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BELTCON 3

High Angle Conveyor offers Mine Haulage Savings

D D Mitchell; D W Albertson

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INTERNATIONAL MATERIALS HANDLING CONFERENCE - BELTCON 3

Paper Title : High Angle Conveyor Offers Mine Haulage Savings

Authors:

J.J. Mitchell
Manager - Systems
Continental Conveyor & Equipment Co. Inc.,
Winfield, Alabama, U.S.A.

D.W. Albertson
General Manager/Director
Spencer (Melksham) S.A. (Pty) Ltd.,
Johannesburg,
South Africa

Synopsis:

Costs of truck haulage from mine pits are high and spiralling with inflation, increasing haul distances and depths. A high angle conveying system is an economic and energy saving alternative, with the capability of achieving very high, steep angle lifts and capacities up to 10 000 t.p.h. Standard locally available components and conventional belts are used.

This paper describes a typical open pit mine's requirements, concentrating on haulage alternatives. Definitive costs for high angle conveyorised systems are compared with truck haulage. These costs have been developed from existing current operations.

Mine operators should find this useful in looking for means of improving productivity and reducing costs per ton.

INTRODUCTION

Trucks, traditionally, have long been a favourite tool in surface mines for hauling material from the pits. The increasing strain of an inflationary economy has caused mine operators to look at alternatives to the longstanding workhorses (trucks) in material haulage.

The intent of any major modification of the time-honoured material handling by trucks is to achieve the goal of a marked reduction in haulage costs; sufficient not only to recoup the capital investment, but to make the final product more competitive in today's world market. In-pit crushing and belt conveyor systems are one prominent alternative that has gained popularity.

More than fifty major conveyorized surface mines are in successful operation around the world. Major savings in capital and operating costs are realised when conveyorized systems are properly applied with other proven mining technologies.

By combining the flexibility of trucks with the low cost of conveyors, an alternative is offered by the application of movable crushing plants followed by belt conveyor systems in conjunction with steep angle conveyors for the main haul out of the pit.

Truck haulage can be restricted to travel between the working face and the pit crusher. This means that trucking is limited to level haulage on individual shovel benches and to very little inclined haulage. It is on the inclines where a truck's efficiency is so low.

A high angle conveyor can be defined as any conveyor that transports material along a slope exceeding the dynamic stability angle of the transported material.

The application of conveyors in this mine study recognizes the cost savings in material haulage that a high angle conveyor has in a total system.

High Angle Conveyor Principles

There are two basic designs which have been developed to a stage of commercial practicability - the sandwich belt system and the pocket belt system.

In this study we are considering the high angle conveyor or HAC as developed by the Continental Conveyor & Equipment Co. in the U.S.A. This is a sandwich belt design which employs two ordinary rubber belts on top of each other sandwiching the material between them.

The geometry and design features of the HAC provide sufficient friction at material/belt and material/material interfaces to prevent the material sliding back. Careful selection of radii, belt tensions and pressing forces are required. The bottom belt is carried on troughing idlers and the top, or cover belt, is softly pressed onto the conveyed material by fully equalised pressing rolls. Material is loaded onto the tail end of the bottom belt in the conventional manner and sandwiching commences at the start of the concave radius leading into the inclined position. In this radius the top belt is supported on inverted troughing idlers and the bottom belt supports the material by virtue of its radial tension component. Ample belt edge distance assures a sealed material package during operation and lump sizes up to the trough depth or slightly more present no problems. All components are standard and proven for conveyor applications.

Economic Feasibility

The viability of the high angle conveyor system application lies in the degree of economic advantage it offers over the conventional truck system it is to replace.

For economic comparison both the high angle conveyor system and the truck haul system are developed for the same mining sequence, pit configuration and production schedule.

Intangible benefits that exist in favour of the conveyorized system are difficult, if not impossible to document, are not included. Logical considerations indicate that these benefits exist. Different cycle times occur between two apparently identical trucks and each driver has different abilities, erratic arrivals and departures at the loading and dumping points and decreases in shovel and truck efficiency. These inefficiencies at such times and shift changes are particularly detectable.

Mine Design

In this study the mine is a hypothetical composite featuring existing conditions in different mines in the United States and represents an average size. The ultimate mine pit configuration measures approximately 1900 metres x 1450 metres. The ultimate depth of the pit floor from the highest pit crest is 550 metres and the average depth to pit floor is 400 metres. The benches have an average slope of 58 degrees and average width of 8 metres. The haul roads inside the pit area are on 8 percent grade and 36 metres wide.

The mine is at a depth of approximately 175 metres. This is reaching the limit of acceptable truck haulage costs. The costs are found to increase at a dramatic rate as the depth of the pit increases. Vertical lifts in excess of 150 metres create traffic and maintenance problems; efficiency drops rapidly and costs rise.

Some 375 million tons of ore reserves were calculated to be excavated from this pit in 22 years. A daily ore and waste mining production of 130 000 tons is desired with a stripping ratio of 1,8 tons of waste to 1 ton of ore (83 500 tons of waste and 46 500 tons of ore).

This mine is assumed to work 365 days per year, 3 eight hour shifts per day. Equipment mechanical availability is approximate at 82 percent, and personnel time efficiency is at 83 percent for an overall utilisation of 68 percent, or 16,3 hours per day.

Equipment Selection

From the work schedule and daily production requirements, the following assumptions were made to determine the number and sizes of the equipment.

I. All Truck Systems:

The waste system has three routes. One route located 45 metres from the rim, the second route located 30 metres below the first route and the third route located 30 metres below the second route. The waste dump is approximately 1 280 metres from pit perimeter. A total of twelve trucks of 170 ton capacity is required. Five, four and three trucks, respectively, for the three routes. Trucks from the two top waste benches use the same ramp and the trucks from the bottom bench use the one exit ramp. Their trip cycle times were calculated as 19, 24 and 31 minutes.

The ore system has two routes, resulting in the use of twelve trucks of 170 ton capacity. Six trucks, respectively, for each unit. These trucks operate from 185 metre and 200 metre levels. The primary crushing station is located 1960 metres from pit perimeter. The trip times are 34 minutes and 35 minutes.

The five shovels required, three for waste and two for ore, are of the 16 metre cubed type.

The all truck system is comprised of the following major equipment:

a) Waste system components

3	16 metre cubed shovels
12	170 ton trucks

b) Ore system components

2	16 metre cubed shovels
12	170 ton trucks
1	crusher station

The all truck haulage system is represented by Figure 1

II. Conveyorized System:

The waste and ore removal and discharge areas are the same as the all truck system.

The waste system has three routings which requires seven trucks of 170 ton capacity. The trip cycle times are approximately 16, 4,5 and 5.0 minutes. The routings of the trucks at bench locations at 45 metre and 75 metre elevation below the rim have the trucks dumping into the same mobile crusher station and the route at 105 metre elevation below the rim dump into a second mobile crusher station. The truck requirements are 2 for the first working bench, 3 for the second working bench and 2 for the third working bench.

The ore system has two routings resulting in trip times of 14 minutes and 12 minutes. The truck requirement is four trucks.

The conveyorized system is comprised of the following major equipment:

a) Waste system components (initial)

- 3 16 metre cubed shovels
- 7 170 ton trucks
- 2 Mobile crushing stations with apron feeder - 2 000 mm wide x 25 metres, 3 500 tph, maximum capacity. Gyratory crusher 54 x 74, Crusher discharge conveyor, 2 400 mm wide x 30 metres.
- 8 In-pit conveyors - 1200 mm wide to transport waste to high angle conveyor, 3 250 tph capacity.
- 2 High angle conveyors, 2 000 mm belt width, 6 500 tph capacity, one with 60 metre lift and one with 50 metre lift.
- 1 Overland conveyor, 1500 mm wide x 1280 metres to handle 6 500 tph.
- 1 Shiftable conveyor with stacker, 1500 mm wide x 2 000 metres.

b) Ore System components (initial)

2	16 metre cubed shovels
4	170 ton trucks
1	Mobile crushing station (same as waste system)
2	In-pit conveyor, 1200 mm wide to transport ore to high angle conveyor, 3 250 tph capacity.
2	High angle conveyors, 1500 mm belt width 3 250 tph capacity, one with 90 metre lift and one with 75 metre lift.
1	Overland conveyor, 1200 mm wide x 1 960 metres, 3 250 tph capacity.

Additional equipment includes two self-propelled crawler transporters of 300 ton capacity. These are used in relocating the mobile crushing stations.

The belt conveyors are sized and powered to permit temporary surges without overloading system components. The ore system average flow sheet rate is 2 853 tph and the belt units are designed for 3 250 tph (+ 14%). The waste system average flow sheet rate is 2 562 tph for each of the two systems and the belt units are designed for 3 250 tph (+ 22,5%).

The conveyorized system is represented by Figure 2.

Operating Costs

The base costs used for estimating operating costs are:

- Diesel fuel = $1.00 gallon
- Electricity = $0,0325/Kwh.
- Operator's wages = Prevailing wages including all fringe benefits.

The costs of the trucks, graders, dozers, etc. are divided in categories covering specific items. The following example is for the 170 ton trucks. The other equipment was figured in a similar manner.

Truck Estimated Operation Cost - All Truck System

1)	Fuel Cost	$56,50/hour
2)	Tyre replacement cost (200 hr life of tyres)	15,82
3)	Tyre repair	1,70
4)	Oil, grease, filters etc.	1,00
		$75,02/hour

Truck Estimated Operation Cost - Truck/Conveyor System

1)	Fuel cost	$33,90/hour
2)	Tyre replacement cost (200 hr life of tyres)	15,82
3)	Tyre repair	1,72
4)	Oil, grease, filters etc.	1,00
		$52,42/hour

Note: The hourly fuel costs are based on simulated conditions.

For the electrical costs, the crushing plants and conveyor system will operate 5 950 hours each year (68% on 16,3 hour/day) loaded and 2 810 hours empty. The Kwh for the system is:

Ore system :	25 533 000 Kwh
Waste system :	42 947 000 Kwh

For extending the high angle conveyor deeper into the pit during years 6, 12 and 18, the following additional electrical power will be required: 7 199 000 Kwh each frame.

In compiling the operating costs, a comparison of the total travel and lifts of the two systems were determined. The run of the truck/conveyor system decreased by approximately 56% and the lift decreased by approximately 89%. To put this in perspective, the following is the tabulation of the estimated runs and lifts:

System	Haulage Distance	Lift
All truck	5850 Km/day	113,9 Km/day
Truck/conveyor	2575 Km/day	14,1 Km/day

Table 1-1 shows the all truck haulage capital asset schedule. Year one is the beginning of the mine plan when truck/conveyor system begins its comparison with all truck system.

Table 1-2 shows the truck/conveyor haulage capital asset schedule. Some existing trucks (approx. 9) being used for the present mining plan would be reserved for retirement and spare parts.

Table 1-3 indicates the capital costs over the life of the mine for both systems.

Table 1-4 lists the personnel requiremnts for the two systems.

Table 1-5 illustrates the operational costs for the two systems

Table 1-6 shows the total costs over the life of the mine at 0% inflation rate.

Advantages and Disadvantages

A. Truck System:

1. System is flexible, a single truck fleet can serve several production areas.
2. It is a proven system.
3. There is efficient loading. Trucks can be spotted at the most efficient location for the loader.

4. It is a non-permanent system.
5. It is very sensitive to inflation.
6. Truck costs increase exporentially with increase in lift height.
7. Truck haulage is dependant on skilled maintenance labour.
8. Trucks are less efficient energy users than conveyors.
9. Truck fuel is subject to sharp price increases and shortages that could result in rationing or being put on allocation.
10. Ore losses are encountered on initial start-up due to long truck ramps.
11. Trucks generally have a lower productivity than conveyors.

B. **Conveyorized Systems:**

1. Flexibility of mine planning is reduced.
2. Initial capital cost of the conveyor system is high.
3. Conveyors cannot be lengthened or shortened as easily as truck haulage.
4. Conveyors must be either straight or have a very large radius of curvature in the plan view.
5. By using a high angle conveyor a much shorter total haul length is encountered.
6. Conveyors almost always provide lower operating and maintenance costs, and are more efficient energy users than trucks.
7. They provide comparable operating availability.
8. Frequently conveyor/high angle conveyor gives a comparable operating flexibility to a truck system, depending on mine plan.
9. They are less sensitive to inflationary pressure and to fuel shortages.
10. They are much less labour intensive.

11. Conveyors are environmentally preferable, because it is much quieter and has fewer particulate emissions.
12. Lower unit costs may extend the economic pit life.
13. Operation is less sensitive to inclement weather.
14. Truck cycle times are shortened.
15. Conveyor components are readily available and are often locally produced.

SUMMARY

This study has determined that a truck-conveyor-high angle conveyor system is economically viable in the open pit mine.

Technically, the high angle conveyor and the attending conveyor system have been developed from proven, state-of-the-art design standards in the areas of belt conveyance of loose, bulk materials.

The new concept of high angle conveyors can be incorporated with minor modification to the pit configuration. From an economic standpoint, the high angle conveyor is a cost saving method of transporting material out of the pit. This cost saving is greatly enhanced when mines are deep with high lifts and long transport distances.

Maximum economic stripping ratios may increase because of lower mining costs, expanding pit perimeters and deepening pit bottoms.

Numerous studies have shown that in many cases conveyors can be more economic to operate, even though they lack the flexibility some desire.

As an addendum and for comparison, a similar study to the above is attached for reader's interest. This study is based on realistic, current South African conditions and was undertaken to evaluate a specific situation.

Every haulage system is extremely site specific. With proper interfacing with mine planning, a conveyor high angle conveyor/haulage system can provide many years of economical and reliable operation for the owner.

It should be noted, of course, that high angle conveying has many other applications both in underground mines and surface plants. The constraints imposed by inclination considerations need no longer inhibit the use of conveyors. When overall savings in land, excavation, services, controls etc. are added to those savings more directly measurable, the potential for improving returns on investment is very attractive.

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TABLE 1-1

ESTIMATED CAPITAL ASSETS SCHEDULE
DIRECT HANDLING - ALL TRUCKS
($1,000)

	170 Ton Truck	Truck Dozer	Motor Grader	Wheel Dozer	Water Wagon
Unit Price	900	291,6	273,9	200,4	531,9
Life/Years	6	3	3	3	3
Years					
-2					
-1	6 300	291,6	273,9	200,4	531,9
1	9 000	291,6	273,9	200,4	531,9
2					
3	2 700	291,6	273,9	200,4	531,9
4		291,6	273,9	200,4	531,9
5	1 800				
6	8 100	291,6	273,9	200,4	531,9
7	900	291,6	273,9	200,4	531,9
8	5 400				
9		291,6	273,9	200,4	531,9
10		291,6	273,9	200,4	531,9
11	1 800				
12	7 200	291,6	273,9	200,4	531,9
13	900	291,6	273,9	200,4	531,9
14	5 400				
15		291,6	273,9	200,4	531,9
16	2 700	291,6	273,9	200,4	531,9
17	1 800				
18	7 200	291,6	273,9	200,4	531,9
19	1 800	291,6	273,9	200,4	531,9
20	4 500				
21	5 400	291,6	273,9	200,4	531,9
22		291,6	273,9	200,4	531,9
Totals	72 900	4 665,6	4 382,4	3 206,4	8 510,4

TABLE 1-2

ESTIMATED CAPITAL ASSETS SCHEDULE
INDIRECT HAULING - TRUCK/CONVEYOR/HIGH ANGLE
($1,000)

	170 Ton Truck	Truck Dozer	Motor Grader	Wheel Dozer	Water Wagon
Unit Price	900	291,6	273,9	200,4	531,9
Life/Years	6	3	3	3	3
Years					
-2					
-1	6 300	291,6	273,9	200,4	531,9
1	9 000	291,6	273,9	200,4	531,9
2					
3					
4		291,6	273,9	200,4	531,9
5					
6	8 100				
7		291,6	273,9	200,4	531,9
8					
9					
10		291,6	273,9	200,4	531,9
11					
12	8 100				
13		291,6	273,9	200,4	531,9
14					
15					
16		291,6	273,9	200,4	531,9
17					
18	8 100	291,6	273,9	200,4	531,9
19		291,6	273,9	200,4	531,9
20					
21					
22		291,6	273,9	200,4	531,9
Totals	39 600	2 332,8	2 191,2	1 603,2	4 255,2

TABLE 1-3

EQUIPMENT
CAPITAL COSTS OVER LIFE OF MINE
($1,000)

Item	All Truck System Qty	All Truck System Cost	Truck/Conveyor System Qty	Truck/Conveyor System Cost
170 ton truck	81	72 900	44	39 600
Track dozer	16	4 666	8	2 333
Motor grader	16	4 382	8	2 191
Wheel dozer	16	3 206	8	1 603
Water wagon	16	8 510	8	4 255
Mobile crushers	-		3	6 300
Conveyors	-		10	19 800
High angle conveyors	-		4	6 200
Spreader	-		1	4 250
Transporters - crawler	-		2	1 200
Relocate crushers	-		-	9 500
Relocate waste shiftable conveyor	-		-	600
Electrical distribution	-		-	1 975
Total		93 664		99 807

NOTE:

Equipment that would be used for either all truck or truck/conveyor not included in above, such as: shovels and their support vehicles, maintenance truck, fuel and lube truck, shop, tyre truck, welding truck, storage tanks for diesel and gasoline, pick-up trucks, mobil radio units etc.

TABLE 1-4

LIST OF PERSONNEL AND ANNUAL TOTAL PAYROLL

(Note: Supervisory personnel same for both systems. Support personnel that is common for both systems not included)

Personnel	All Truck No.	All Truck Annual Cost	Combination No.	Combination Annual Cost
Truck driver	72	2 265 840	33	1 030 510
Track dozer operator	6	188 820	3	94 410
Grader operator	6	188 820	3	94 410
Wheel dozer operator	6	188 820	3	94 410
Water wagon operator	6	188 820	3	94 410
Truck mechanic	12	377 640	6	188 820
Truck mechanic helper	4	85 028	3	63 771
Dozer mechanic	6	188 820	3	94 410
Dozer mechanic helper	3	63 771	3	63 771
Grader/Water Wagon mech.	4	125 880	3	94 410
Grader/Water Wagon mech. helper	3	63 771	3	63 771
Labour pool*	33	956 142	24	695 376
Conveyor mechanics**	-		34	794 376
Total (Avg. per year for Mine Life)	161	4 882 172	124	3 474 855
Total Avg. Mine Life (22 years)		107 407 784		76 446 810

* Weighted average of all classifications. Men required for vacation time, absenteeism and odd shifts on seven-day work schedule.

** Weighted average of all classifications

TABLE 1-5

OPERATING COSTS (TYRES, FUEL LUBE, ETC.)
($1 000)

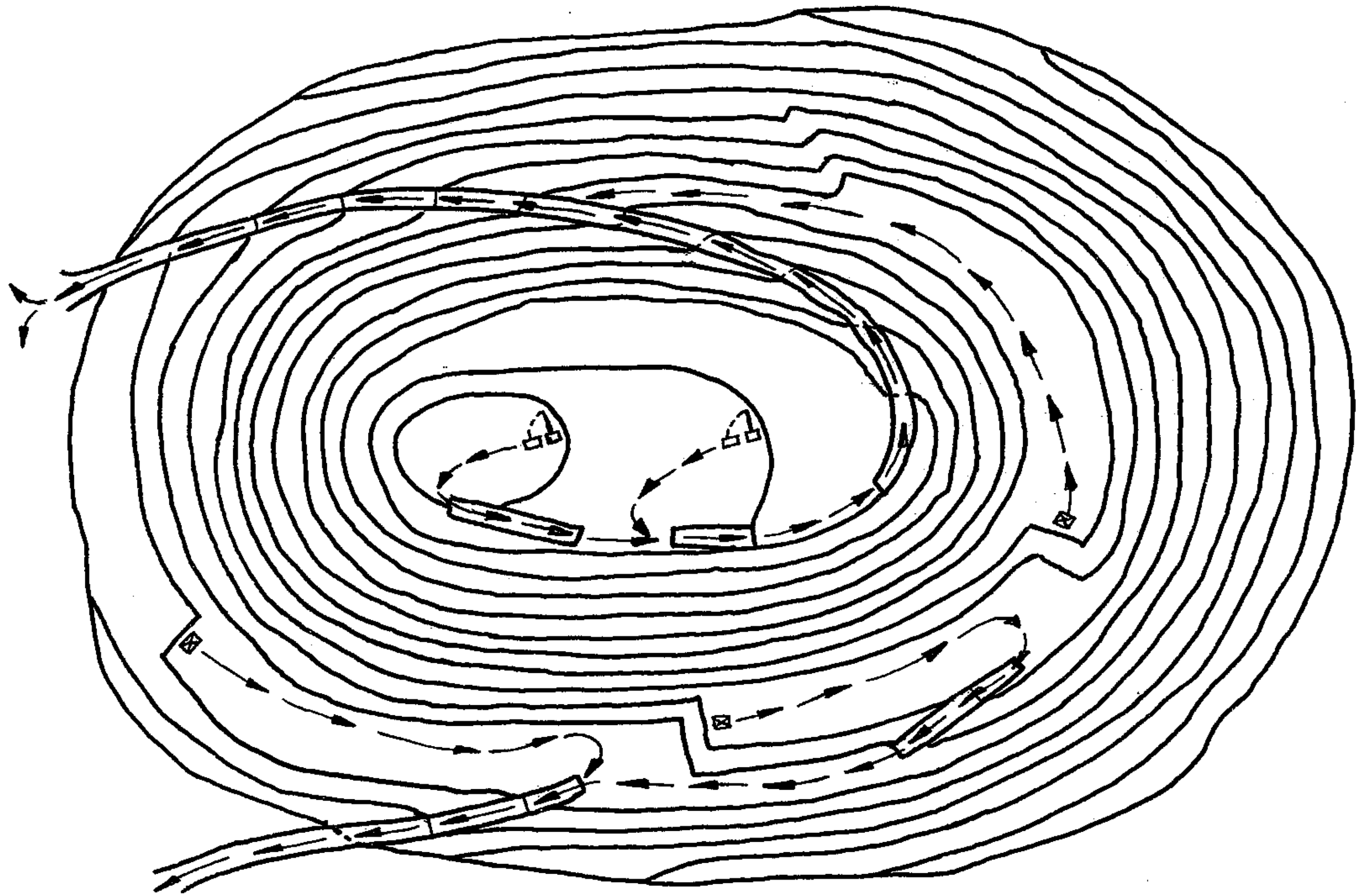
	All Trucks		Truck/Conveyor	
Item	Qty	Amount	Qty	Amount
170 Trucks	24	10 730,8	11	3 436,7
Track dozer	2	783,2	1	391,6
Motor grader	2	715,3	1	265,9
Wheel dozer	2	624,8	1	312,4
Water wagon	2	894,2	1	379,8
Electrical power (base system)	-		1	2 225,6
Sub Total per year		13 748,3		7 012,0
Sub Total Life of Mine		302 462,6		154 264,0
Additional electrical power (Years 6,12 & 18)				702,0
Total Operating Costs		302 462,6		154 966,0

Based on operating 16,3 hours per day for hauling materials and 7,7 hours per day of idle time.

TABLE 1-6

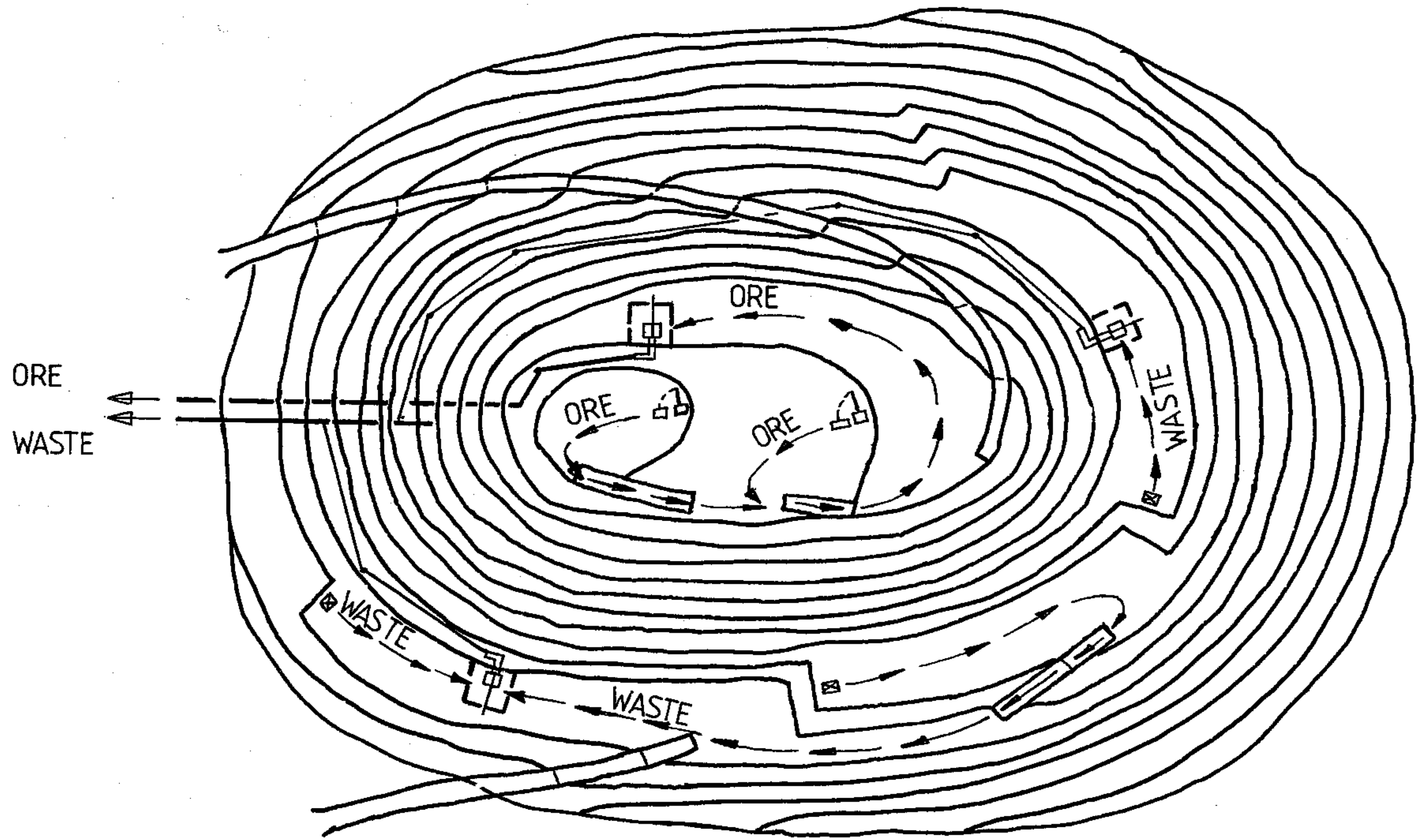
TOTAL COST OVER 22 YEAR MINE LIFE
(0% ANNUAL INFLATION)
($1 000)

	All Truck	Truck/Conveyor
Capital Costs	93 664,0	99 807,0
Labour Costs	107 407,8	76 446,8
Operating Costs	302 462,6	154 966,0
	503 534,4	331 219,8
Average cost per ton (375 million tons)	1,3428/ton	0,8833/ton



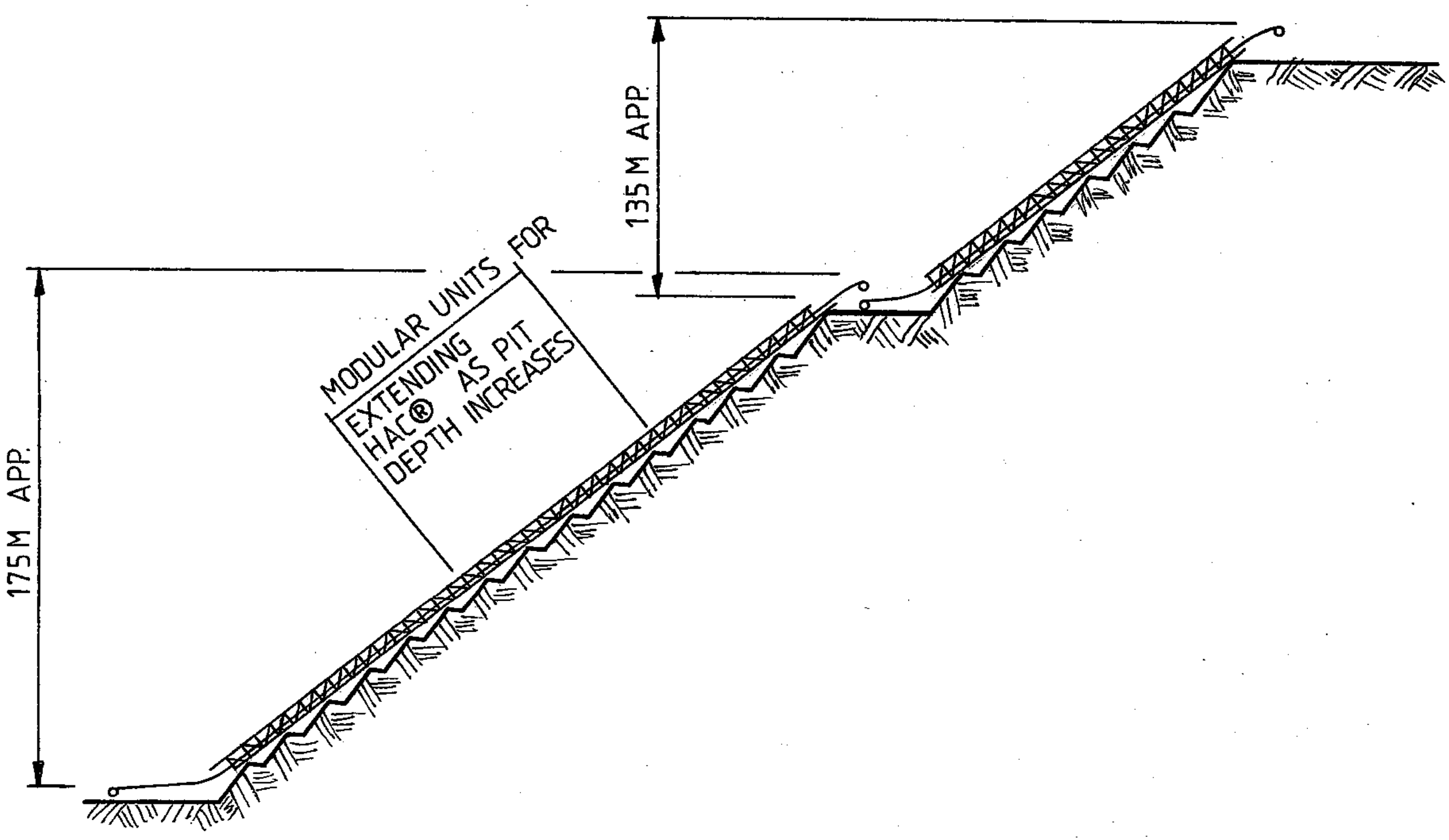
PIT SHOWING TRUCK HAULAGE SYSTEM

FIG. 1.



SAME PIT SHOWING IN-PIT CRUSHER - CONVEYOR HAULAGE SYSTEM.

FIG. 2.



TYPICAL ARRANGEMENT OF MODULAR HIGH ANGLE CONVEYORS

FIG. 3.

Spencer (Melksham) S.A. (Pty) Ltd.

A D D E N D U M

COMPARATIVE COSTS OF CONVENTIONAL VERSUS HIGH ANGLE CONVEYING IN A SOUTH AFRICAN OPEN PIT MINE

Introduction

This is a summary of a study which evaluates the difference in Initial and Maintenance costs (over a 15 year period) of two alternative systems for conveying material out of an open pit mine. It compares only the conveyors needed to lift material from pit bottom to it's lip.

SYSTEM 1

CONVENTIONAL conveyors, each of capacity 5 000 tph, Single flight length, 1 000 metres, lift 80 metres. 3 flights with total length of 3 000 metres for overall lift of 240 metres. Angle of lift 4,3 degrees.

SYSTEM 2

HIGH ANGLE conveyor, capacity 5 000 tph, Single flight length 391 metres, lift 240 metres, Angle of lift 53 degrees.

The conclusion reached is that the High Angle Conveyor is the most economical alternative. The cost per tonne of ore transported is 4 cents versus 6 cents for conventional conveyors. Truck haulage could, by comparison, cost 41 cents per tonne or more.

In this study certain design parameters are based on the requirements of the specific application. For example, the conventional conveyors would be routed along the existing truck haulage road thus obviating the need for extensive new earthworks and difficult access.

To avoid contentious debate on intangible benefits and for the sake of simplification, certain costs have not been included in either case. This approach has been followed when it was felt that the benefit so derived was clearly in favour of the conventional system. These items include:

Site preparation
Earthworks
Civils
Electrical Power and Controls
Lighting
Weather protection

A. CAPITAL COSTS

Capital costs were established by estimating each system in detail to an accuracy of +-10%.

These costs are summarised on Table A.

The High Angle Conveyor does not require a separate drive house as the drives are positioned in the head end structure.

	Capacity TPH	No. of Flights	Total Lift	Total kW Inst	Full Load kW	50% Load kW	No.Load kW	Head Sect Cost R000s	Lin.M. Costs R000s	Tail & TU Sect Cost R000s	Drive Hse Costs R000s	Total Installed Cost R000s
Conventional Conveyors 3 off each 1 000 m long 80 m lift 1800 mm wide 3,0 m/sec	5 000	3 @ 4,3°	240m	6 030	4 797	2 745	399	4 825	5 898	578	928	12 229
High Angle Conveyor 1 off 391 m long 240 m lift 2100 mm wide 3,48 m/sec	5 000	1 @ 53°	240m	4 800	4 292	2 404	520	3 549	3 833	1 134	–	8 516

TABLE A : BASIC PARAMETERS AND CAPITAL COST SUMMARY

B. MAINTENANCE COSTS

To establish a base for maintenance costs, the following must be assumed:

1. A single flight of 1000 metres of a conventional conveyor shall be assessed for maintenance on 1 shift on the 7th day of a 6 day working week. Therefore, the conventional conveyor systems shall have 3 maintenance crews for 1 shift on the 7th day of a 6 day working week.

2. Each belt of the High Angle Conveyor shall be assessed for maintenance for 1 shift on the 7th day of a 6 day working week. Therefore the High Angle Conveyor shall have two maintenance crews for 1 shift on the 7th day of a 6 day working week.

3. Running hours shall be 6 days a week, 24 hours per day, 309 days per year, making 7416 hours per year.

4. Each conveyor belt maintenance shift shall be serviced by one maintenance crew consisting of:

1 fitter	)each R95 per 8 hour shift,
1 boilermaker	)plus 12% escalation per year
1 electrician	)for inflation.
6 labourers	each R26 per 8 hour shift plus 12% escalation per year for inflation.

5. Each artisan and 2 labourers shall have separate transport facilities (bakkie). R10 per hour plus 12% escalation a year for inflation.

6. There shall be a standard charge per maintenance shift for consumables. This charge shall be increased by 20% per year to allow for escalation and increased usage.

7. Idler replacement shall be based on the following unit usage and subject to 12% per year escalation.

1st	10%
2nd year	5%
3rd year	7½%
4th year	7½%
Thereafter	10%

8. The following will be replaced at their time periods and are also subject to 12% per year increase in cost for escalation.

Belt scraper blades	: 1 set per scraper per year.
Skirt Rubber	: Complete replacement every 6 months
Chute Liners	: 1 set per chute per year
Wire ropes	: 1 set every 5 years
Sheaves	: Complete bearing replacement every five years.
Pulleys or bearings	: We shall allow 5% of the initial cost of these items to be reserved annually at 12% escalation.

9. <u>Belting:</u>

We shall allow for complete renewal in 5 years. Therefore $\frac{100}{5}$ reserved annually at 12% escalation for belting.

Table B.1 summarises maintenance costs over a 15 year period. It should be noted that the figures given allow for annual escalation of 12%.

Tables B.2, B.3 **and** B.4 analyse the maintenance costs in detail. Table B2 covers one conventional conveyor. Tables B3 and B4 cover the HAC bottom and top belts respectively.

INDICATION OF COSTS SUMMARY

MAINTENANCE COSTS OVER 15 YEARS

R x 1000

	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th year
Conventional Conveyors 3 off	878	941	1 079	1 210	1 386	1 243	1 393	1 563	1 753	1 966	1 810	2 031	2 280	2 560	2 875
High Angle Conveyor 1 off	403	424	500	561	648	616	691	776	870	977	962	1 080	1 213	1 363	1 531

TABLE B.1 : MAINTENANCE COSTS SUMMARY

MAINTENANCE COSTS PER SYSTEM

TYPE: CONVENTIONAL OVERLAND   TPH: 5 000   NO. OF BELTS: 1   WIDTH OF BELT: 1800   PULLEY CENTRES: 1000 m

1 x Maintenance Crew: 1 Fitter, 1 Boilermaker, 1 Electrician, 6 Labourers	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr
Total 1 shift R441	22 491	25 178	28 200	31 584	35 374	39 619	44 373	49 698
Transport: R10 ph 3 bakkies req.R240	12 240	13 708	15 353	17 195	19 259	21 571	24 159	27 058
Consumables:R60 shift	2 880	3 456	4 147	4 976	5 971	7 166	8 599	10 319
Idler Replacement: Rolls only,Initial cost R255 477	25 547	14 306	24 035	26 919	40 199	45 023	50 426	56 477
Belt Scraper Blades Initial Cost R950 x 2 = R1900	1 900	2 128	2 383	2 669	2 989	3 347	3 749	4 199
Skirt Rubber: Initial costs R415 x 2 = R830	830	929	1 041	1 166	1 306	1 462	1 638	1 834
Chute Liners: Initial costs R8000	8 000	8 960	10 035	11 239	12 588	14 098	15 790	17 685
Wire Ropes: Initial Cost R200	200	224	250	280	314	352	394	442
Sheaves: Initial Cost R150x8=R1200	1 200	1 344	1 505	1 685	1 888	2 144	2 368	2 652
Pulley & Bearings: Initial Cost	6 458	7 232	8 100	9 073	10 161	11 381	12 746	14 276
Belting: R1054848 1st 5 yr R1340255 2nd 5 yr R1702886 3rd 5 yr	210 969	236 285	264 640	296 397	331 964	268 051	300 217	336 243
Total per Year	292 715	313 750	359 689	403 184	462 013	414 214	464 459	520 883

1 x Maintenance Crew: 1 Fitter, 1 Boilermaker, 1 Electrician, 6 Labourers	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	15th yr
Total 1 shift R441	55 662	62 341	69 822	78 201	87 585	98 095	109 867
Transport: R10 ph 3 bakkies req.R240	30 305	33 942	38 015	42 577	47 686	53 409	59 818
Consumables:R60 shift	12 383	14 860	17 832	21 398	25 678	30 814	36 976
Idler Replacement: Rolls only,Initial cost R255 477	63 255	70 845	79 347	88 868	99 533	111 477	124 854
Belt Scraper Blades Initial Cost R950 x 2 = R1900	4 703	5 267	5 899	6 607	7 400	8 288	9 283
Skirt Rubber: Initial costs R415 x 2 = R830	2 055	2 301	2 577	2 887	3 233	3 621	4 056
Chute Liners: Initial costs R8000	19 807	22 184	24 846	27 828	31 167	34 907	39 096
Wire Ropes: Initial Cost R200	495	554	621	695	779	872	977
Sheaves: Initial Cost R150x8=R1200	2 971	3 327	3 727	4 174	4 675	5 236	5 864
Pulley & Bearings: Initial Cost	15 989	17 908	20 057	22 464	25 160	28 179	31 560
Belting: R1054848 1st 5 yr R1340255 2nd 5 yr R1702886 3rd 5 yr	376 592	421 783	340 577	381 446	427 220	478 486	535 905
Total per Year	584 217	655 312	603 320	677 145	760 116	853 384	958 256

TABLE B.2

C. OPERATING COSTS PER TONNE

		Conventional Conveyors	High Angle Conveyor
1.	Actual operating hours: 6 days at 24 hours per day, 309 days a year =	7 416 hrs per year	7 416 hrs per year
2.	Conveyors 1st year maintenance costs =	R878 145	R402 574
	Per hour =	R118,41	R54,28
3.	Full load power consumption @ R0,037 per kW/hr	4 797 kW R177,49	4 292 kW R158,80
4.	Total operating and running costs for 1 hour =	R295,90	R213,08
	Cost per tonne @ 5000 tph =	R0,06	R0,04

MAINTENANCE COSTS PER SYSTEM FEASABILITY ONLY

TYPE: TOP BELT HAC TPH: 5000 NO. OF BELTS 2 of 2 WIDTH OF BELT: 2 200 PULLEY CENTRES: 391 m

240 m Lift

	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	15th yr
1 x Maintenance Crew 1 Fitter 1 Boilermaker 1 Electrician 6 Labourers															
Total 1 shift=R441	22 491	25 178	28 200	31 584	35 374	39 619	44 373	49 698	55 662	62 341	69 822	78 201	87 585	98 095	109 867
Transport: R10 ph 3 bakkies req.R240	12 240	13 708	15 353	17 196	19 259	21 571	24 159	27 058	30 305	33 942	38 015	42 577	47 686	53 409	59 818
Consumables: R60 Shift	2 530	3 456	4 147	4 976	5 971	7 166	8 599	10 319	12 383	14 860	17 832	21 398	25 678	30 814	36 976
Idler Replacement Rolls only.Initial cost R301 293	30 129	16 872	28 345	31 747	47 409	53 098	59 469	66 606	74 593	83 550	93 577	104 806	117 383	131 468	147 245
Belt Scraper Blade Initial costs R950 x 2 = R1 900	1 900	2 128	2 383	2 669	2 989	3 347	3 749	4 199	4 703	5 267	5 899	6 607	7 400	8 288	9 283
Skirt Rubber : Initial costs R415 x 2 = R830	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chute Liners	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Wire Ropes : Initial Cost R200	200	224	250	280	314	352	394	442	495	554	621	695	779	872	977
Sheaves: Initial costs R150 x 8 = R1 200	1 200	1 344	1 505	1 685	1 888	2 144	2 368	2 652	2 971	3 327	3 727	4 174	4 675	5 236	5 864
Pulleys & Bearings Initial Costs	14 336	16 056	17 983	20 141	22 557	25 264	28 296	31 692	35 495	39 754	44 525	49 868	55 852	62 555	70 061
Belting: R 453792 1st 5 yr R 607440 2nd 5 yr R 771792 3rd 5 yr	90 758	101 648	122 995	137 754	154 285	121 468	136 066	152 394	170 681	191 163	154 358	172 881	193 627	153 695	242 885
Total per Year	176 134	180 614	221 161	248 032	290 046	274 049	307 473	345 050	387 288	434 758	428 376	481 207	540 665	607 599	682 976

TABLE B.4

MAINTENANCE COSTS PER SYSTEM

FEASABILITY ONLY

TYPE: BOTTOM BELT HAC   TPH: 5 000   NO. OF BELTS: 1 of 2   PULLEY CENTRES: 391 M   240 M LIFT

	1st yr	2nd yr	3rd yr	4th yr	5th yr	6th yr	7th yr	8th yr	9th yr	10th yr	11th yr	12th yr	13th yr	14th yr	15th yr
1 x Maintenance Crew 1 Fitter 1 Boilermaker 1 Electrician 6 Labourers															
Total 1 shift = R441	22 491	25 178	23 200	31 584	35 374	39 619	44 373	49 698	55 662	62 341	69 822	78 201	87 585	98 095	109 867
Transport:R10 hr 3 bakkies req. = R240	12 240	13 708	15 353	17 195	19 259	21 571	24 159	27 058	30 305	33 942	38 015	42 577	47 686	53 409	59 818
Consumables: R60 shift	2 880	3 456	4 147	4 976	5 971	7 166	8 599	10 319	12 383	14 860	17 832	21 398	25 678	30 814	36 976
Idler replacement Rolls only. Initial cost= R185 304	18 530	10 377	17 433	19 525	29 157	32 656	36 575	40 964	45 880	51 386	57 552	64 458	72 193	80 857	90 560
Belt Scraper Blades Initial Cost R950 x 2 = R1900	1 900	2 128	2 383	2 669	2 989	3 347	3 749	4 199	4 703	5 267	5 899	6 607	7 400	8 288	9 283
Skirt Rubber : Initial Cost R415 x 2 = R830	830	929	1 041	1 166	1 306	1 462	1 638	1 834	2 055	2 301	2 577	2 887	3 233	3 621	4 056
Chute Liners: Initial cost R8000	8 000	8 961	10 035	11 239	12 588	14 098	15 790	17 685	19 807	22 184	24 846	27 828	31 167	34 907	39 096
Wire Ropes: Initial Cost R200	200	224	250	280	314	352	394	442	495	554	621	695	779	872	977
Sheaves: Initial cost R150 x 8 = R1200	1 200	1 344	1 505	1 685	1 888	2 144	2 368	2 652	2 971	3 327	3 727	4 174	4 675	5 236	5 864
Pulley & Bearings Initial cost	38 390	42 996	48 156	53 935	60 407	67 656	75 775	84 868	95 052	106 458	119 233	133 541	149 566	167 514	187 616
Belting:R598896 1st 5 yrs, R760937 2nd 5 yrs R966823 3rd 5 yrs	119 779	134 152	150 251	168 281	188 474	152 187	170 450	190 904	213 812	239 470	193 364	216 568	242 556	271 663	304 262
Total per Year	226 440	243 453	278 754	312 536	357 727	342 258	383 870	430 623	483 125	542 390	533 488	598 934	672 518	755 276	848 375

TABLE B.3

D. OFF HIGHWAY HAULAGE VEHICLES

For order of magnitude comparison purposes, a brief look at the haulage truck alternative is given.

Assume plus/minus 160 tonne capacity Diesel Electric Drive Trucks are used and that these are fitted with trolley assists to utilise external electric power for haulage on the incline section of the loaded trip.

The electrical rating of each truck is plus/minus 1193 kW and when using electrical assist the diesel consumption of the idling diesel engine at 21 km/hour on a 8% grade is 8 litres.

There are many costs in truck haulage that must be considered and to be accurate a proper analysis is necessary. Discussion with users has indicated that normal daily maintenance and running costs are in the area of R0,41 to R0,46 per tonne hauled on the incline section of their route. It should be stressed however that no claim is made that these figures are any more than indicative.

To road haul 5000 tph of ore in the case examined, an actual operating fleet of 15 trucks is required. This does not include any standby vehicles.

The purchase price for each 160 tonne capacity truck is plus R2 million each.

The comparison of capital and maintenance costs with conveyors, leads one to suspect that conveying up the inclined section of an open pit mine warrants careful consideration.