CABLE BELT PVL CONVEYOR

TECHNOLOGY ON THE MOVE

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Summary:

This paper sets out to explain the concept of the **CABLE BELT** conveyor and the developments that have been undertaken to improve the design, operation and maintenance of the system. These developments have included increasing the carrying capacity of the belt and the creation of the **TRITON** cable. The **TRITON** cable reduced the operational costs for the conveyor, significantly reduced noise levels and preceded the development of the Horizontal Curving Unit improved the ability of the conveyor to follow the terrain and blend into the existing environment, with minimal disturbance.

The distinctive features of some **CABLE BELT** installations highlight the benefits that a **PVL/TRITON** conveyor can offer today's bulk material handling and transportation industry.

1. Introduction

Over the past 45 years Cable Belt have installed 195 conveyors in 21 countries. The total length of these installations is 579 km, an average of over 12 km of **CABLE BELT** conveyors have been installed each year. During the next 12 months Cable Belt will be installing an additional 24 km of conveying systems.

Conveyors installed to date range in:

(i) length from 0,75 km to 30 km (in a single flight);
(ii) capacity from 500 mtph to 2500 mtph;
(iii) operating speed from 1,35 m/s to 7,6 m/s.

Developments have been undertaken to produce the **PVL/TRITON** conveyor system which:

a) improves the load carrying ability of the belt;
b) allows tighter horizontal curve radii to be used;
c) reduces O & M costs;
d) provides a conveying system which blends into the environment.

2. Concept

The concept of the **CABLE BELT** design is unique and proven in the field of bulk material handling.

When handling bulk materials the majority of conveyors use troughing belts and roller idlers. The belt on these systems functions as the driving medium and it also carries the material load.

On the **CABLE BELT** conveyor these two functions are separated, the belt supports and carries the load with the driving force provided by the cables.

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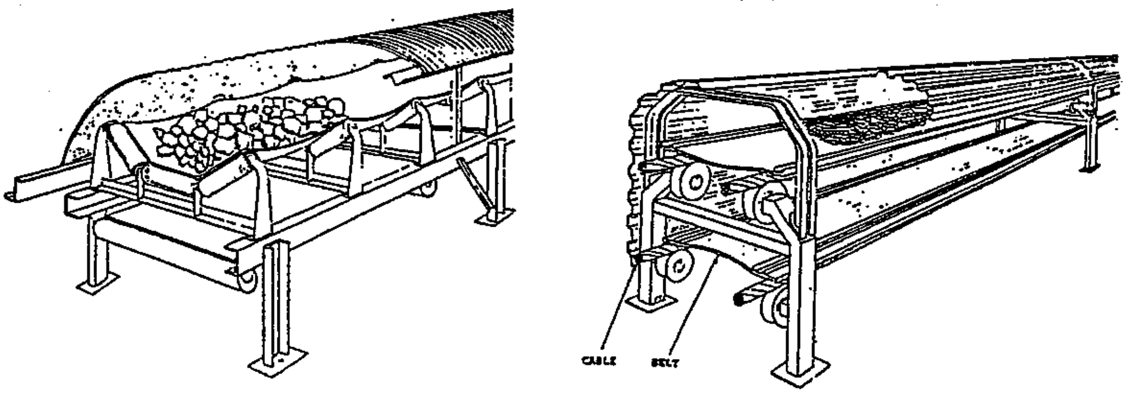
On the top line the belt is supported via shoeforms, set slightly inboard of the belt edge and on the return line by similar shoeforms on the reverse side. (see Sketch 2).

Sketch 1 shows pictorially the basic difference between a troughing idler conveyor and a **CABLE BELT** conveyor.



TROUGHING BELT/IDLER CONVEYOR

CABLE BELT CONVEYOR

Sketch 1: Troughing Idler Conveyor V CABLE BELT Conveyor

The **CABLE BELT** design has several benefits:

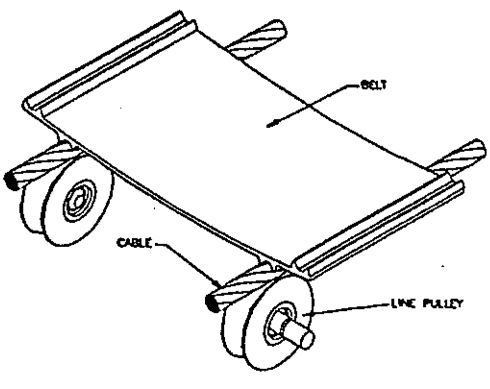
a) The belt has no significant longitudinal tensions and is only reinforced to support the load, the belt therefore has a comparatively low weight.

b) It provides a smooth, positively tracked arrangement with less rotating components (along the line) than a troughed belt system.

c) The material on the belt is not shaped or moulded by the belt and, therefore, has an angle of surcharge very close to its static angle of repose.

d) The cables provide all the driving forces and are positively located in the line pulleys.

e) Around horizontal curves the location of the belt on the cables maintains the positive tracking along the alignment. (See Sketch 2).



Sketch 2: Positive tracking, belt located on cables and cables on pulleys.

3. Belt Improvements

Flat Belt

For the first 30-35 years Cable Belt produced a flat belt which operated successfully allowing the material to rest naturally on the belt on its travel along the conveyor.

It was found, however, that with the inevitable intermittent and fluctuating loads that occur (due to a variety of site/operational factors) at reduced capacities, the flat belt allowed the material to 'wander' on some systems.

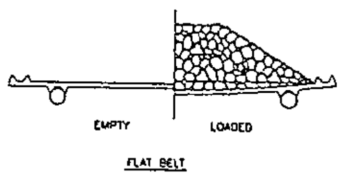
When loaded the belt deflects and this deflection is carefully assessed in the design of the belt.

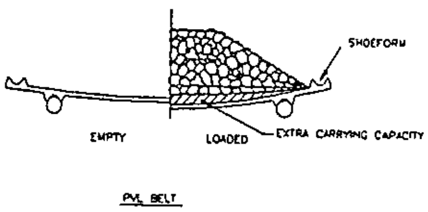
Under reduced loadings (approx. 10-20% design load) the deflection is significantly reduced and the belt remains relatively flat, due to its lateral stiffness. At these low capacities any vibration allow the material to migrate to the edges of the belt. The outer shoeforms assist in preventing spillage.

To counteract the migration of material at these low tonnages the **PVL** belt was designed.

PVL Belt

The Preformed (for) Variable Loading (**PVL**) Belt is not flat but has a 6° trough preformed during manufacture. This pre-forming centralises the load, particularly at low operational tonnages and increases the load carrying capacity. (See Sketch 3).





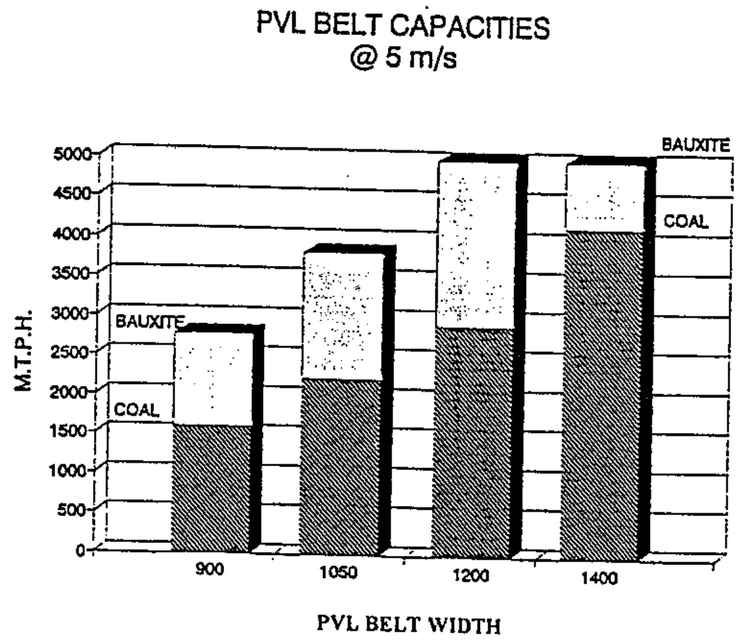
Sketch 3: Comparison of flat & PVL/TRITON belt capacities

Standard belt widths are now adopted on **PVL/TRITON** systems, and these are 900, 1050, 1200 and 1400.

Belt Capacity

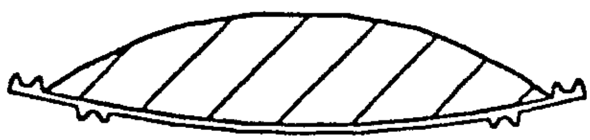
The **PVL** belt is unique in its ability to carry large volumes of material along undulating alignments and around horizontal curves, at faster speeds than an equivalent troughing idler conveyors.

The smooth operation and simple line supports on the **CABLE BELT** conveyor allow large capacities of material to be transported on relatively narrow belt widths.



Graph 1 shows the maximum belt capacities for the four standard **PVL** belt widths carrying coal and bauxite at 5 m/s. For denser materials greater capacities can be carried.

A typical cross section of the material on a **PVL** belt is shown in Sketch 4. Note in the capacity calculation, no account is taken of the edge support afforded by the upper shoeforms which would further increase the volume carried.



Sketch 4: Cross Section through 1050 PVL Belt Carrying Coal at 2000 mtph at 5 m/s (Coal Density 880 kg/m³)

The **PVL** belt can be (and has been) installed on existing systems.

4. Cable Improvements

Steel Cable

The 'traditional' **CABLE BELT** conveyor used 'standard' langs lay steel cables which supported the belt and provided the conveyor driving medium. In turn the steel cables were supported on polyurethane lined pulleys.

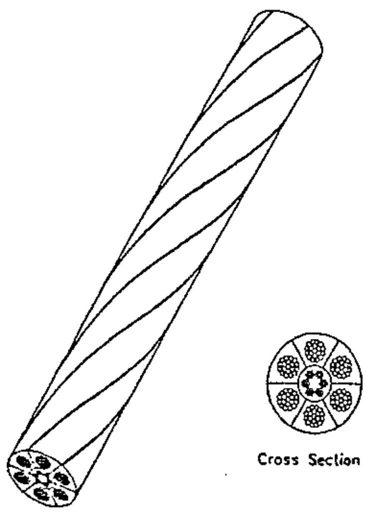
The performance or life of the cable was basically influenced by the maintenance of the polyurethane line pulleys, terminal pulleys and the life of the cable splices.

Polyurethane line pulleys (or polypulleys) were developed to provide a 'softer' support to the steel cables and reduce cable wear. With this in mind the **TRITON** cable was developed over a period of some 10 years.

TRITON Cable

The **TRITON** cable (as it is known) is a steel cable covered with an engineering thermoplastic elastomer. Each of the six strands of the steel cable is covered in a thick coating of plastic before closing. The 'jacket' of plastic effectively separates the strands. This design:

a) prevents internal friction;
b) protects the strands from the environment;
c) provides a smooth surface, considerably reducing noise levels;
d) reduces splice maintenance with no increase in diameter at the splices.



Sketch 5: TRITON cable

The performance characteristics of the elastomer are:

(i) tough and resilient;
(ii) high resistance to abrasion, creep, impact and fatigue;
(iii) low temperature flexibility at high temperatures and property retention;
(v) unaffected by moisture and resistant to many industrial oils, chemicals and solvents.

Extensive testing of the **TRITON** cable was carried out and the results were far better than the equivalent steel cable under the same test conditions.

For example on the three pulley fatigue rig test (carried out at Bochum) the **TRITON** cable exceeded the cycle life of the equivalent steel cable by a factor in excess of 3.

A standard range of cables have been designed with diameters from 34mm to 75mm.

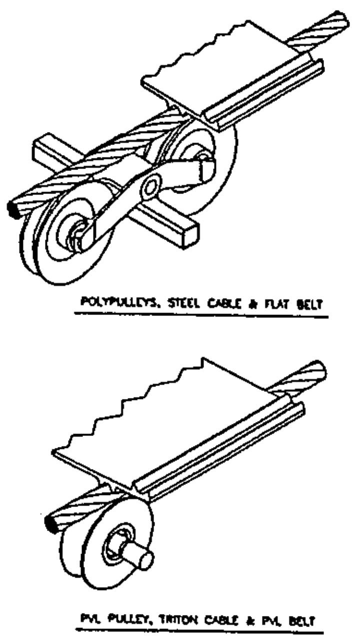
One major advantage of the **TRITON** cable is that it allows the use of steel line pulleys.

5. Line Pulley Development

With the steel cable system the size and design of the polypulley developed over 20-30 years was based on load and wear characteristics of the polyurethane requiring the use of twin polypulley assemblies.

These were (and still are in some cases) a maintenance headache requiring replacement on a regular basis. With the covered **TRITON** cable now providing the cushioning and wear components a steel line pulley was developed.

The steel line pulley has been designed to carry more load and only one pulley is used in place of the twin polypulleys. (See Sketch 6).



Sketch 6: Line support changes

The smooth **TRITON** cable with the single steel pulley significantly reduces noise along the line. In addition, the steel pulleys last 3 times longer than the equivalent twin polypulleys, thereby significantly reducing line maintenance.

Further developments and trials have now taken place with a solid polymer replacing steel in the line pulley.

The design of the line pulley has been standardised with a unique profile design to accommodate the range of cable diameters.

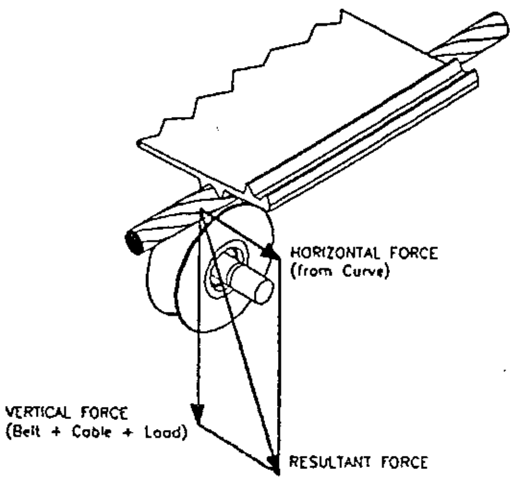
6. Horizontal Curving Unit (HCU)

Linestand Pulley Loading

On a straight section of a **CABLE BELT** conveyor the linestand pulley loading from the cable weight, belt weight and material being conveyed, is vertical.

When a plan curve exists, however, the pulley is subjected to a horizontal loading in addition to the vertical loads. The horizontal force is generated from the drive cable tension and the angle of deviation of the cable as it passes over the pulley. However, with no significant tensions in the belt (due to Cable Belt's unique design) curving around small radii was considered to be realistic.

The plan angle is proportional to the horizontal radius of the conveyor and the linestand pitch. By resolution the combined effect of the two forces is a resultant force acting on the pulley at an angle determined by the relative magnitudes of the vertical and horizontal components. (See Sketch 7).



Sketch 7: Forces on line pulley around horizontal curves

The vertical and horizontal forces are not constant and vary with the conveyor load states. The drive cable tension at any point is determined by its position on the conveyor route and can fluctuate over a wide range dependent upon the loaded condition of the conveyor.

There is, of course, a further force acting on the pulley in the line of the conveyor but this does not significantly affect the transverse forces.

The **CABLE BELT** design assesses in detail the effect of linestand pulley pitch on vertical loading and allows some tolerance on positional accuracy. These tolerances recognise the practical limits of installation.

It is acknowledged in all types of conveyor design, that an accurate installed conveyor alignment gives better performance and reduces maintenance.

Horizontal Curving Unit Design

The development of the **TRITON** cable and the single line pulley made the provision of lateral restraint to the cable around horizontal curves practical.

The solid line pulleys can be tilted on horizontal curved sections of the conveyor to provide the necessary restraint to the resultant loads. This was not practical with polypulleys due to their rate of wear.

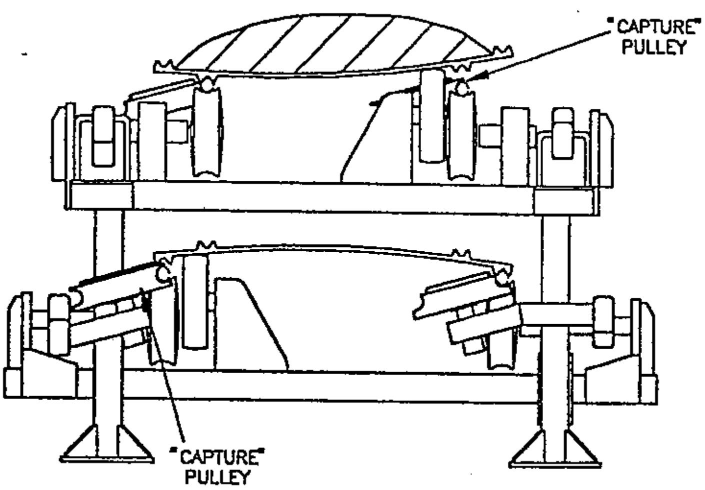
Belt Curying Horizontal Plan

With no significant tensions in the belt (due to Cable Belt's unique design) curving around small radii was considered to be achievable, however, extensive tests were carried out in our factory at various temperatures. The major concern investigated being the effect of the relatively tight radius on the belt. The tests proved that the belt could comfortably 'bend' around a 270m plan radius, at -40°C and 170m radius, at normal temperature.

Alignment Control

It became obvious during the trials that whilst the principal of providing tilted pulleys was sound, practical and safe designs had to be adopted to cater for all anticipated operational occurrences. It was therefore decided that along a horizontal curve, at each linestand, one cable was to be fully 'captured' by a tilted pulley. This meant that the belt had to be lifted clear of the cable over a discrete distance local to the captured pulley.

This is illustrated on the detail of the HCU shown in Sketch 8. Each drive cable is 'captured' alternatively from linestand to linestand.



Sketch 8: Horizontal Curving Unit Typical Section

The HCU allows much tighter curves to be negotiated along routes and effectively improves the viability of the **CABLE BELT** conveyor to meet any environmental constraints.

All the accepted principles of the **CABLE BELT** design are maintained in this HCU. (Previous to this design only a 1500m horizontal radius had been achieved on a **PVL/TRITON CABLE BELT** installation).

7. PVL/TRITON Installations

To date three conveyors have been installed with **PVL** belt and **TRITON** cable. These are shown in Table 1.

TABLE 1
PVL/TRITON INSTALLATIONS

OPERATING

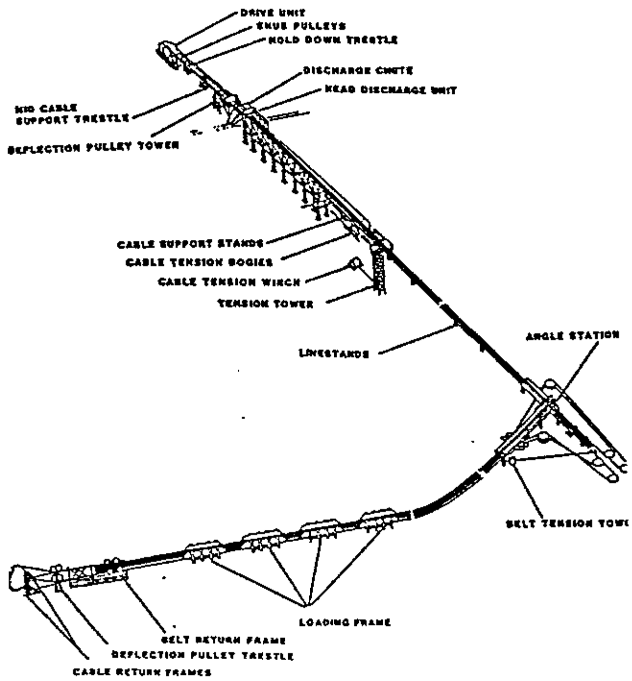
LOCATION	YEAR INSTALL	LENGTH KM	CAPACITY MTPH	MATERIAL CARRIED
CANADA	1989	1,20	900	NICKEL ORE
JAMAICA	1990	5,20	1,000	BAUXITE
USA	1991	6,40	660	COAL

UNDER DESIGN/MANUFACTURE

LOCATION	PLANNED INSTALL	LENGTH KM	CAPACITY MTPH	MATERIAL CARRIED
BOTSWANA	1996	3,3	350	COPPER/NICKEL ORE
PHILIPPINES	1996	6,5	1,000	LIMESTONE
CANADA	1996	10,5	1,070	COAL

Customer experiences on these installations have been very favourable acknowledging the improvements afforded by the **PVL/TRITON** system.

One significant benefit of the system has been the reduction in line noise. With the reduced number of line components and the smooth covered cable the measured reduction in noise level has been recorded at 23dB, a significant improvement benefiting the environment.



Sketch 9: Two flight single drive CABLE BELT conveyor

8. Distinctive Features

Cable Belt is able to offer several distinctive and unique features in conveying which can make the transportation of material cheaper, efficient or more practical than other methods.

Some of these features are:

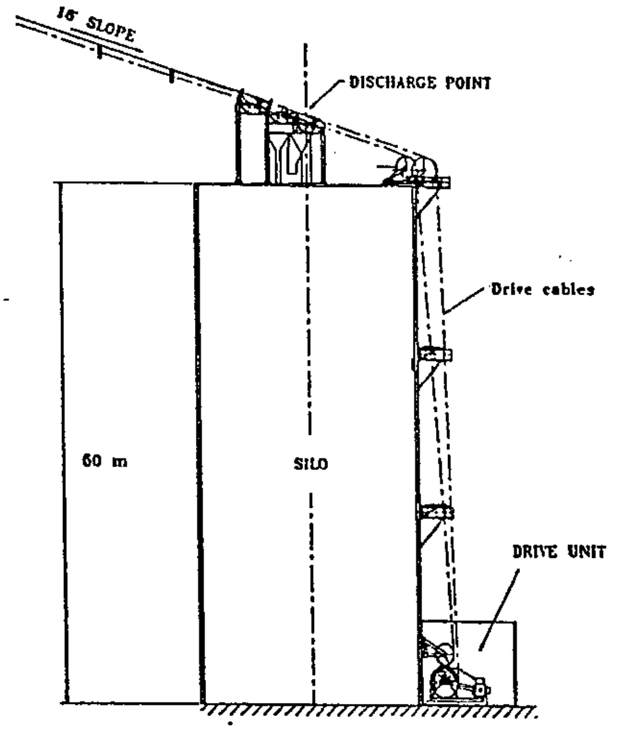
a) Single Drive Location on Two Flight Belt

At Middelburg Mine, the **CABLE BELT** conveyor transports coal around an 80° angle with a single drive unit, located at discharge. (See Sketch 9). This conveyor has a horizontal curve of 3460m radius.

In Jamaica, Cable Belt have a **PVL** conveyor transporting bauxite around a 90° angle with a single drive unit located at the Angle Station.

b) Remote Drive Location

In some cases the location of the drive at the discharge point may be too expensive or impractical. On a **CABLE BELT** conveyor the drive is separated from the discharging belt and can be located in a preferable location. (See Sketch 10).



Sketch 10: Drive remote from discharge on PVL conveyor

c) Fast Speed

To be economical some conveyors need to be run at fast speeds to reduce tensions and belt widths. With the **CABLE BELT** conveyor's positive tracking this can be an attractive and reliable solution. Cable Belt's fastest conveyor operates at 7,6 m/s bringing coal up a drift, in Selby, UK.

Note: Cable Belt's longest conveyor system is 51 km long (two flights) and operates at 6,1 m/s.

d) 18° Inclines

As the material is undisturbed by the smooth carrying and positive tracking aspects of the **CABLE BELT** design, transportation up 18° inclines has been achieved in many installations. Currently Cable Belt are designing a system with a World Record lift of 1020m over 3300m, **all at 18°.**

Inclines up to 29° have also been achieved by a **CABLE BELT** conveyor with the addition of chevrons to the top cover.

e) Reliability and Durability

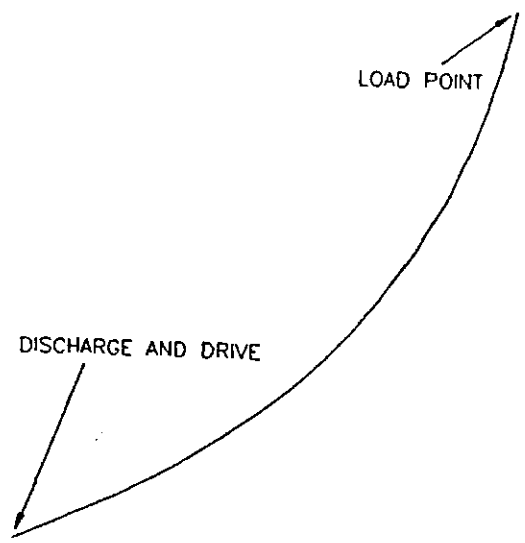
This particular aspect is exemplified in South Africa by the **CABLE BELT** conveyor at Doornfontein Gold Mine which has been running for 42 years. This is the oldest **CABLE BELT** conveyor system in the world.

f) Horizontal Curves

Since the early 1980's Cable Belt have installed 8 km of curved conveyors every year. Some of these installations highlight the ability of the **CABLE BELT** conveyor to blend into the terrain or avoid obstacles.

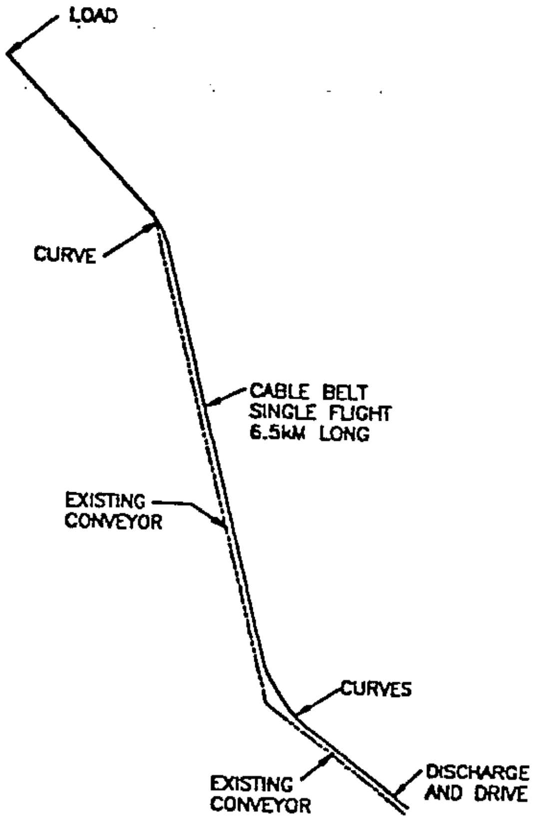
At Falkirk, USA, we have one of our most curved conveyors and this is shown in Sketch 11.

75% of the route is curved.



Sketch 11: Most curved CABLE BELT conveyor

Our current design in the Philippines is very distinctive running parallel to two existing conventional conveyors and extending to a new load point. Three horizontal curves are used to avoid transfer points with radii of 500m and 400m. The **CABLE BELT** conveyor effectively achieves in one flight what would typically require 3 flights, and two transfer points. (See Sketch 12).



Sketch 12: Plan: Three flights to one

All these distinctive features of the **CABLE BELT** conveyor system are tabulated in Appendix A.

9. CONCLUSIONS

Cable Belt's commitment to development is ongoing, responding to the needs of our existing customers with improvements to our polypulley/steel cable systems and looking at the requirements specified by our future customers.

Cable Belt's **TRITON/PVL** conveyor provides a system which

a) is low in maintenance;

b) blends into the surrounding environment;

c) has horizontal curve radii as small as 270m, closely following the existing topography;

d) can offer a material transportation system where other alternatives may not be viable, economic or environmentally acceptable.

APPENDIX A

DISTINCTIVE CABLE BELT CONVEYORS

LOCATION	LENGTH (m)	LIFT/FALL (m)	SPEED (m/s)	CAPACITY (mtph)	FEATURE
Doornfontein Gold Mine, South Africa	1216	-12	1,35	355	Oldest CABLE BELT conveyor in the world - 42 years old.
Buchwa Iron Mining Company, Zimbabwe	6003	-544	2,50	500	With a maximum fall of 576m along its length, Cable Belt's largest fall conveyor in the world. 18° Decline slopes along route.
Longannet Power Station, Scotland	8851	326	3,80	731	World's longest underground single drive conveyor. Installed in 1968. (World record in 1968).
American Commercial Terminals, U.S.A.	14593	9	4,00	1361	World's longest single drive overland conveyor. Installed in 1970. (World record in 1970).
Algoma, Canada	4614	741	3,50	800	World's biggest lift conveyor. Installed in 1975.
Selby, England	9500	630	7,60	2300	Designed for 14900 metres long , incorporating a lift of 990m. Fastest CABLE BELT conveyor operating in the world today. Largest CABLE BELT conveyor Drive Unit at 8750 kW.
Worsley Alumina, Australia	30441 20712	-72 -14	6,10 6,10	2300 2300	Largest single drive conveyor system in the world. Installed in 1982. Current world record.
Z.C.C.M., Zambia	11385	-39	3,50	850	Longest CABLE BELT conveyor in Africa, incorporating horizontal curves. Installed in 1983.
Middelburg Mine, South Africa	7321	58	3,00	1400	Longest CABLE BELT conveyor in South Africa, incorporating an Angle Station and a horizontal curve. Installed in 1983.
Nalco, India	14550	-340	4,70	1800	Longest CABLE BELT conveyor in Asia. Incorporates 11 horizontal curves. Installed in 1985.
Dead Sea Works, Israel	18113	773	4,60	800	Longest CABLE BELT conveyor in the Middle East. Incorporates 11 horizontal curves. Installed in 1986.
Bauxiven, Venezuela	4232	-535	4,00	1600	Largest regenerative drive CABLE BELT conveyor in the world at 2500 kW. Installed in 1989.
Alcan, Jamaica	5185	-34	3,30	1000	First PVL CABLE BELT conveyor system. Installed in 1991.
Falkirk Mine, U.S.A.	6183	12	4,75	1633	20 Horizontal curves along its route.
Selebi-Phikwe, Botswana	3300	1020	2,75	350	Third PVL CABLE BELT conveyor system . 18° Drift slope. Current world record lift of 1020m.
Line Creek, Canada	10510	-291	4,80	1070	Sixth PVL CABLE BELT conveyor system. Follows existing haulage road. Minimum horizontal radius of 430m.