MIDDELBURG MINE SERVICES
CRU II OVERLAND CONVEYOR SYSTEM

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INTRODUCTION

Middelburg Mine Services required a belt conveyor transport system to take 1 800 tons per hour of coal a distance of almost 13 km. The coal is fed onto the 3 conveyor system by a truck tip, crushing and silo storage installation at Klipfontein. The conveyor system discharges onto longitudinal stacker reclaimer stockpile located adjacent to the washing plant.

The conveyor system has run most successfully transporting in twelve months up to April 2001 almost 9 000 000 tons. This is above the original project requirements. The best 24 hours throughput was 42 299 tons and best months throughput was 958 215 tons.

This paper serves to describe the installation and aspects of the design except for the detailed dynamic analysis.

PLAN ON CONVEYOR ROUTE

CONVEYOR K1

General

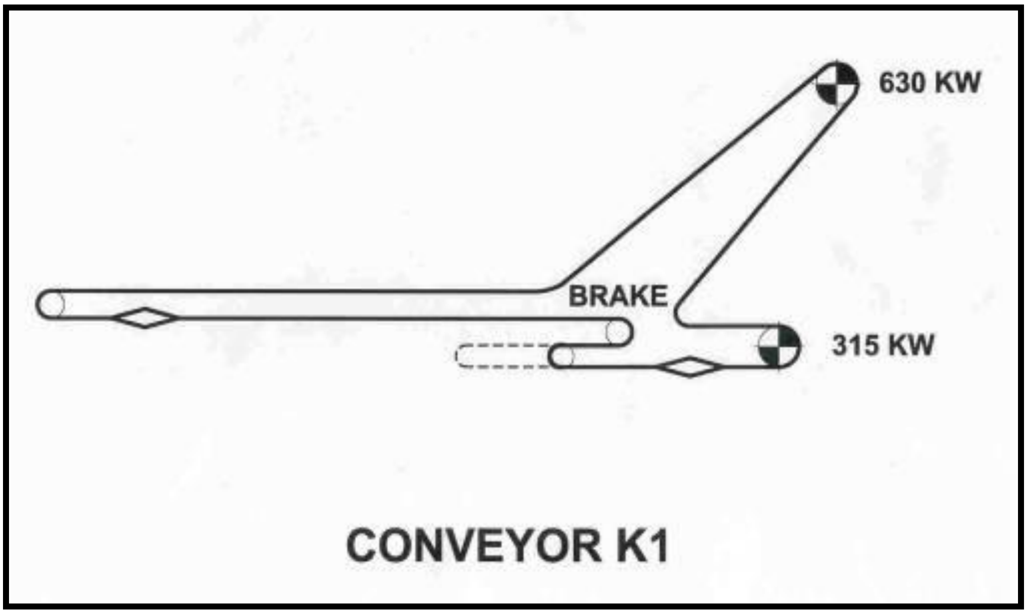
The first of the 3 conveyor system, conveyor K1 receives a controlled discharge rate from a silo complex. The discharge rate, 1 800 tph is provided by vibrating feeders controlled by a belt weigher. The material is sized and tramp metal is removed by an overband magnet.

The feed rate to K1 was initially very erratic with peaks well in excess of the rated 1 800 tph, the failure of part of the crushing circuit also resulted in a period of oversize lumps.

K1 used a conveyor structure, idlers and belt previously installed at Rand Mines Majuba. The belt class, belt width, structure and idlers were all over sized for K1. This conveyor as a result was not affected by overloading or by large lumps.

Data

MAJUBA ORIGINAL		CRU II K1
1 200	Belt width (mm)	1 200
4.75	Belt speed (m/sec)	5.0
6 000	Conveyor length (m)	3 068
2 281	Capacity (tph)	1 800
1.5	Carry idler pitch	3.0
4.5	Return idler pitch	4.5
Yes	Horizontal curve	No
No	Belt turn over	Yes
DC drive	Soft start	Drain Coupling
Coal	Material	Coal
1 600	Drive (kw)	1 x 630; 1 x 315
62	Lift (m)	5.5
No	Brake	Yes
-300	Lump size (mm)	-100
ST 2250	Belt Class	ST 2250



Route selection

K1 route is straight and the ground profile is reasonably flat. The original head end position was revised, increasing the lift slightly and resulted in the original design for 1 x 630 kw drive being revised to 1 x 630 kw plus 1 x 315 kw. This added secondary drive, while not the optimum technical solution maintained the standard of only 2 drive unit sizes for the total conveyor system.

Re-use of an old conveyor

The Client had access to a dismantled conveyor from Majuba mine. This conveyor had seen some service but the belting and structure were in superb condition. The idlers proved to be in only reasonable condition, suffering no doubt from long storage in less than ideal circumstances.

The Majuba conveyor supplied by Bateman in 1990 was a design using technology based on the early understanding of belt conveyor dynamics. A brake was fitted to the take up assembly to cope with the expected dynamic wave, rather than to design it out. This did however work well but the effect on the take up was overestimated. Also of interest this conveyor, 6 km long with a horizontal curve had a single variable speed DC drive of 1 600 kw.

The belt class of the old belt was well in excess of what was required for K1, the structure was easily adapted to a wide pitch idler (by double spacing). The structure and sheeting, galvanised originally, was revised with a new head and tail end.

The idlers however were less than perfect with a higher than normal failure rate. With a large pool of available surplus used idler rolls the high failure rate was considered and accepted as a possibility at the concept stage.

New pulleys and drives were used, the resulting installation is capable of tonnages well in excess of the rated 1 800 tph and any overloading or large oversize material has no significant effect on K1.

Belt turnover

K1 was equipped, as were conveyors K2 and K3, with a belt turnover system using flat full belt width pulleys located at horizontal, 45 degree and vertical positions. This type of turn over is simple, easy to set up, maintain and operate.

The client favoured the use of palisade fencing with locked gates as a guarding system around the turnovers and take-ups. This allows wash down from outside, good visibility of components and easy access. This method of safety enclosure has significant merits.

Drive K1

The drive system consists of 1 x 630 kw on the primary pulley and 1 x 315 kw on the secondary pulley. The use of 1 x 630 kw primary would have resulted in a marginally underpowered conveyor : the use of only two drive sizes for all the conveyors dictated the drive configuration, for example 2 x 350 kw on the primary would have been economical but non standard.

K1 has 2 drive sizes 630 kw and 315 kw with different size gearboxes. Both drives are fitted with drain couplings to :

- Give a "soft" start.
- Load share during starting.
- Load share during running.

A variable valve controls the rate of fill of each coupling. The response time of this valve from open to close is about 8 seconds and the response tends to allow some oscillations during start up probably due to overcompensation.

However the starting control works acceptably well under all load conditions with a torque control of about 130% of motor nameplate. Load sharing at start up is only important at full load and this is achieved with less accurate sharing at low loads.

The reliability of the equipment, with pump motor failures (including K3) and oil leaks, has been disappointing. Noise is also (from the pump) above the level of all other adjacent equipment.

Power Consumption

K1 Running : Test Results

CAPACITY	AT MOTOR
1 400 tph	525 kw
1 800 tph	600 kw
1 900 tph	625 kw
1 950 tph	650 kw
2 250 tph	740 kw

Installed is 945 kw. The conveyor is designed for 1 800 tph.

CONVEYOR K2

General

The second of the 3 conveyors in the system is conveyor K2. It receives discharge from K1 conveyor almost at right angles and being the base conveyor of a very wide flat 'U' shaped, 3 conveyor system it also discharges almost at right angles onto conveyor K3.

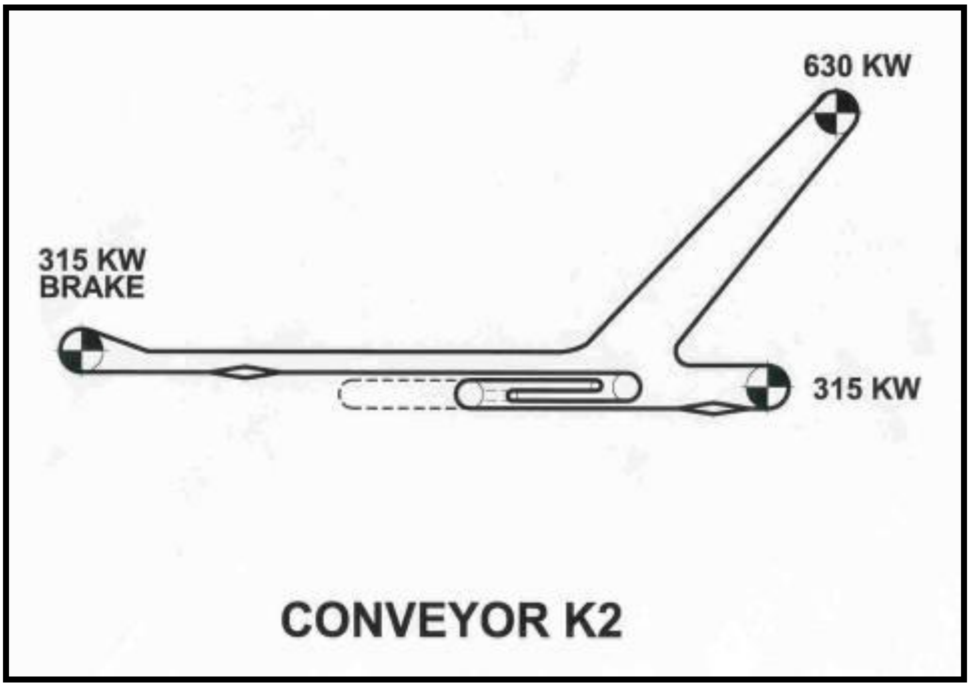
Data

CONVEYOR K2	
Belt width (mm)	1 050
Belt speed (m/sec)	5.0
Conveyor length (m)	8 883
Capacity (tph)	1 800
Carry idler pitch (max)	4.5
Return idler pitch (max)	9.0
Belt turn over	Yes
Horizontal curves	2
Horizontal curves radius (m)	2 500
Primary head drive (kw)	630
Secondary head drive (kw)	315
Tail drive (kw)	315
Soft start	VFD
Material	Coal
Lump size	- 100 mm
Lift	See x Section
Brake	At tail
Belt class	ST 1100
Belt safety factor	5.0 running

CDI Calculations K2

CDI analysed the conveyors and provide the basic design inputs. K2 conveyor, by far the most complex required the major attention from CDI.

Costs are reduced, both on capital and operations by good up to date design. Low belt safety factors reduce capital and replacement costs. Lower belt class reduces belt weight and thus power consumption and component life. Wider idler pitch reduces structural costs, improves the sharing of load on idlers. Above all the controlled starting and stopping avoids dynamic problems, provides less variations in belt tensions and better behavior on curves.



Power Consumption K2

K2 Running : Test Results

CAPACITY	*AT MOTOR*
Nil tph	400 kw
1 400 tph	675 kw
1 800 tph	820 kw
1 950 tph	850 kw

Installed is 1 260 kw.

The conveyor is designed for 1 800 tph.

Belt Safety Factors K2 : Calculated

	SAFETY FACTOR
Running	5.0
Start up	4.6
Edge safety factor	4.09

Starting time K2

Zero to 100% torque on drives, 300 seconds.

Stopping time K2

20 to 42 seconds, including PLC fault condition.

Brake is spring applied, hydraulically released, located at the tail drive. K2 is not ramped down on stopping as this will require a long stopping time, but the drives are switched off and the brake applied, K2 has small flywheels on the head end drives to regulate the carry side tensions during stopping.

Take up K2

The horizontal gravity take up is located after the secondary drive at the head end. The belt tension at this point is 80 kN.

Start up K2

The three drives are equipped with variable frequency controllers. The control is in 3 steps :

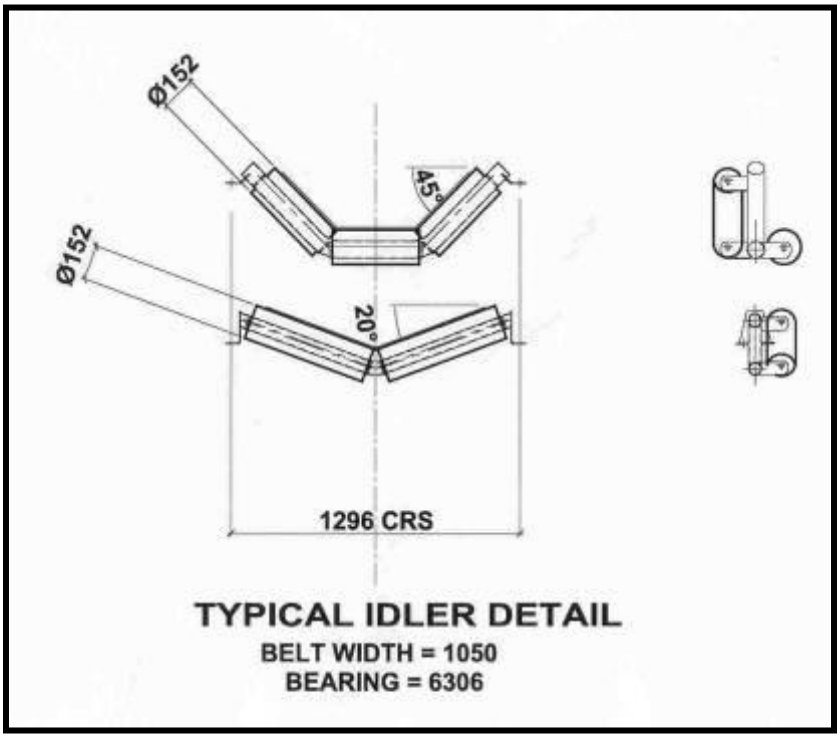
- Linear acceleration - Step I
- Constant velocity - Step II
- S curve acceleration - Step III

The tail drive is started about 20 seconds after the head drive, to allow the head drive to pretension the carry side and prevent the tail drive slipping at start up.

The start is extremely smooth.

Idler pitch K2

	CARRY	RETURN
Straight sections	4.5 m	9.0 m
Curved sections	2.25 m	4.5 m



Route selection K2

The K2 route is difficult, it includes two horizontal curves, 2 500 mm radius each, both on downhill sections of the route, 20 concave curves and 17 convex curves. The conveyor passes under 2 major roads via concrete culverts, the Bethal Road and a major mine haul road. There are minor stream crossings and a section of flood area. At the lowest point, the haul road tunnel, the conveyor is 1 m above the 50 year flood plain.

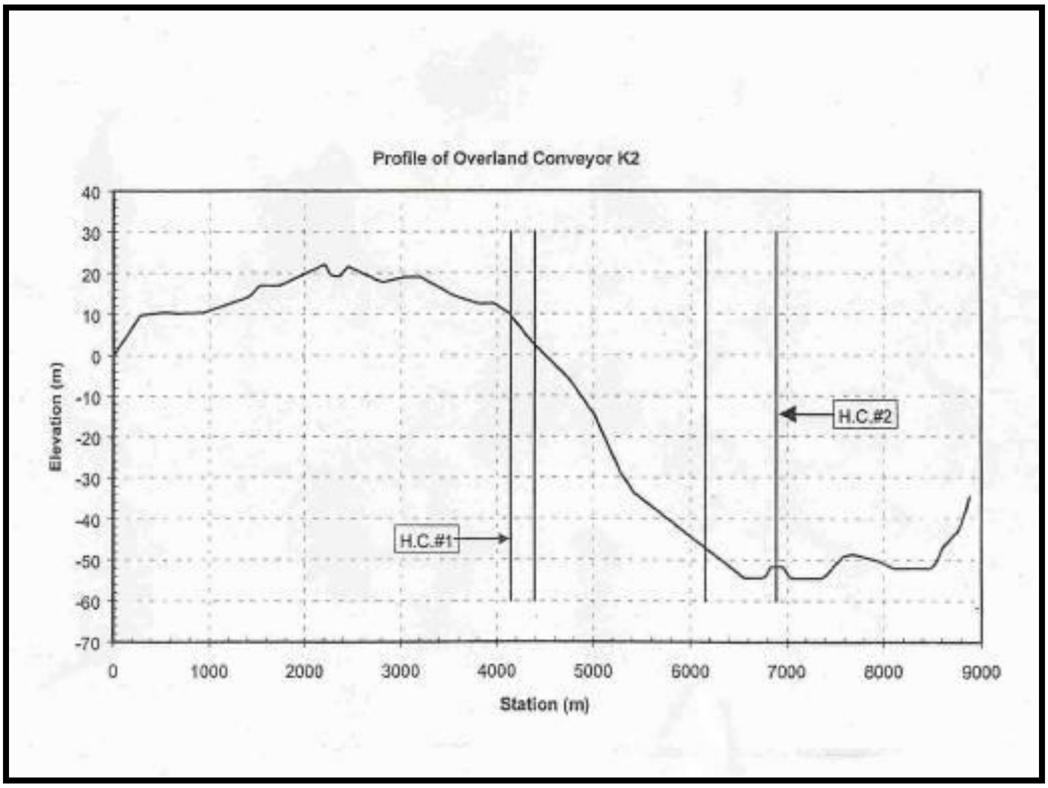
This conveyor uses the optimal belt class, drive selection and structural design. Conveyor K3 then adopts those selections to provide standardisation.

Lateral Displacement of the Belt K2

On the curves the behavior of the belt was monitored under near full load conditions with various lengths of loaded conveyor and at start up. This creates the greatest lateral movement of the belt in the curves.

The worst condition was obtained by loading a section of the belt to near full load (1 703 tph) and moving the loaded section to the inclines and declines for each start up. This created a 80 mm movement in the worst case.

This showed, and has occurred in practice, the belt is extremely stable under normal operating conditions and even behaves well under unusual load conditions.



Structural module

For cost effectiveness an overland conveyor system must have an economical, fit for purpose standard straight line and standard curved structural ground line module.

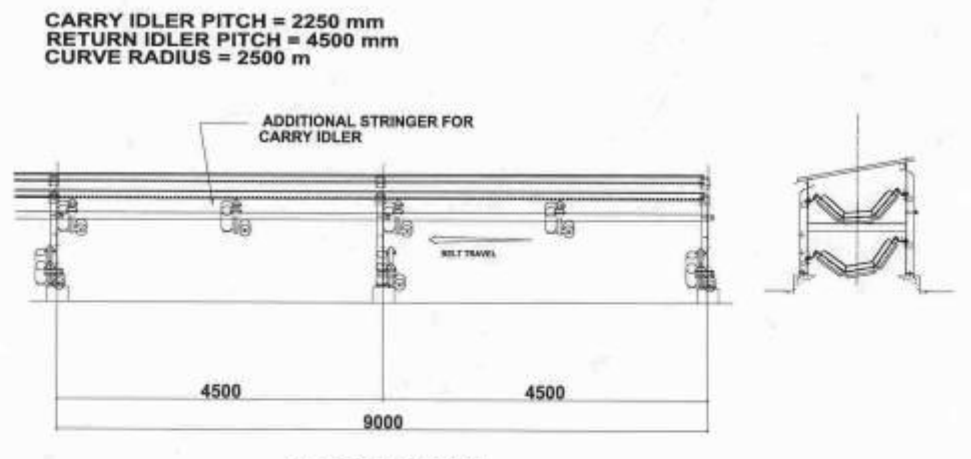
The design of the K2 module is a development of the Zisco (15½ km long) conveyor module and the CRU module is approximately half the weight of the K1 module designed in 1990.

In principle it consists of :

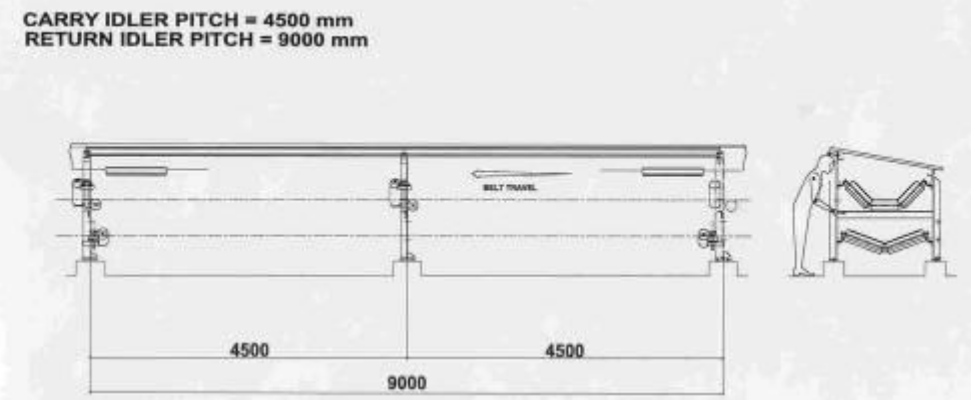
- A flat roof with a slight pitch.
- A 'H' upstand at 4,5 m centres along the conveyor length.
- Wind guards on above ground sections.

The conveyor structure is galvanised with the carry and return idlers mounted on the 'H' section upstands only. There are 2 longitudinal connection members required between upstands to support the roof sheeting.

The flat roof (not dog house) is positioned close to the carry belt but allowing easy access to both sides of the conveyor for maintenance. The ground line section has no wind guards, the belt lift during heavy wind conditions has not been a problem but cannot be discounted under extreme conditions.



CURVED SECTION
TYPICAL ELEVATION ON MODULE



STRAIGHT SECTION
TYPICAL ELEVATION ON MODULE

Erection

It is important to note that special attention was paid to alignment both horizontally and vertically during erection. This high level and quality of site supervision resulted in easy commissioning and a short period of minor adjustments. The area at the lowest point below the haul road requiring minor adjustment and use of packers.

Tunnels and civil works

The Murray and Roberts Group (Gillis and Mason) carried out the earth works civil works and most of the erection. They were selected subcontractors at tender stage and provided a most welcomed participation in the project team as distinct from the adversarial relationship caused by the more normal contract relationship.

It should be noted that the two tunnels are self-draining to nearby lower areas thus avoiding the need for pump installations along the route.

K2 Belt Rip

Shortly after commissioning the belt on K2 was ripped for over 15% on its belt length. The rip was caused by a large ± 400 mm lump being trapped in the chute. The belt rip detection, the operation, the massively oversize lump, the chute design and some other contributory factors all played a part.

A second hand belt taken out of service because of its poor condition was installed. This belt ST 1000 (Not ST 1100) with some damaged cords was installed and run successfully with no adjustment to the control system until a locally manufactured section of belt could be manufactured and installed. The main problem with this old belt was the existing splice conditions and splice repairs were necessary.

CONVEYOR K3

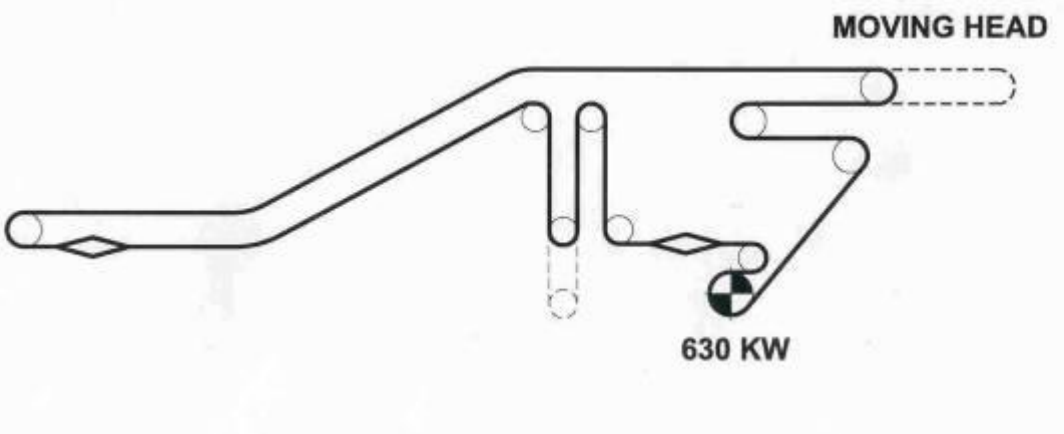
General

The third and last conveyor receives feed from K2 and discharges at a high level via a moving head into one of 3 points.

K3 uses the standard equipment selected for K2 and other than the moving head is of little technical interest.

Data

CONVEYOR K3	
Belt width (mm)	1 050
Belt speed (m/sec)	5.0
Conveyor length (m)	1 418
Capacity (tph)	1 800
Carry idler pitch (max)	4.5
Return idler pitch (max)	9.0
Horizontal curves	No
Belt turn over	Yes
Soft start	Drain coupling
Material	Coal
Lump size	- 100 mm
Drive	1 x 630 kw
Lift	10 m
Brake	No
Belt class	ST 1100



CONVEYOR K3

CONVEYOR BELTING

The quality of the conveyor belting on CRU received special attention. At tender stage the belt supplier was identified and discussions on guarantees, quality and cover compounding discussed.

The result were that the belting supplied was of extremely high quality, was delivered on time, and used cassettes to deliver the belt in lengths in excess of 1 000 m each, reducing the number of splices required.

It is also important to note that typical of conveyors the power required to run the K2 empty belt is about 400 kw, over 30% of the installed power, and almost 50% of the full running power. As a result the compound used on the bottom cover was selected to be a recently developed compound to reduce power consumption. Similar compounds are available from a few leading belting manufacturers. It is difficult to quantify the power / cost saving at this stage but the results look promising.

CHUTE DESIGN

The chute design developed from working chutes on trial at the Middelburg washing plant. These chutes favoured by the clients project team were adapted to suit the needs of the overland conveyors.

The chutes were required to transfer at right angles, K1 to K2 and K2 to K3.

- The discharge pulley positioned approximately above the receiving belt, allowing a very steep sloping fine spillage section to collect fines from the scrapers and the head snub pulley. This section is similar to a standard chute top section.

- A large wide single drop box with a sloped floor to collect the material discharge trajectory and slide the material down the slope caused by the material angle of response onto the belt allowing only a short vertical drop of the material, at right angles, onto the belt.

  Aspects of the design

  - Loads material very centrally.
  - Collects from scrapers and snub pulleys.
  - Small area of liners needed.
  - Can contain all the material caused by differing stopping times.
  - Does not accelerate the material in the direction of the belt.
  - Large in size.
  - Requires a profile plate to limit load on receiving belt when starting up with material in chute.
  - The receiving belt runs on steeply troughed idlers.

WHAT NEXT ?

- Improved chute designs to allow differing stopping times, reduce risk of belt rips and to give even controlled feed onto the next belt on start up.

- Continued improvements to belt construction, quality, cover compounding and reduced safety factors. Splice efficiency improvements are necessary.

- Better soft start control with a move towards electronic systems.

- More attention to SCADA and remote monitoring of operating and maintenance.

- Better quality of equipment, idlers, pulleys, gearboxes, belting, better installation standards.

- Developing environmentally sensitive crossings of rivers, streams and wet lands.

- Developing conveyor equipment in conjunction with the manufacturer building fit for purpose designs and not necessarily following industry norms.

- Fast tracking, the enquiry time, the adjudication period and the project completion time.

ACKNOWLEDGEMENTS

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The Bateman project team headed by Rick Tonini, the Conveyor Dynamics support team headed by Larry Nordel, Bridgestone Belting of Japan, Siemens RSA, Murray and Roberts Civil Design and Erection, numerous RSA suppliers with excellent equipment and most importantly the outstanding contribution from the Ingwe project management and engineering team headed by Mike Macey.

PRESENTER

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After 13 years as a Maintenance Engineer, Sugar and Mineral Processing Plant, he joined Bateman in South Africa in 1980.

With Bateman he has specialised in bulk handling equipment and has been directly involved in all the long and high tonnage conveyors built by the company.

Ian McTurk is General Manager of the Bateman Bulk Handling Business Unit, a Director of Bateman Materials Handling and a fellow of the SA Institute of Materials Handling.