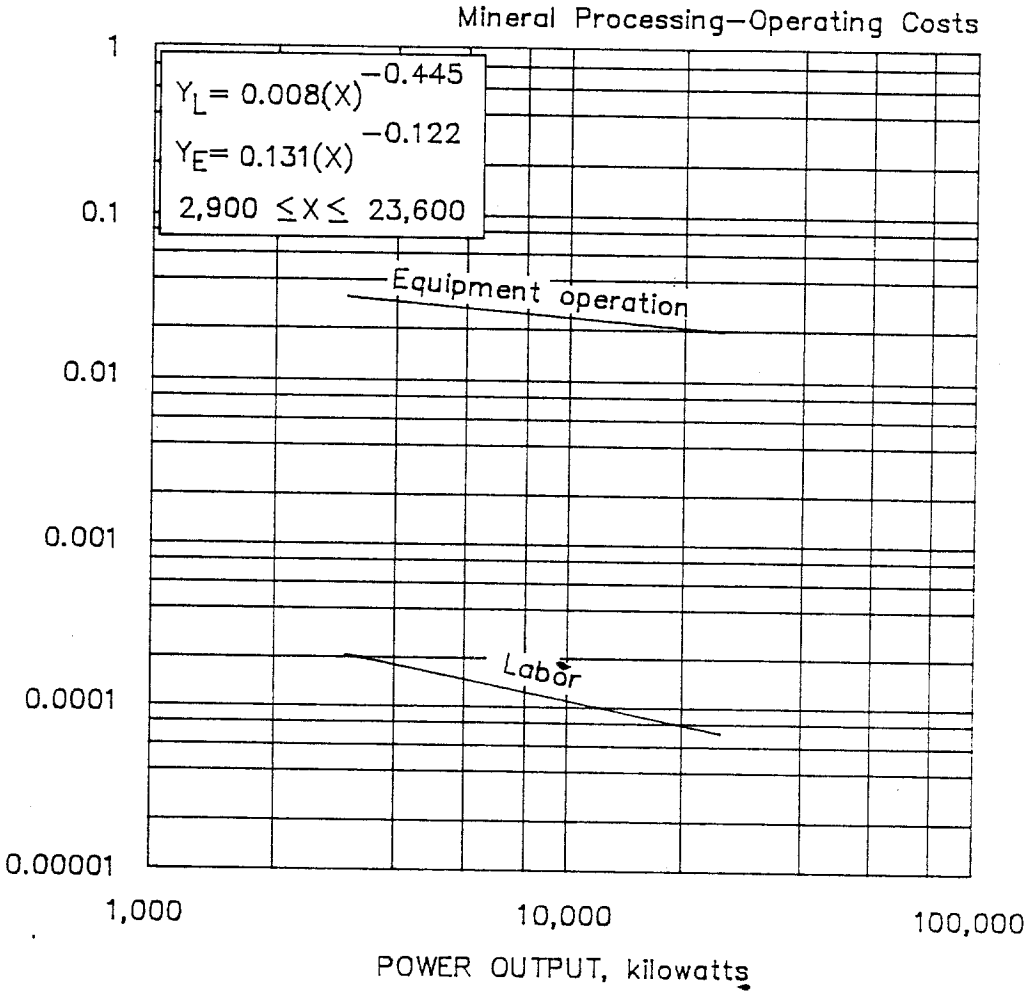
Power Source For those cases where power is supplied to the mine and mineral processing plant from different sources as a result of geographic or economic constraints, separate cost estimates, using this section, must be made to reflect the independent power outputs. This will result in different power costs for mines and mineral processing plants and must be accounted for separately in the mining and mineral processing sections of this manual.



7.1.8.11.a Portable power generation



7.1.8.11.b Portable power generation



7.1.8.11.c Portable power generation

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.12. STOCKPILE STORAGE FACILITIES

Stockpile operating costs, as determined in this section, are based on metric tons of stockpiled material reclaimed during a two-shift-per-day operation. The costs represented are only applicable for stockpiles formed and reclaimed by conveyors. The daily reclaim rate is typically about 67% of the stockpile's live storage capacity. Total stockpile capacity is normally about 600% of the daily reclaim rate. For example, a coarse ore stockpile for a mill operating at 10,000 mt of ore per day has a live storage capacity of about 15,000 mt and a total stockpile capacity of 60,000 mt.

The total daily operating cost is the sum of three separate cost curves (labor, and supplies, equipment operation) based on the production rate (X), in metric tons material reclaimed from the stockpile per day. The curves are valid for operations between 2,000 to 200,000 mtpd, operating two shifts per day.

BASE CURVES

(L) Labor Operating Costs $(Y_L) = 7.229(X)^{0.503}$
The operating labor costs are distributed as follows:

Direct labor.....	33%
Maintenance labor.....	67%

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

		Av salary per hour (base rate)
Mechanic.....	72.0%	$17.99
Conveyor operator.....	14.8%	14.89
Laborer.....	13.2%	13.26

Average operating labor cost per worker-hour is $16.91 (including burden and average shift differential).

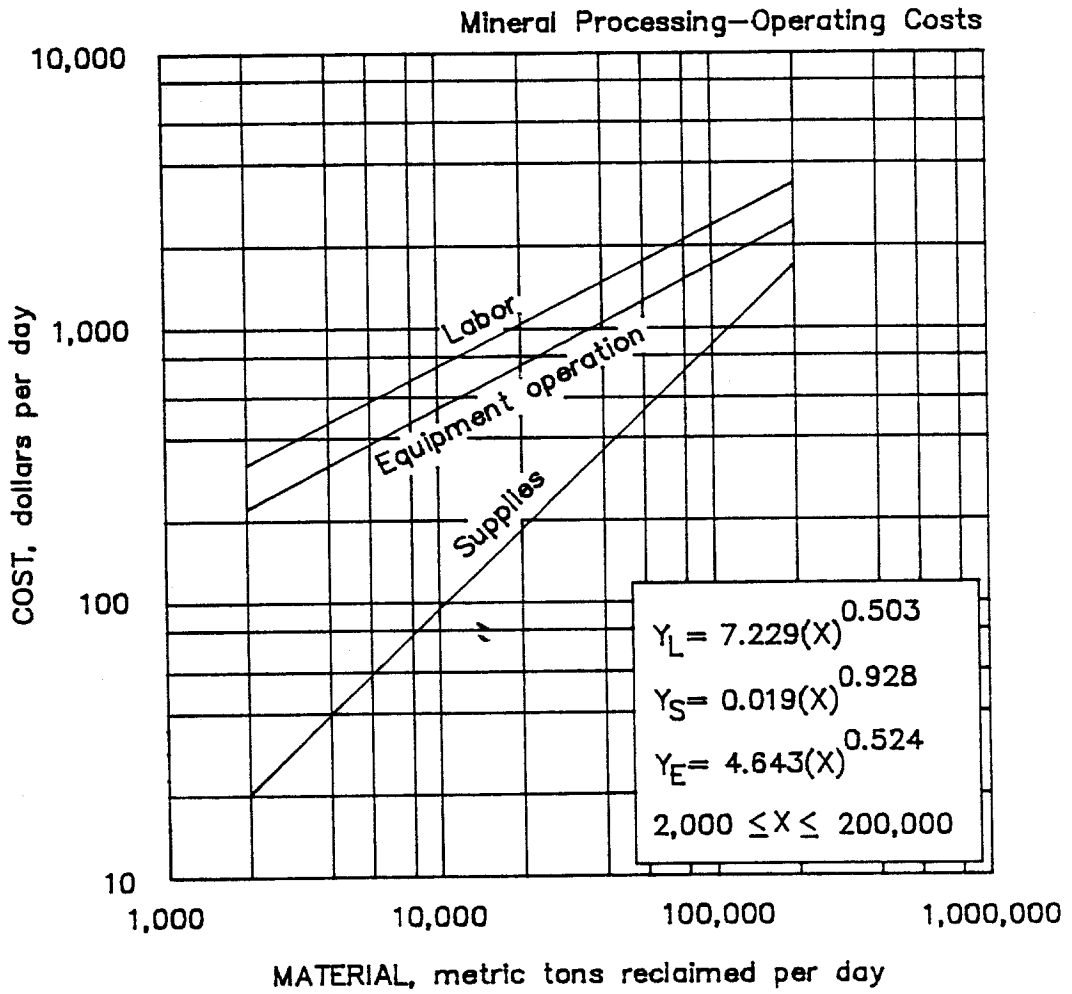
(S) Supply Operating Costs $(Y_S) = 0.019(X)^{0.928}$
The supply cost consists of 100% electric power.

(E) Equipment Operating Costs $(Y_E) = 4.643(X)^{0.524}$
The equipment operating cost consists of 94% for repair and maintenance parts and 6% for lubrication.

ADJUSTMENT FACTOR

Shift-Reclaim Rate If a stockpile facility is operated one shift per day, multiply the daily reclaim rate by two; calculate the operating costs from the base curves using the adjusted reclaim rate; then decrease the calculated cost by 50% to arrive at the adjusted cost. If the facility is operated three shifts per

day, multiply the daily reclaim rate by 0.67; calculate the operating costs from the base curves using the adjusted reclaim rate; then increase the calculated cost by 50% to arrive at the adjusted cost.



7.1.8.12. Stockpile storage facilities

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.14.1. WATER AND DRAINAGE SYSTEM
DRAINAGE AND DISPOSAL SYSTEM

These curves cover the cost of general drainage control around the mineral processing area, including collection conduits, sumps and pumps, and pipelines or culverts.

The total operating cost is the sum of three cost curves (labor, supplies, and equipment operation) based on the capacity rate (X), in metric tons of mill feed per day. The curves are valid for operations between 100 and 100,000 mtpd, operating three shifts per day. These curves include all daily maintenance costs associated with the disposal of minor solids (spillage and dust) and water (used in equipment and floor washing) to an area 1 km outside the mineral processing plant.

BASE CURVE

(L) Labor Operating Cost $(Y_L) = 0.028(X)^{0.595}$
The operating labor costs consist of the following typical range of personnel:

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

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

	Small (100 to 10,000 mtpd)	Large (10,000 to 100,000 mtpd)	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 $15.55 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.038(X)^{0.691}$
The supply curve consists of 47% electric power, 43% steel, 7% miscellaneous materials, and 3% concrete.

(E) Equipment Operation Cost $(Y_E) = 0.029(X)^{0.591}$
The equipment operation curve consists of 96% for parts and 4% for lubricants. It covers the daily cost related to pumping and minor conduit maintenance.

ADJUSTMENT FACTORS

The operating cost curves are based on disposing of a water quantity equal to one-third of the plant makeup water, containing an average solids equivalent of 0.25% of plant feed. The makeup water is considered here to be 25% of the total water required daily for mineral processing.

Pumping Head Adjustment The supply curve is based on an typical pumping head of 16.3 m, 15 m static head and 1.3 m friction head. If the actual drainage circuit involves gravity flow or an unusually high head (H), multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.040+0.059(H)$

Supply factor $(F_S) = 0.530+0.029(H)$

Equipment operation factor $(F_E) = 0.040+0.059(H)$
where H = actual head, in meters.

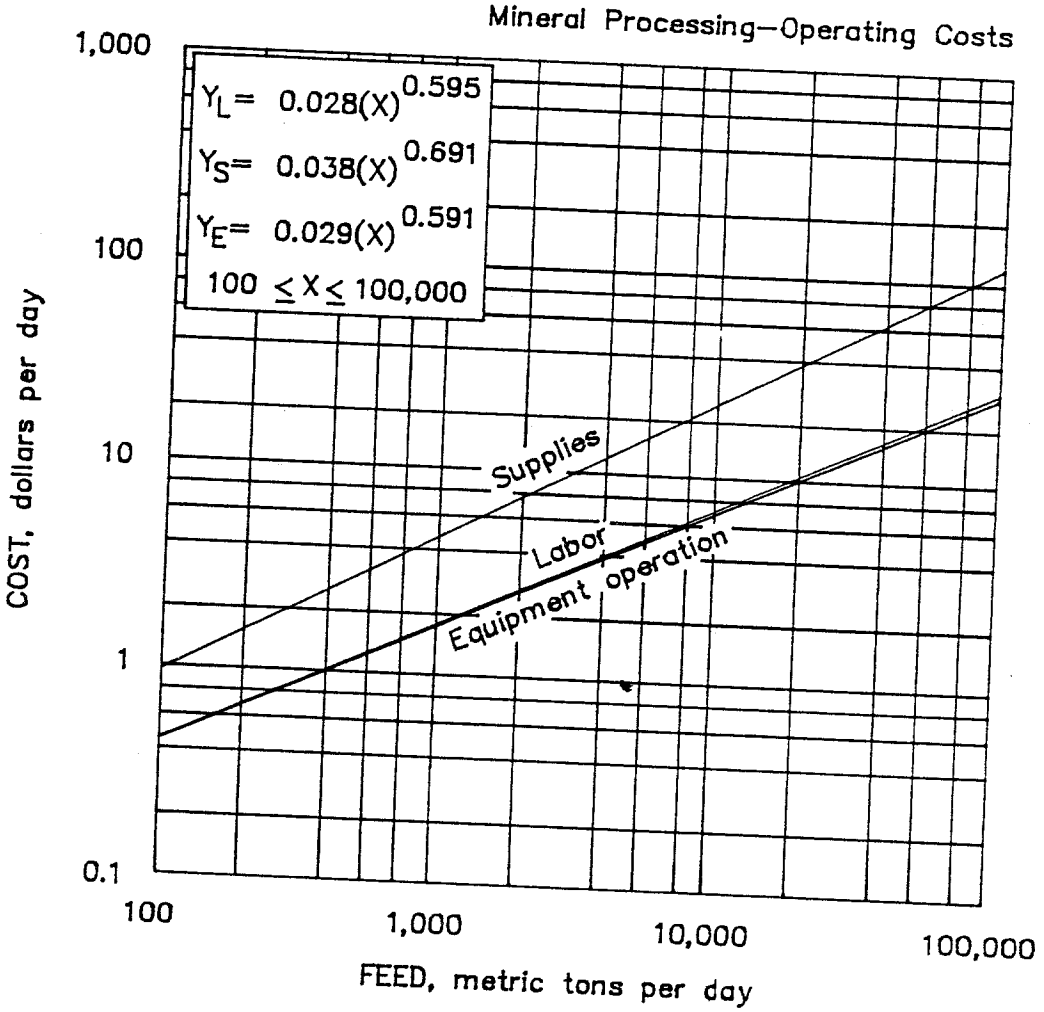
For approximate values of H, add to the static head (lift) 1 to 2 m for each kilometer of pumping distance. For gravity flow the static head is zero.

Pumping Distance Adjustment The curves are based on a pumping distance of 1 km. For distances other than 1 km, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.96+0.04(D)$

Supply factor $(F_S) = 0.47+0.53(D)$

Equipment operation factor $(F_E) = 0.96+0.04(D)$
where D = actual pumping distance, in kilometers.



7.1.8.14.1. Water and drainage system
DRAINAGE AND DISPOSAL SYSTEM

7.1. MINERAL PROCESSING--OPERATING COSTS

7.1.8. GENERAL OPERATIONS

7.1.8.14.2. WATER AND DRAINAGE SYSTEM
WATER SUPPLY SYSTEM (MAKEUP WATER)

Water is used in mineral processing plants primarily for washing or concentration. Depending on the mineral processing method, the water volume required will vary. The water supply system operating cost for a processing plant [and/or an adjoining mine, section 3.2.4.10.2. (IC 9142)] is based on the daily water consumption.

The total daily operating cost is the sum of three separate cost curves (labor, supplies, and equipment operation) based on the makeup water volume (X), in cubic meters of water per day. The curves are valid for volumes between 1,000 and 150,000 m^3/d, operating one shift per day. The curves cover all daily maintenance and operating costs associated with water wells, storage tanks, pipelines and distribution. For mill water reclamation, see section 6.1.4.5.

For flotation plants, the total water required varies from 2.5 to 4.5 m^3/mt floated. Ten to forty percent of the water required is makeup water. Gravity concentration may require as much as 8 m^3 of water per metric ton of ore feed. About 10% of this figure is new water and the rest reclaimed.

If total daily volume (processing-plant makeup water and mine water) is known, the manual user should enter this volume in the equations given below (unless the mine is supplied with water from an independent source). The total operating cost may be allotted as follows:[1]

a. 91% to mineral processing (section 7.1.8.14.2.).

b. 9% to surface mine [section 3.2.4.10.2. (IC 9142)].

[1]Percentages derived from BuMines IC 8285 dealing with water consumption for U.S. mines and mineral processing plants. Different percentages may be obtained if an actual breakdown of mine and mineral processing plant is known.

BASE CURVE

These curves are valid for a total pumping head ranging from 260 to 330 m with an average of 291 m, and pumping distances ranging from 3 to 53 km.

(L) Labor Operating Cost $(Y_L) = 1.937(X)^{0.445}$
The operating labor costs consist of the following typical range of personnel:

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

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

	Small (1,000 to 13,000 m^3/d)	Large (13,100 to 150,000 m^3/d)	Av salary per hour (base rate)
Mechanic-welder.....	25%	14%	$16.33
Pipefitter.....	34%	39%	$22.80
Helper.....	41%	47%	$13.66

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

(S) Supply Operating Cost $(Y_S) = 0.045(X)^{0.997}$
The supply cost consists of 100% electric power. Power is required to overcome the static head (well depth and lift) and pipeline head losses.

(E) Equipment Operation $(Y_E) = 0.054(X)^{0.864}$
The equipment operation curve covers the daily operation cost for pipelines, pumps, and storage tanks. It consists of 95% for parts and 5% for lubricants.

ADJUSTMENT FACTORS

Pumping Distance Factor To correct for actual pumping distance, multiply the costs obtained from the curves by the following factor:

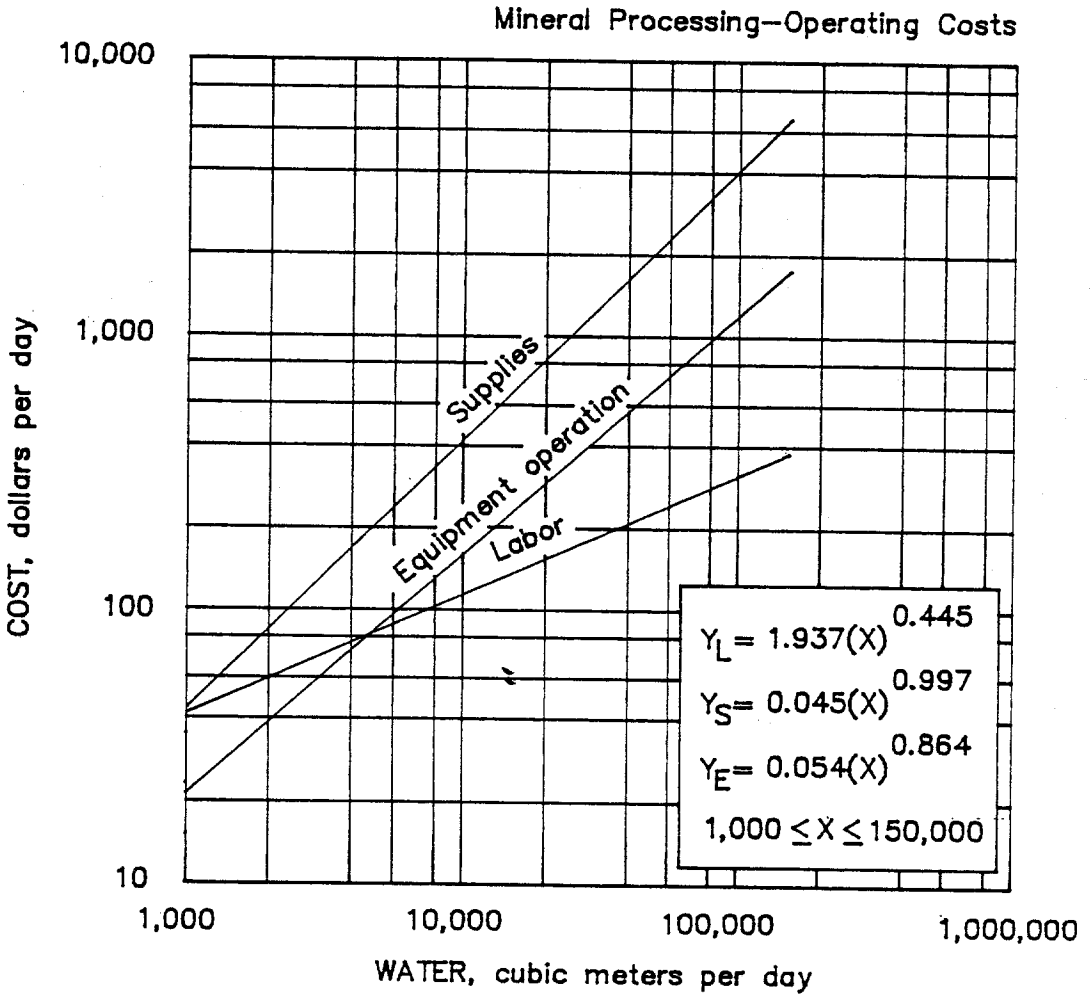
Pumping distance factor $(F_D) = 0.85+[1.95(D)(X)^{-0.549}]$
where D = actual distance, in kilometers,
and X = volume, in cubic meters per day.

Because a change in distance results in a change in friction head, also multiply the costs by the pumping head factor (F_H).

Pumping Head Factor The three cost curves are based on 244-m static head (well depth and lift) and a 47-m friction head. To adjust for actual total heads, multiply the costs obtained from the curves by the following factor:

Pumping head factor $(F_H) = H/291$
where H = sum of the actual static, friction, velocity, fitting, and discharge heads, in meters.

Purchased Water Factor If water is purchased, estimate the labor, supply, and equipment operation costs (from the delivery point to the mine and processing plant), and add them to the purchasing cost.



7.1.8.14.2. Water and drainage system
WATER SUPPLY SYSTEM (MAKEUP WATER)