5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.1. HOISTING

Mine hoist operating costs, as determined in this section, are based on metric tons of ore and waste hoisted per hour from a specific depth on a two-shift-per-day schedule. When analyzing the hoisting system, the estimator should consider the following:

1. Double-drum hoists are applicable to multilevel hoisting for all sizes of mines.
2. Friction hoists are applicable for deep level (+915 m) and/or single level hoisting.
3. Mines that hoist over 4,000 mtpd often have more than one hoist (i.e., one hoist may haul ore and waste and one hoist may be used for servicing the mine). The costs are only applicable for one hoist. If more than one hoist is required, recalculate the curve(s) for each additional hoist (see ADJUSTMENTS for service hoists).
4. Mines that hoist over 20,000 mtpd typically have more than one production hoist in conjunction with at least one service hoist.
5. In choosing the hoisting system it is best to remember that these facilities are usually designed for a higher capacity than required. This is especially true for smaller mines or mines anticipating an increase in capacity (i.e., a hoist operating at 100 mtph may have a design capacity of 200 mtph).
6. Single hoist mines typical hoist muck for about 80% of the daily schedule (i.e., 13 h of a 16-h work day), the remaining 20% of the schedule is devoted to transporting personnel and supplies and performing maintenance. Mines serviced by more than one production hoist typically hoist muck about 90% of the daily schedule.

The curves show costs for double-drum and friction hoists and are based on hoisting from 914 m (3,000 ft).

The total cost per hour is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on hoist capacity (X), in metric tons material, per hour. The curves are valid for operations between 100 and 800 mt, operating two shifts per day. The total cost per day is the sum of the equipment operation, labor, and supply curves multiplied by the number of hours of operation daily.

BASE CURVES

(L) <u>Labor Operating Costs</u> $(Y_{L\ DOUBLE\text{-}DRUM}) = 860+[0.036(X)^{1.000}]$
$(Y_{L\ FRICTION}) = 860+[0.031(X)^{0.990}]$

The operating labor costs are distributed as follows:

Direct labor................	99%
Maintenance labor..........	1%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Hoist operator.............	34%	\$18.67
Cager......................	34%	18.11
Assistant cager............	32%	16.33

Average wage for labor is \$17.54 per worker-hour (including burden and average shift differential).

(S) Supply Operating Costs $(Y_{S\ \text{DOUBLE-DRUM}}) = 5.280(X)^{0.994}$
$(Y_{S\ \text{FRICTION}}) = 4.485(X)^{0.983}$

The supply costs consists of 95% electric power and 5% wire rope replacement.

(E) Equipment Operating Costs $(Y_{E\ \text{DOUBLE-DRUM}}) = 0.036(X)^{1.000}$
$(Y_{E\ \text{FRICTION}}) = 0.031(X)^{0.990}$

The equipment operating cost consist of 80% for repair and maintenance parts and 20% for lubrication.

ADJUSTMENT FACTORS

Depth Factor To determine operating costs for hoisting facilities whose maximum hoisting depth varies from 914 m (3,000 ft), multiply the costs obtained from the supply and equipment operation curves by the following factors:

Double-drum hoist:

Supply factor $(Y_{S\ \text{DOUBLE-DRUM}}) = 0.0009(D)^{1.032}$

Equipment operation factor $(Y_{E\ \text{DOUBLE-DRUM}}) = 0.001(D)^{1.019}$
where D = maximum hoisting depth from the surface, in meters.

Friction hoist:

Supply factor $(Y_{S\ \text{FRICTION}}) = 0.005(D)^{0.768}$

Equipment operation factor $(Y_{E\ \text{FRICTION}}) = 0.007(D)^{0.729}$
where: D = maximum hoisting depth from the surface, in meters.

Shift Factor If hoists are operated one shift per day decrease costs 50%. If hoists are operated three shifts per day, increase costs 50%.

Hoist Factor Under the following conditions multiply the labor cost obtained from the curves by the following factors:

If a hoist is used for production hoisting only:
Labor factor $(F_L) = 0.69$

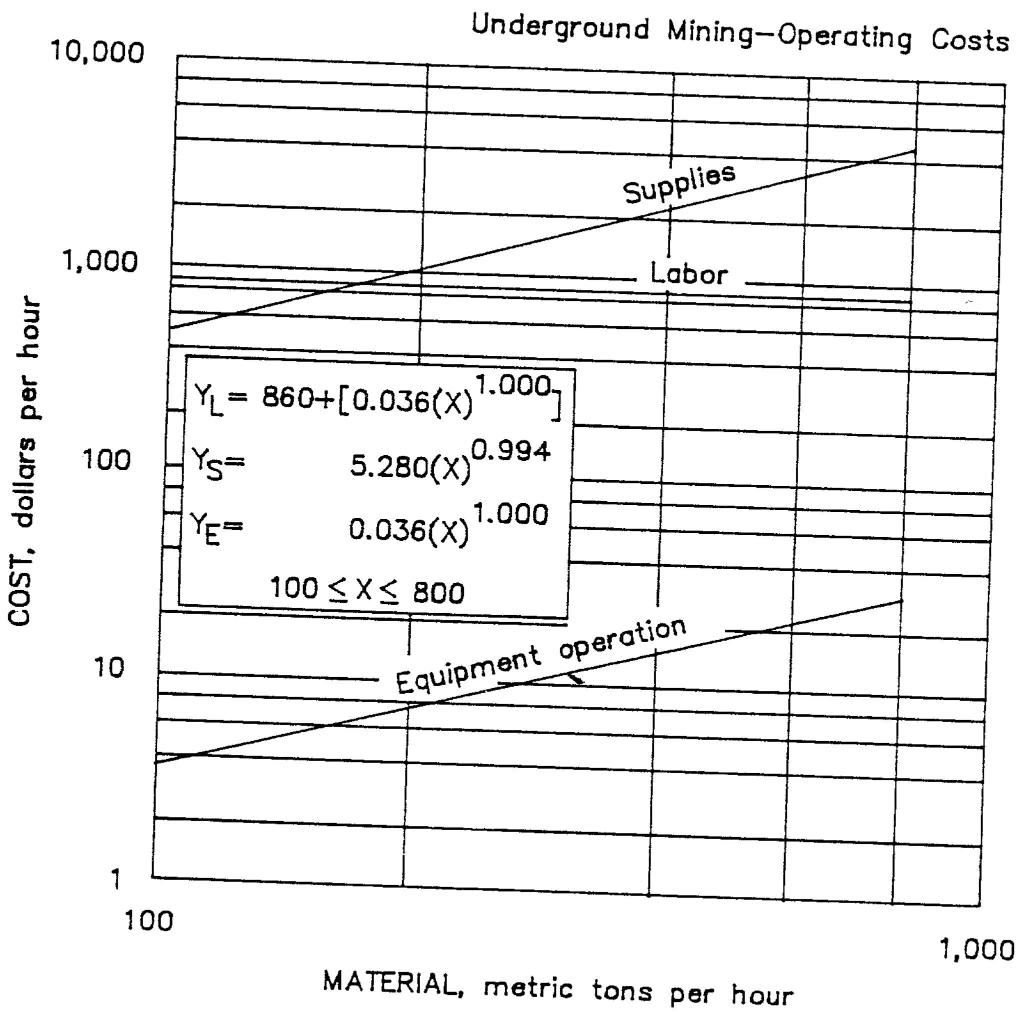
If a fully automatic hoist is used:
Labor factor $(F_L) = 0.71$

If a fully automatic hoist is used for production hoisting only:
Labor factor $(F_L) = 0.40$

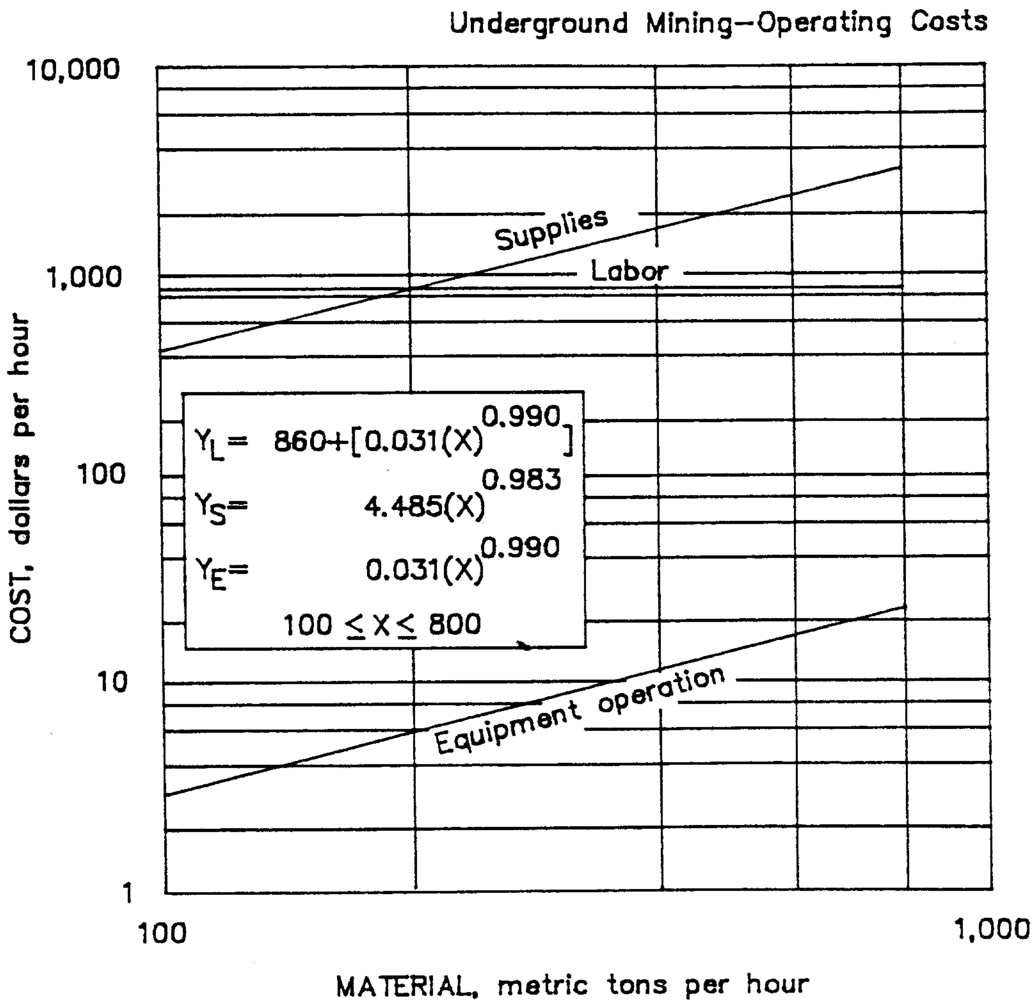
Use Factor If a hoist is used for service hoisting only, multiply the costs obtained from the supply and equipment curves by the following factors:

Supply factor (F_S) = 0.33

Equipment operation factor (F_E) = 0.33



5.2.3.1.a Hoisting
DOUBLE–DRUM



5.2.3.1.b Hoisting
FRICTION

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.5. CONVEYOR HAULAGE

Cost estimates derived through this section depict the operating cost of fixed conveyor systems underground. Typically the ore will be conveyed from an underground crusher installation to an ore pocket at a shaft station or to the surface through a portal. The base case assumes a haul distance of 300 m (980 ft) and that the conveyor system is utilized two shifts each day. As it will invariably be necessary to adjust for the actual haul distance of the case under evaluation the distance factor formulas contained in the ADJUSTMENT FACTORS section should be consulted. They should be used as multipliers of computed labor and equipment operation values derived form the base curves.

A factor is also provided to allow for adjustment of power requirements for other than horizontal workings. This factor should be employed if the grade is greater than 2%. At no time should conveying be considered at pitches greater than 17°.

BASE CURVES

The total daily cost is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a haulage rate (X), in metric tons of material conveyed per day. The curves are valid for operations between 100 and 50,000 mt, operating two shifts per day. Costs derived include all daily operating and maintenance costs associated with the operation of the conveying system. The curves are based on a 300-m (980-ft) conveying distance. System capacities may vary from 363 to 4,460 mt/h, utilizing belt widths of 610 to 1,829 mm. Because of practical limitations, lesser capacity systems would only be designed by limiting the operating period only and thus would be determined by proportion of the time employed.

(L) Labor Operating Cost $(Y_L) = 10.036(X)^{0.415}$

The operating labor costs are distributed as follows:

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

All required field and shop maintenance is performed by the operators and mechanics.

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Belt operators..............	50%	$15.64
Belt mechanics..............	50%	15.64

Average wage for labor is $15.64 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.018(X)^{0.771}$
The supply costs consist of 100% electric power for conveyor drive and facility lighting.

(E) Equipment Operating Cost $(Y_E) = 1.010(X)^{0.535}$
The equipment operating costs consists of 100% for replacement parts and belting.

ADJUSTMENT FACTORS

Distance factor For haul distances other than the assumed 300 m (980 ft), multiply the costs obtained from the curves by the following factors:

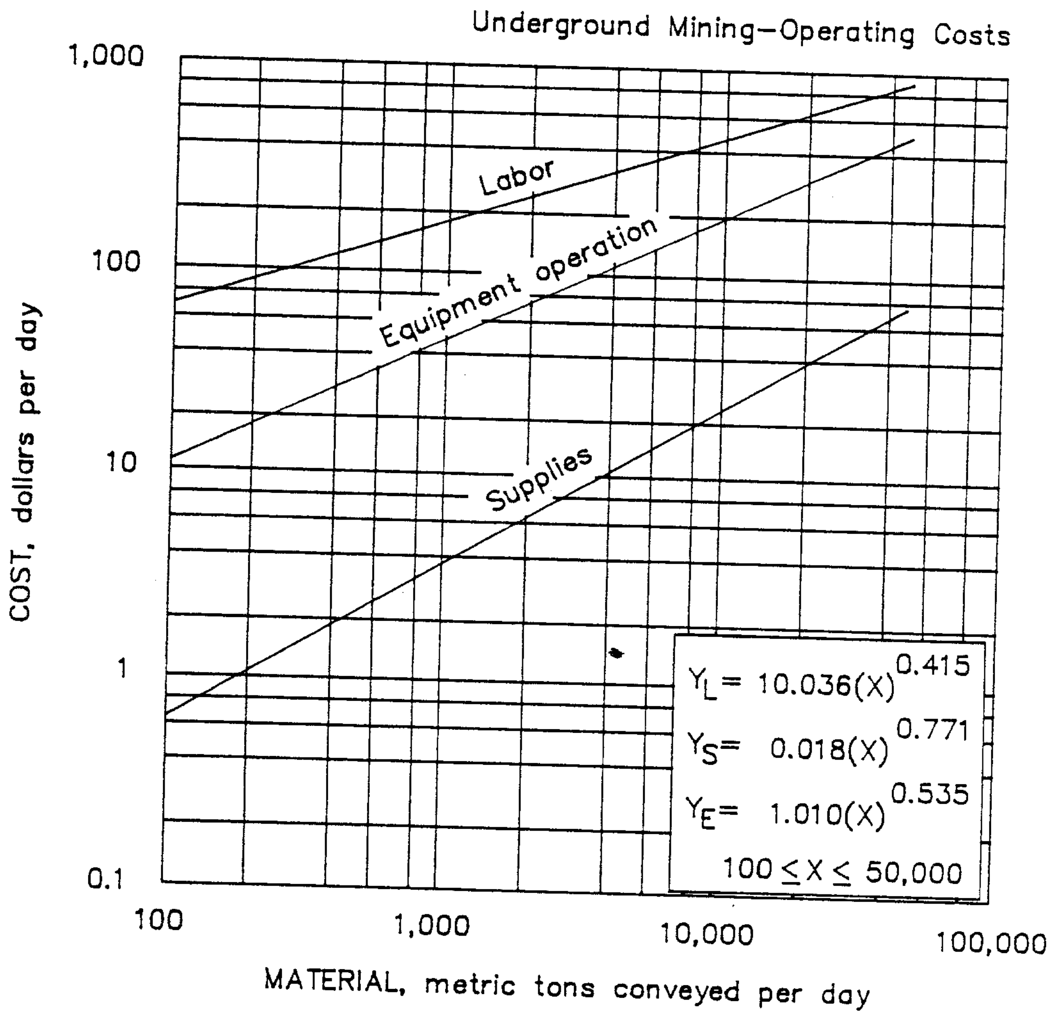
Labor factor $(F_L) = 0.095(D)^{0.413}$

Supply factor $(F_S) = 0.003(D)^{0.996}$

Equipment operation factor $(F_E) = 0.003(D)^{0.996}$
where D = distance conveyed, in meters.

Grade factor For other than horizontal belts, multiply the cost obtained from the supply curve by the following factor:

Supply factor $(F_S) = 0.983+0.355(R)$
where R = slope of the incline or decline, in degrees.



5.2.3.5. Conveyor haulage

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.7. LOAD-HAUL-DUMP HAULAGE

Through this LHD haulage curve, the cost of main haulage systems using LHD units can be determined. The base curve is designed to assess the cost of haulage in horizontal or near horizontal workings for a 500-m (1,600 ft), one-way trip distance. As it will invariably be necessary to adjust for different haul distances, factors are supplied that should be used as multipliers of the derived labor and equipment operation curve values.

The total daily cost is the sum of the two separate cost curves (labor and equipment operation) based on a haulage rate (X), in metric tons of ore and waste moved per day. The curves are valid for operations between 100 and 20,000 mt, operating two shifts per day. Costs derived include all daily operating and maintenance costs associated with the operation of the LHD units. Actual haul units used for the basis of the curve were determined by comparison of operating costs of several units with capacities ranging from 0.8-to 9.9-m^3 buckets.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 1.584(X)^{0.812}$
The operating labor costs are distributed as follows:

	Small (100 to 5,000 mtpd)	Large (5,000 to 20,000 mtpd)
Direct labor................	52%	38%
Maintenance labor...........	48%	62%

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
LHD Operators...............	100%	$16.09

(E) Equipment Operating Cost $(Y_E) = 1.165(X)^{0.859}$
The equipment operating cost consists of 50% for replacement parts, 19% for fuel, 6% for lubrication, and 25% for tires.

ADJUSTMENT FACTORS

Distance factor For haul distances other than 500 m (1,600 ft) one way, multiply the costs obtained from the curves by the following factors:

Labor factor $(F_L) = 0.426+0.00124(D)$

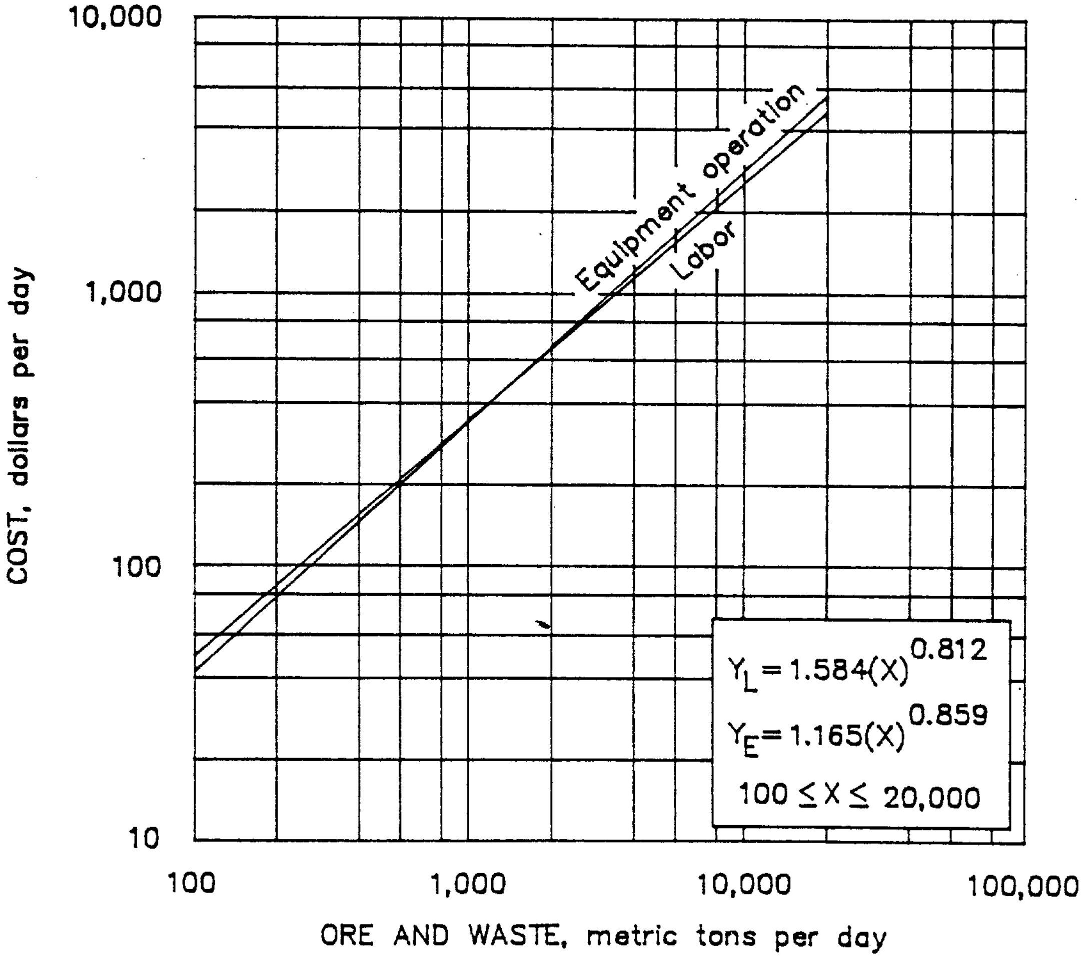
Equipment operation factor $(F_E) = 0.293+0.0014(D)$
where D = one way haul distance, in meters.

Grade factor A factor is also supplied for other than horizontal workings with cost related to percent grade. This factor should be used if the grade exceeds 2% and is equally applicable if dealing with inclines or declines. For other than horizontal haulageways, multiply the costs obtained from the curves by the following factors:

$$\text{Grade factor} \quad (F_G) = 0.929(1.037)^G$$

where G = grade, in percent of incline or decline.

Underground Mining—Operating Costs



5.2.3.7. L.H.D. Haulage

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.8.1. RAIL HAULAGE MAIN LINE

Main line haulage system costs are based on two trains, each consisting of one trolley or diesel locomotive and side-dump ore cars, operating each shift with an average one-way haul of 3,049 m with a 1% grade in favor of the loaded train.

The total daily cost for a main line rail haulage system is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a haulage rate (X), in metric tons of ore and waste moved per day. The curves are valid for operations between 100 and 50,000 mt, operating two shifts per day. These costs consist of charges for operation, maintenance, and repair of locomotives and ore cars, as well as electric, battery, or diesel power to run them, and infrequent track repair.

BASE CURVES

(L) Labor Operating Cost (Trolley) $(Y_{L\ TROLLEY}) = 128.402(X)^{0.386}$
The operating labor costs for trolley locomotives are distributed as follows:

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

Main line maintenance labor costs are distributed 11% for locomotive repair and maintenance labor, 31% for ore car and flat car repair and maintenance.

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Production loader...........	31%	$16.33
Production motorman.........	33%	15.89
Electrician.................	25%	27.73
Laborer.....................	11%	15.25

Average wage for labor is $18.82 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost (Trolley) $(Y_{S\ TROLLEY}) = 0.043(X)^{0.971}$
The trolley locomotive supply cost consists of 6% track repair materials and 94% electric power.

(E) Equipment Operating Cost (Trolley) $(Y_{E\ TROLLEY}) = 7.797(X)^{0.579}$
The trolley locomotive equipment operating costs consist of 27% for locomotive repair and maintenance parts, 64% for ore car and flat car repair and maintenance parts, and 9% for lubrication.

If diesel locomotives are used instead of trolley locomotives for main line haulage, use the following equations:

(L) Labor Operating Cost (Diesel) $(Y_{L\ DIESEL}) = 104.954(X)^{0.402}$
The operating labor costs for diesel locomotive are distributed as follows:

Direct labor................	49%
Maintenance labor...........	51%

Diesel maintenance labor costs are distributed 18% for locomotive repair and maintenance labor, 33% for ore car and flat car repair and maintenance labor.

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Production motorperson......	40%	$15.89
Production loade............	43%	16.33
Laborer.....................	17%	15.25

Average wage for labor is $15.97 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost (Diesel) $(Y_{S\ DIESEL}) = 0.385(X)^{0.331}$
The diesel locomotive supply cost consists of 100% track repair materials.

(E) Equipment Operating Cost (Diesel) $(Y_{E\ DIESEL}) = 4.382(X)^{0.680}$
The diesel locomotive equipment cost consists of 30% for locomotive repair and maintenance parts, 51% for ore car and flat car repair and maintenance parts, 9% for lubrication, and 10% for fuel.

ADJUSTMENT FACTORS

Haul Distance Factor If one-way haul distance varies from 3,049 m (10,000 ft) for a main line system, multiply the costs obtained from the curves by the following factors:

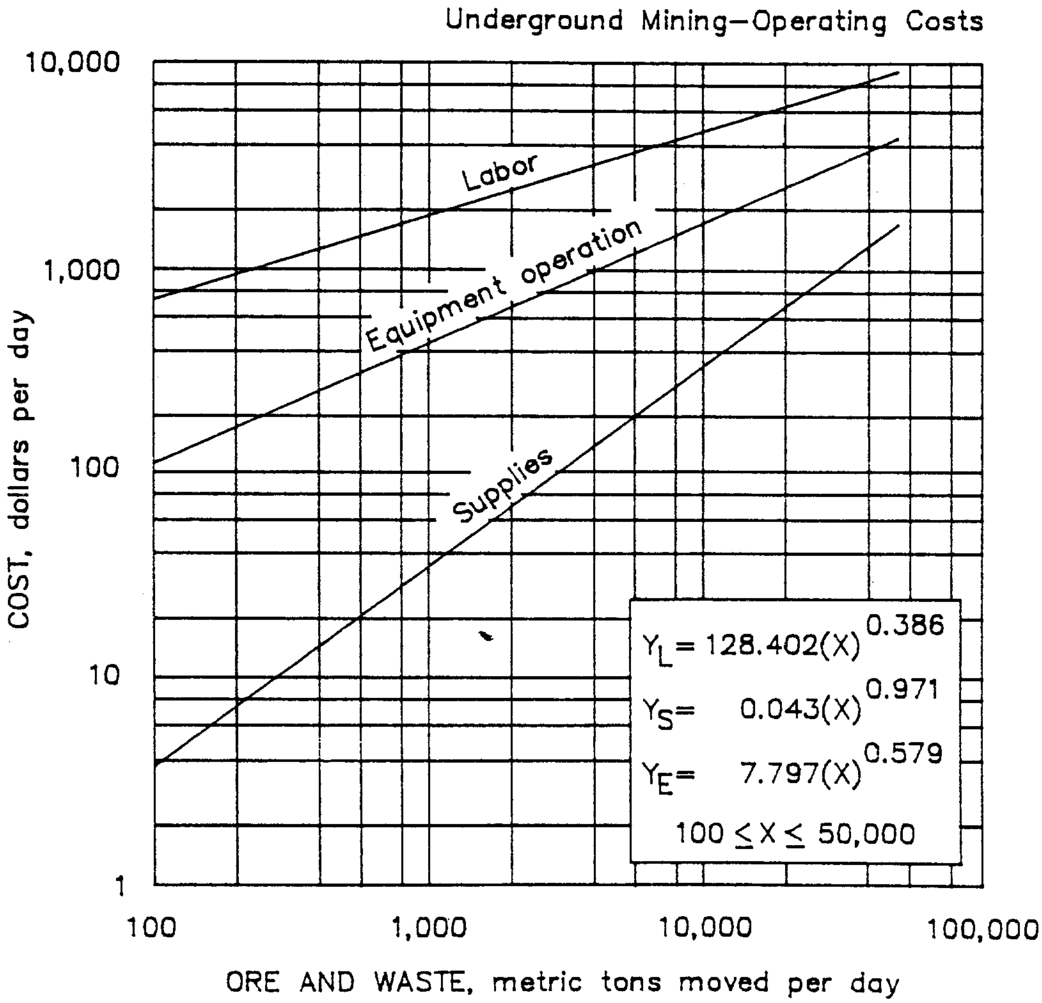
Main line trolley:
Labor factor $(Y_{L\ TROLLEY}) = 0.259(D)^{0.169}$

Main line diesel:
Labor factor $(Y_{L\ DIESEL}) = 0.171(D)^{0.221}$

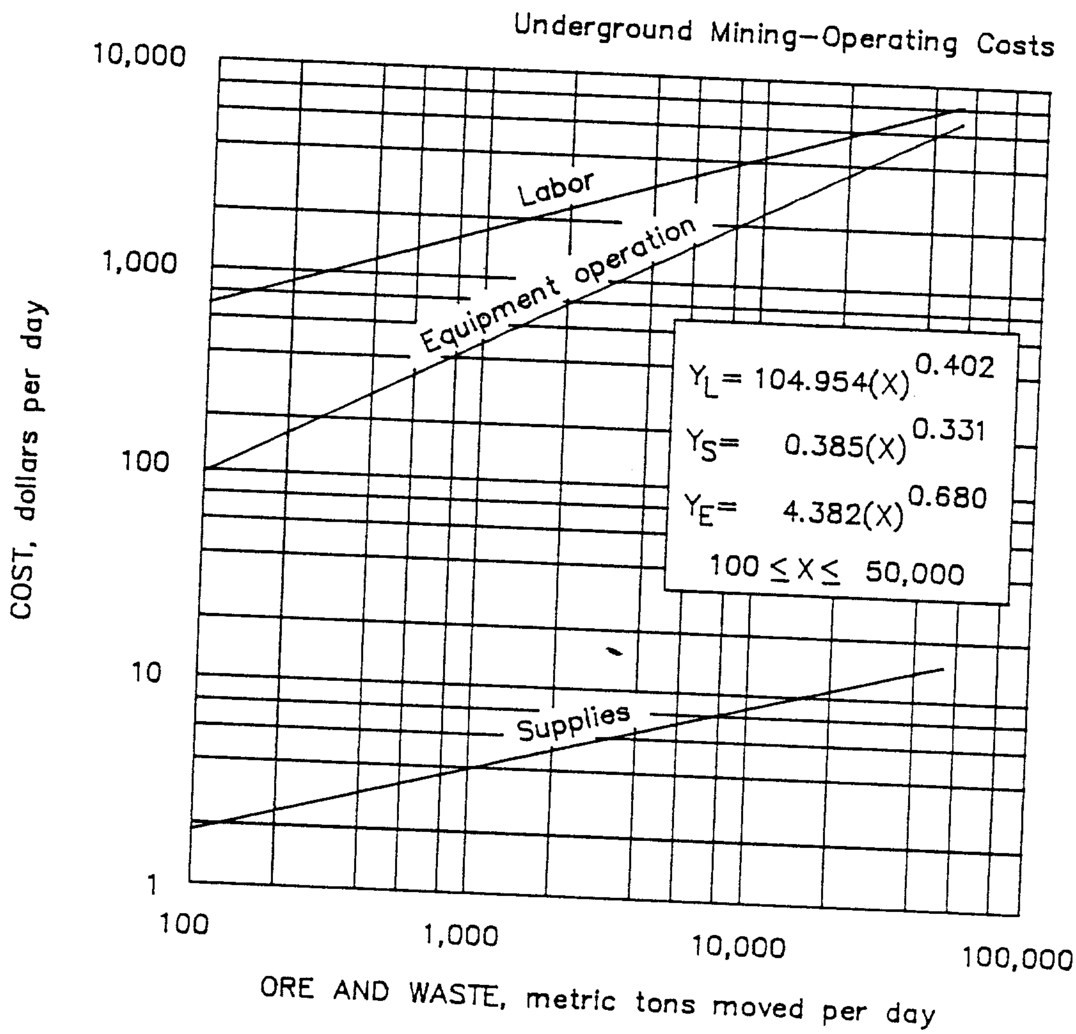
Main line trolley and diesel:
Supply factor $(Y_{S\ TROLLEY\ \&\ DIESEL}) = 0.042(D)^{0.396}$

Equipment operation factor $(Y_{E\ TROLLEY\ \&\ DIESEL}) = 0.042(D)^{0.396}$
where D = one way haul distance, in meters.

Shift Factor If a rail haulage system operates one shift per day, derive the appropriate cost by entering the cost curves at two times the system capacity, and then decrease the derived costs by 50% (i.e., a main line system operates one shift per day at 400 mtpd, use 800 mtpd, to derive curve costs, then decrease these costs by 50%). If a rail system operates three shifts per day, enter the cost curves at two-thirds the system capacity, and then increase the derived costs by 50% (i.e., a main line system operates three shifts per day at 900 mtpd, use 600 mtpd to derive the curve costs, then increase these costs by 50%).



5.2.3.8.1.a Rail haulage—main line
TROLLEY



5.2.3.8.1.b Rail haulage—main line
DIESEL

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.8.2. RAIL HAULAGE
MULTILEVEL

Multilevel haulage system costs are based on one train, comprising a battery locomotive and side-dump ore cars, operating each shift with an average one way haul distance of 915 m (3,000 ft) with a 1% grade in favor of the loaded train. The number of trains operating are determined from the daily production from each mine level. For example, a 2,000-mtpd mine has four mine levels; however, only two levels are producing ore while the other two levels are being developed; so the haulage system on each level should be capable of transporting 1,000 mtpd.

The total daily cost for a multilevel rail haulage system is the sum of the three separate cost curves (labor, supplies, and equipment operation) based on a haulage rate (X), in metric tons of ore and waste moved per day. The curves are valid for operations between 100 and 15,000 mt, operating two shifts per day. These costs consist of charges for operation, maintenance, and repair of locomotives and ore cars, as well as electric, battery, or diesel power to run them, and infrequent track repair.

BASE CURVES

(L) Labor Operating Cost $(Y_L) = 155.792(X)^{0.290}$
The operating labor costs are distributed as follows:

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

Multilevel labor operating curve costs are distributed 80% for locomotive repair and maintenance labor, 20% for ore car and flat car repair and maintenance labor.

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Production motorman.........	33%	$15.89
Production loader...........	34%	16.33
Laborer.....................	33%	15.25

Average wage for labor is $15.83 per worker-hour (including burden and average shift differential).

(S) Supply Operating Cost $(Y_S) = 0.105(X)^{0.564}$
The supply cost consists of 43% track repair materials and 57% electric power to recharge locomotive batteries.

(E) Equipment Operating Cost $(Y_E) = 5.062(X)^{0.558}$
The equipment operating cost consist of 28% for locomotive repair and mainten-

ance parts, 60% for ore car and flat car repair and maintenance parts, 9% for lubrication, and 3% for locomotive battery replacement.

ADJUSTMENT FACTORS

Haul Distance Factor If one-way haul distance varies from 915 m (3,000 ft) for a multilevel system, multiply the cost obtained from the curves by the following factors:

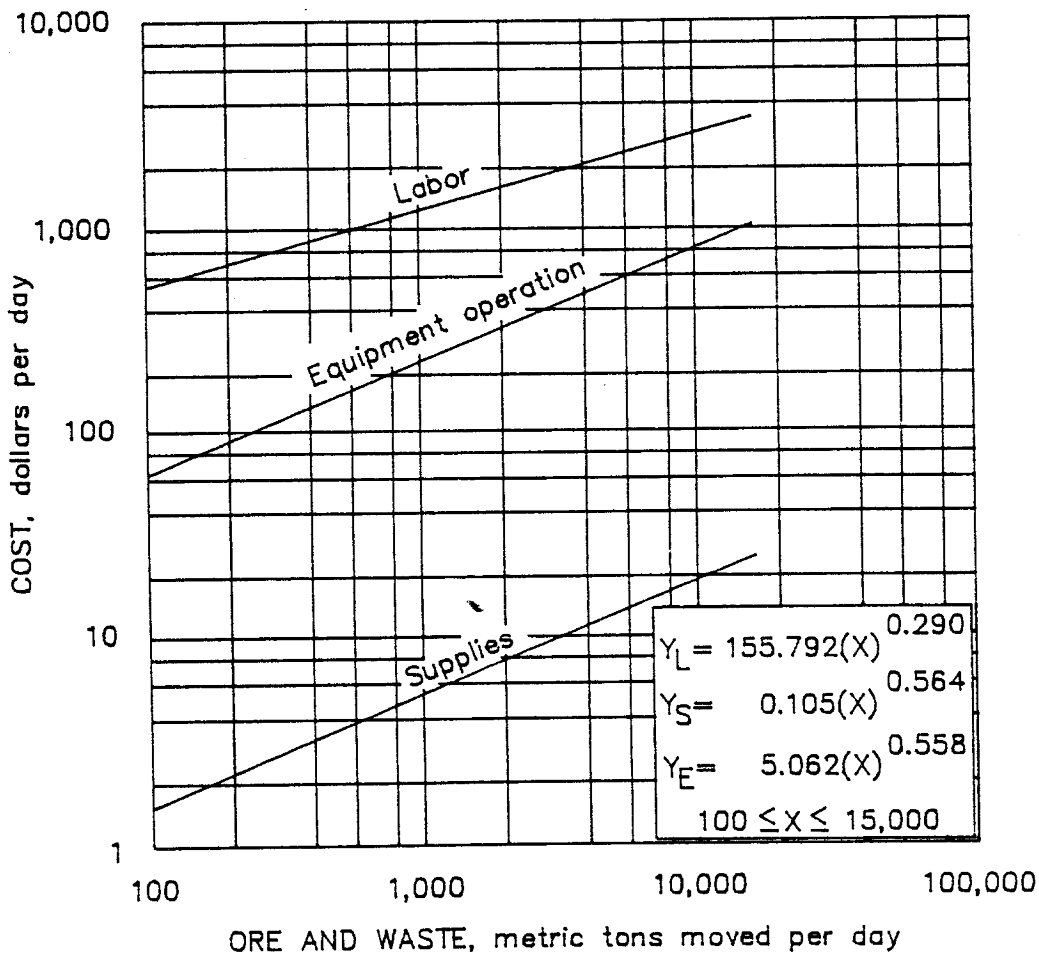
Labor factor $(Y_L) = 0.539(D)^{0.091}$

Supply factor $(Y_S) = 0.097(D)^{0.344}$

Equipment operation factor $(Y_E) = 0.097(D)^{0.344}$
where D = one way haul distance, in meters.

Shift Factor If a rail haulage system operates one shift per day, derive the appropriate cost by entering the cost curves at two times the system capacity, and then decrease the derived costs by 50% (i.e., a multilevel system operates one shift per day at 400 mtpd, use 800 mtpd, to derive curve costs, then decrease these costs by 50%). If a rail system operates three shifts per day, enter the cost curves at two-thirds the system capacity, and then increase the derived costs by 50% (i.e., a multilevel system operates three shifts per day at 900 mtpd, use 600 mtpd to derive the curve costs, then increase these costs by 50%).

Underground Mining—Operating Costs



5.2.3.8.2. Rail haulage—multilevel

5.2. UNDERGROUND MINING--OPERATING COSTS

5.2.3. MINE HAULAGE

5.2.3.9. TRUCK HAULAGE

The truck haulage curves cover costs of transporting ore and waste in rear-dump trucks. It is assumed that front-end loaders or LHD's are used for loading, and that one loader is required for every two trucks in use. One way haulage occurs over an average distance of 680 m (2,250 ft). The curves for truck haulage are designed to cover situations where the trucks start on a level grade, and are at a maximum attainable speed when uphill or downhill segments of the haulage route are encountered. In most instances the actual haul distance for a mine under evaluation will differ from the one given above. Adjustment can be made by consulting the haulage distance factor contained below.

The total daily cost is the sum of the two separate cost curves (labor and equipment operation) based on a haulage rate (X), in metric tons of ore and waste moved per day. The curves are valid for operations between 1,000 and 50,000 mt, operating two shifts per day.

BASE CURVES

(L) Labor Operating Costs (Front-End Loader) $(Y_{L\ FEL}) = 0.386(X)^{0.974}$

(L) Labor Operating Costs (LHD) $(Y_{L\ LHD}) = 0.361(X)^{0.980}$

The operating labor costs are based on straight days pay and consist of the following typical range of personnel:

		Av salary per hour (base rate)
Truck drivers...............	61%	$16.90
Loader Ooerators............	39%	16.90

(E) Equipment Operating Costs (Front-End Loader) $(Y_{E\ FEL}) = 0.747(X)^{0.915}$

(E) Equipment Operating Costs (LHD) $(Y_{E\ LHD}) = 0.506(X)^{0.953}$

The equipment operating cost consists of 28% for parts, 47% for fuel and lubrication, and 25% for tires. The equipment operating curve includes the daily overhaul and maintenance costs for parts, and daily fuel, lube, and tire costs.

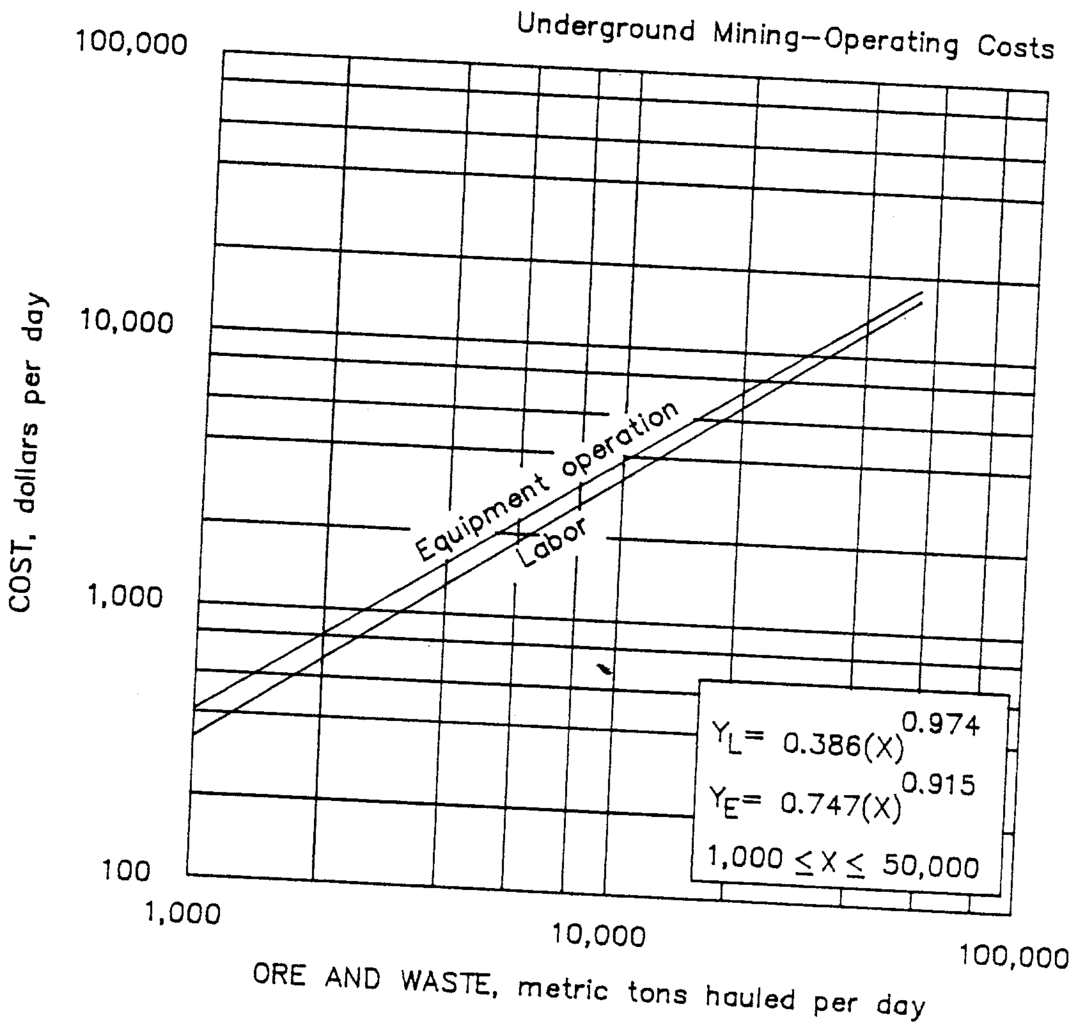
ADJUSTMENT FACTOR

Haulage Distance The given curves are valid for one-way haul distances of approximately 680 m (2,250 ft). To determine equipment and labor costs for one way-haul distances of other than 680 m (up to 3,000 ft), multiply the costs obtained from the truck haulage curves by the following factors:

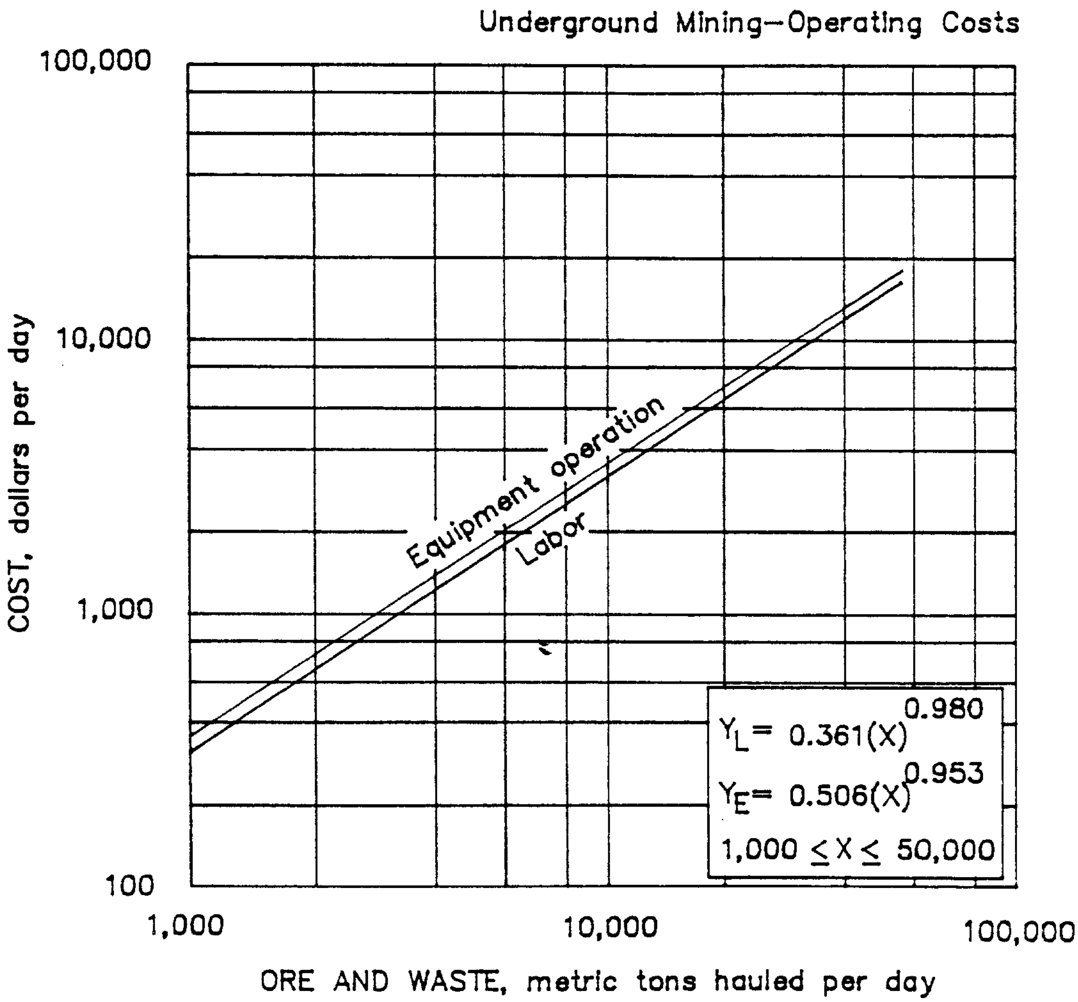
Labor factor $(F_L) = 0.055(D)^{0.445}$

Equipment operation factor $(F_E) = 0.053(D)^{0.450}$
where D = actual one way haul distance, in meters.

When the haulage distance is increased, the cycle time will show a corresponding increase, and more trucks will be needed to haul an equivalent amount of material.



5.2.3.9.a Truck haulage
FRONT-END LOADER



5.2.3.9.b Truck haulage
L.H.D.