THE DESIGN AND OPERATION OF HIGH-POWERED BELT CONVEYORS IN BRITISH COAL

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SYNOPSIS

Since the early 1950's when coal was transported underground in vehicles hauled by ropes and locomotives, the British mining industry has totally converted to the conveying of coal by belt conveyor from face to shaft bottom and at some mines up drifts to the surface.

The paper concentrates on long haul, high-powered conveyor designs of the past 10 years and the experience gained in their operation. The designs for both fabric and steel cord belts will be discussed together with those for drive and take up units and conveyor idlers and structure.

The experience gained from the coal clearance system in the Selby Coalfield will be described which utilises an 8750 kW Cable Belt conveyor, a 10,100 kW steel cord belt conveyor, and 5 x 1500 kW and 1 x 750 kW underground steel cord belt conveyors.

1. INTRODUCTION

1.1 Trends in mineral conveying

Over the last few decades in the United Kingdom, mineral transportation has progressively been converted from rope or locomotive hauled trains to belt conveyors. This has been made possible initially by the development of fire-resistant anti-static belting, and then by the advancing development of higher strength textile and steel cord carcase materials.

The need for increasing performance has arisen firstly from higher coalface outputs and secondly from a tendency to combine mines, with all coal output concentrated at a single exit. Thus modern mineral clearance requirements for belt conveyors are for high tonnages to be transported long distances, and, in the case of drift, rather than shaft, mines, vertical lifts approaching 1000 m.

1.2 Available options for high duty conveyors

Once the power requirement of the mineral clearance system in a given application has exceeded that which might be currently considered a 'normal' duty (eg solid woven textile belting up to, say, 750 kW depending on speed) there are several options which may be pursued, as follows:

(a) tandem/multiple drives
(b) booster belts
(c) cable belt
(d) steel cord belt.

(a) tandem/multiple drives

The use of tandem drives allows the operator to employ conventional solid woven belting. However, this option results in proliferation of drive units, transfer points and monitoring equipment, with the consequent additional mining/civil costs, additional manpower requirements, increased mineral degradation, spillage, blockages and delays.

(b) booster belts

Booster drives have been introduced in a limited number of installations within British Coal, to reduce peak belt tensions and allow the use of a lower strength belt, whilst retaining the advantages of single flight conveying. Against this is the extra mining/civil work required and complex starting arrangements.

The use of such drives in the UK is normally considered as a temporary option, eg on a gate conveyor operating against a steep gradient, rather than in a permanent application.

(c) cable belt

Cable belt conveyors operate worldwide and are a well established high duty conveying option. Their use in the UK in underground coal mine applications has been comparatively limited, possibly by the need for large excavations for the drive and for rope tensioning.

(d) steel cord

Apart from a single installation at Newstead colliery between 1961 and 1983, steel cord belts have not until recently been employed within UK coal mines; most experience has been gained in the lignite mines of Germany since the 1950's, and more recently in applications in Australia and South Africa. British Coal's current installations of steel cord conveyors are summarised in Table 1 (for mines other than in the Selby complex) and Tables 2 and 3 (for Selby).

Whichever of the above options is considered for a given high duty application, a life cycle total costing exercise is an essential part of the selection process; what might appear a cheap option from the point of view of capital cost may in fact be the worst option when maintenance and operating costs are included. On the other hand, where a high conveying duty is required from an area of high mining risk (eg faulted ground) a high capital cost system would not be justified.

2. GENERAL DESIGN FEATURES OF HIGH-DUTY CONVEYORS

2.1 Belting

All conveyor belting, regardless of type, used in British Coal's underground mines has to be proven fire-resistant and anti-static, by means of electrical and fire tests according to BC Specification 158:1989. This is normally achieved by the use of polychloroprene, PVC or nitrile rubber, or a combination of these, for the cover material (or, in the case of cable belts, the total belt thickness).

2.1.1 Textile carcase belts

Traditionally, the strength of textile carcase belting for use in British Coal mines has been designated by a type number, eg type 10;

this signifies a strength of 10000 lbf per inch width. Hitherto, the strongest available belt was type 15, but trials are proposed with an installation of type 18 belting, ie 18000 lbf/inch or 3150 kN/m tensile strength. This belt, which has a similar modulus to that of steel cord belt, is being offered for a 2.6 km long application with a guaranteed belt life of 15 years and a splice life of 10 years.

As far as splicing of textile belts in general is concerned, improvements are continually being made and it is not unrealistic to expect that, at least for the higher strength belts, splice strength approaching 90% of that of the belt is achievable; this could allow the conventional factor of safety for textile belt installations to be reduced below 10:1 in future.

2.1.2 Steel cord belts

The construction of the belt allows a range of wire rope configurations to be embedded in the matrix material; currently the strongest such belt is BTR's FR7000 (7000 kN/m of belt width) which is equivalent to a type 40 textile belt if such a design were available.

Steel cord vulcanised splices can be made on site to achieve a guaranteed minimum of 90% of the parent belt strength. Accelerated testing of test splices has proved that this strength is maintained even after 15 years' equivalent life.

With the use of torque-controlled starting, these belt and splice strengths allow safety factors down to 5:1 to be employed. A life of 15-20 years is expected provided that good installation and maintenance are achieved; the Newstead installation previously mentioned achieved a 22 year life with negligible cover wear.

Against these advantages, steel cord belt is heavy, which has implications for handling during transport and installation as well as giving a higher mass to accelerate and retard during operation. Also, steel cord belt has little lateral strength and requires care to avoid linear damage which leads to cord corrosion. The downtime involved if belt changing and vulcanising are necessary can also be extensive, 12 to 16 hours being required for a pre-prepared joint and 36 hours for a non-prepared joint.

2.2 Drive, take-up and tail end units

As conveying duties increased there has been a tendency to employ uprated standard drive units, particularly where there was a need for uprating an existing installation. This had an adverse effect on reliability as individual components were operated at stresses sufficient to cause premature failure owing to fatigue; this was particularly the case for drive drums.

With the strategic importance of new installations, such as those at the Selby complex described later in this paper, experience has shown that the necessary reliability can only be achieved by employing purpose-designed drives.

With higher-powered drives the need for good torque control on starting, and even on rundown, becomes apparent, owing to the very high transient forces which could otherwise be generated in the belt and the structure. As installed drive power increases, increasingly sophisticated hydrodynamic couplings become necessary, until at the highest powers the use of direct drive DC motors such as are employed on winding engines becomes the most suitable option.

The provision of belt maintenance stations, often incorporated in the loop take-up area, is considered essential on high duty conveyors. The initial cost of a maintenance station can be comparable to that of a drive unit, but this expense must be borne in order to reduce downtime; it is becoming more the norm to expect the belt to run at weekends to service roadway development activities, leaving less time for inspection and maintenance.

The aspects touched on in this section will be further expanded in Section 3 by way of examples from the conveyors in the Selby coalfield.

2.3 Structure

One of the most consistently troublesome items of conveyor structure, at least as far as British Coal is concerned, has been idlers;

premature failure of these, especially in arduous environmental conditions, can be a cause of underground fires. Recent investigations have highlighted the inadequacy of sealing arrangements, which could be a result of excessive commercial pressure on the suppliers to keep prices down. Trials of idlers with improved sealing are now in progress. In addition, in acknowledgement of the trend towards high capacity conveyors, a design study is being undertaken to develop an idler to suit conveyors operating at up to 6 m/s, 2 m wide with capacity up to 4000 t/h.

With the high belt tensions associated with high duties, it is important to maintain close tolerances on the alignment for the structure, particularly on curves in the vertical plane. This is not easy to ensure in unstable strata, and experience within the Selby complex has pointed towards the use of suspended rather than floor-mounted structure.

2.4 Monitoring and Control

British Coal's computer system MINOS (MINe Operating System) for conveyor monitoring and control is now widely employed. This provides sequencing and control for conveyor starting, stopping, and bunker infeed and outfeed; monitoring of belt slip, torn belt, chute blockage, belt alignment etc is also included with displays of system and component condition in the colliery control room. How the system is applied to the Selby complex will be described later in this paper.

The importance of reliable, effective monitoring on high duty conveyor systems cannot be overemphasised as a means of preventing expensive production delays or even catastrophic failure. The cost of production loss for, say, 4 hours' delay on the main coal clearance system at a mine producing 2 M tons per year saleable is estimated at £80,000.

Physical examination of a long conveyor by a normal belt patrol is a tedious, difficult and imperfect process, and together with the need for the conveyor to be available for duty for an increasing number of hours and at weekends, has led to pressure for improved monitoring equipment, especially insofar as steel cord belts are concerned.

In the case of the steel cords themselves, a magnetic reluctance instrument is available to monitor cord corrosion and cord breaks. The 'signature' of the cords over the length of the belt can be compared over successive tests, which assists prediction of splice failure, cover thickness reduction and loss of cord adhesion. Specific local examination can be made in more detail with a magnetometer. A further method which is under development uses Hall effect devices to sense changes in the residual magnetic characteristics which occur at areas of damage; this method is designed to be used on a continuous basis and it is also hoped to be able to detect splices so as to enable joint 'parking' to be easily achieved through a conveyor maintenance station controller.

Again with steel cord belts, early detection and action on tears is essential. Consideration is being given to implanting wire loops into each belt length, a break in which could be detected by means of inductance. An alternative method under investigation is the use of an ultrasonic transmitter and receiver on either side of the belt. At the time of writing the development is at an early stage, but if it is to be successful, it will have to be capable of working through the coal pile.

With long conveyors, the incidence of expected idler failures becomes sufficiently high to make some means of failure monitoring almost essential. One such unit uses infra-red sensors positioned about 50 mm away from the belt surface to pick up heat from failing idlers. When the conveyor stops, the 'hot' idler will transfer some heat to the belting. On restart, the hot spot is sensed and the position along the belt length computed within the monitor. This information can then be transmitted through the MINOS link to the control room.

2.5 Belt Cleaning

As with monitoring, the importance of adequate belt cleaning is paramount, with the emphasis on a cleaning system with its individual components chosen to give optimum results for the type of belt and the coal condition.

On high duty belts, the segmented scraper has been found to be generally superior to the flat scraper, with the use of 'squeegee' rollers to remove excess moisture. Removal of the wet fines, if on other than on-line conveyor, requires a purpose designed spillage conveyor to transfer these to the receiving belt reliably and without any tendency for spillage to build up. Both push plate and scraper chains have been used for this purpose, with scraper chains tending to be preferred for simplicity and compactness.

3. SELBY COALFIELD CONVEYORS

3.1 General description of Selby Complex

The Selby complex is a crucial element in the present and future business plan for the British coal industry. As far as mineral transportation is concerned, the principle employed is the concentration of output at a single surface location, Gascoigne Wood drift (Figure 1), although five satellite mines are required spread across the coalfield to provide ventilation and efficient transportation of men, materials, and equipment. This eliminates the need to hoist coal at the satellite mines, thereby minimising surface environmental problems of noise, dust, and road/rail surface coal transportation links. Eaton and Massey (Ref. 1) and Siddall (Ref. 2) give further details of the mining engineering aspects of the coalfield.

The two main tunnels ('spine' tunnels) of Gascoigne Wood drift are each equipped with conveyors which can transport up to 10 Mt per year, the designed coalfield output. The reason for duplication was that the duty was unprecedented in underground mining, and back-up would be present in case of maintenance or breakdown downtime; furthermore, expansion potential would be provided for the coalfield, which has been considered for uprating to as much as 15 Mt per year.

The conveyors installed are a Cable Belt in the north tunnel and an Anderson Strathclyde steel cord belt in the south tunnel. These belts are fed via vertical strata bunkers or boreholes from the in-seam conveyors 70 m above.

The coalfaces have their mineral, which is crushed to minus 200 mm size, cleared by 1.2 m wide textile reinforced gate belts running at between 2 and 2.5 m/s, capable of clearing up to 1500 t/h, and of up to 600 kW installed power including booster belts. The trunk conveyors which convey the coal between the gatebelts and the spine roadway bunkers or boreholes vary in construction, but include 6 steel cord belts of 1500 kW and 1 of 750 kW installed power, running at up to 4 m/s and carrying up to 2000 t/h.

Tables 2-4 give the salient features of the two spine belt conveyors and of the steel cord trunk conveyors. Kirk (Ref. 3) describes the design and operation of the steel cord conveyors in more detail than is possible in this paper, and Milford (Ref. 4) describes the Cable Belt conveyor.

Because of the high speed of the two spine tunnel conveyors, at each of the delivery points onto these conveyors is a short accelerating conveyor which is placed after the bunker outlet weighfeeder; these conveyors are of variable speed, controlled to operate at 75% of the spine conveyor's speed. Their provision avoids excessive spillage, degradation and belt damage which might occur when accelerating material from a conventional chute discharge onto a conveyor running at around 8 m/s.

3.2 Control Strategy

Managing the coal throughput of the Selby coalfield is a complex problem, principally owing to the multiple delivery points onto the spine conveyors, each of which has an independently variable feed rate. The spine belts themselves have infinitely variable speed, and are installed in roadways of variable gradient (Figure 2), which affects power requirements at various conditions of loading and distribution of coal along the conveyors.

The control system must adapt to suit the various loading conditions, and at the same time maximise coal throughput, avoiding spillage at delivery points or bunker overloading, and optimising power consumption without overloading the drive motors.

These objectives are achieved by a purpose designed set of MINOS packages. Each of the satellite mines has a MINOS computer controlling its own coal clearance to the spine roadway bunkers with a data link to and from the main MINOS computer at Gascoigne Wood. This main computer is fully configurable to suit changing and developing requirements, and controls bunker and borehole outfeed rates onto the spine conveyors through an overload prediction routine. It also includes monitoring of conveyor health and safety functions, a total of 650 monitored outputs for each spine conveyor, each of which has assigned to it an appropriate action (eg data display only, warning only, controlled stop, emergency stop) depending on the function and the consequences of any departure from its normal state.

3.3 Cable Belt Conveyor in North Spine Tunnel

3.3.1 Specification

Table 4 summarises the principal features of the duty and of the design of the conveyor assembly, as currently installed. As originally designed, the conveyor (in common with that in the south tunnel) was intended to have a length of 14.9 km and a lift of 990 m. However, strata control problems beyond the 12 km point resulted in a decision to curtail the spine conveyors at 12.2 km, with a lift of 805 m; this necessitated redefining the plan for the underground trunk conveyors, and coal from North Selby and Whitemoor mines is delivered via Stillingfleet and Riccall mines respectively, rather than direct to the spine tunnels.

During start-up, the twin thyristor-controlled 4375 kW DC motors are regulated to maintain 10% speed until constant cable tension is established, speed then being increased to the desired value up to the maximum of 7.6 metres per second. By this means, the cable overtension is minimised, and, in common with other high power cable belt installations, a factor of safety of 3 to 1 on the drive cables can be achieved.

A full suite of transducers for monitoring belt/cable separation, belt break, drive component temperature/pressure/vibration etc is provided.

Belt and cable installation and handling facilities are permanently installed in the drive house at the drift mouth

3.3.2 Installation and Operational Experience

The initial installation of the conveyor, at short centres of 5.1 km, was completed in May 1985, to provide mineral clearance facilities for Wistow mine whilst development proceeded on the rest of the complex, including the drivage of the remaining sections of the spine tunnels.

The conveyor was subsequently extended to 9.6 km in 1988, and a decision has recently been taken to terminate the conveyor at that point rather than extend it to the full 12.2 km. This is due to continuing strata control problems and their potential effect on the return end tension drift excavation at the 12.2 km point.

Operational experience has brought out some problems, principally low rope life owing to operating at short centres (5.1 km) for several years, and also to the abrasive nature of some of the mineral carried as drivage proceeds. Also, a resonance is present in the drive gears at about 50% speed which it has not been possible to eliminate; current practice is to avoid continuous operation at that speed.

3.4 Selby Underground Steel Cord Trunk Conveyors

3.4.1 Specification

Table 2 gives the principal features of these conveyors, which have duty requirements beyond the capabilities of textile reinforced belt, at least at the time of installation, taking into account the lower allowable factor of safety with steel cord belts.

It was considered that a standardised design would offer the most cost effective and best performance solution for these conveyors, which were to be designed for a 30 year life, operating 20 hours per day in ambient temperatures up to 30°C at full load.

Thus the drives are of modular construction with identical motor, gearbox, fluid coupling, drive and snub pulleys and bearings, and, as far as possible, other pulleys in the drive, loop take-up and return end areas. Belt installation and maintenance facilities are built in.

A key feature of the installation of the drive units is the facility for on-site adjustment to cater for side-crush and floor-blow at the depths involved (up to 1100 m). This is achieved by incorporating purpose built jacking points beneath the drive frame, and mounting the drive on transverse shear beams set above the roadway floor with up to 300 mm crush allowance each side.

The twin 750 kW induction motor drives are fitted with scoop-trim fluid couplings with acceleration control, to minimise belt overtension and allow a belt factor of safety down to 7 to 1 to be employed. The couplings ensure a torque-controlled acceleration of up to 90 seconds duration with a balancing of load between the drives during acceleration and constant-speed running. The coupling scoops are controlled by electrohydraulic actuators, with temperature compensation of stroking time. An external oil cooling circuit is fitted to provide heat dissipation during starting. Although not currently used, a powered rundown is also possible with the chosen drive arrangement.

3.4.2 Installation and Operational Experience

During installation, the major effort involved with the underground steel cord trunk conveyors was the excavation of the drive house, each of which involved drivage of 80 m of 8 m square section roadway. Close tolerances were also required on the belt catenary profile in vertical roadway curves. Handling of the 300 m lengths of belting in rolls weighing 14½ t each required purpose-designed lifting and handling equipment.

In operation, the conveyors have generally been reliable, with only minor problems occurring. The only consistent problems have been the need for regular checking and correction of drive alignment owing to strata movement, and some early unreliability of the fluid coupling electrohydraulic actuators. Also, the adequacy of the cooling arrangements for the fluid couplings is marginal under frequent start-stop conditions which occasionally occur as a result of outbye delays.

3.5 Steel Cord Conveyor in South Spine Tunnel

3.5.1 Specification

Table 3 summarises the design and duty features of the installation, which was the most powerful belt conveyor in the world at the time of installation, with a design throughput of more than 200000 t of mineral in a five day working week, from 800 m depth to the surface over a distance of 12.2 km.

The drive is direct, by two 5050 kW DC winder motors, of infinitely variable speed up to 60 rev/min giving a maximum conveyor speed of 8.4 m/s on the 2.67 m diameter drive pulley. The pulley and drive shafts are machined from a single forging and weigh some 90 t.

The design T_1 of the belt is 190 t with T_2 68 t at full load.

Runback is prevented by force lubricated roller clutches.

A loop take-up is installed at the drive house which incorporates belt installation and maintenance facilities with up to 43 m of loop bogey travel to accommodate all foreseeable maintenance requirements. Tensioning is provided by a 150 t weight through a rope reeving system to give the 68 t T_2 tension as stated.

With this conveyor, in common with other high duty conveyors, control of dynamic loading of the belt, drives and structure is essential to minimise the transient forces which occur, particularly on start up.

The electronic control system applies a ramped speed increase to accelerate the conveyor, which when fully loaded weighs 3400 t, from standstill to full speed over a period of 4½ minutes; the maximum torque applied within this period exceeds the normal full load torque by only 6%. Sensors are installed at the head and tail pulleys to indicate movement. On initiation, the motors apply a gradually increasing torque until the head pulley starts to rotate; this torque is then maintained constant until the tail pulley is detected as rotating, at which point the torque is increased again and the acceleration characteristic follows the built-in speed ramp.

Control of the belt tension in this way allows a belt factor of safety of 5 to 1 to be employed.

A capstan brake is employed to prevent rapid lifting of the tension weights as the T_1 and T_2 tensions equalise on rundown, and to 'lock in' tension to minimise transient forces on subsequent start-up.

3.5.2 Installation and Operational Experience

The installation of the initial length of 5000 m of conveyor was commenced in October 1982, and the first coal was brought to the surface in June 1983. A further extension to 7800 m took place in 1985, with the final extension to 12200 m taking place by the end of 1987.

A problem which became apparent at an early stage was that of shock loading when the conveyor was stopped. Although transient forces on start up had been adequately catered for, during conveyor rundown under certain conditions, travelling tension waves could be induced in the belt as a result of dynamic interaction between the drives, the tension weights and the capstan brake.

This was overcome by introducing a powered rundown of the conveyor, to reduce the transient forces. This now operates on all rundowns other than power trip conditions. The effects of this change are shown in Figure 3, which shows conveyor tensions, drive torque and speed versus time for the loaded conveyor.

Also at an early stage in the life of the conveyor, the tail pulley bearings failed. This is thought to have been contributed to by the shock loading conditions (return end T_3 tension values between 3 and 4 times steady state values had been measured), together with oil starvation owing to centrifugal action.

Two more serious failures took place in September 1987, with the conveyor operating at 7.8 km centres, and in February 1988 (extended to 12.2 km centres), when one of the main drive bearings failed.

In each case, one roller had broken but without causing any significant consequential damage. The bearings concerned were unique with respect to diameter, loading, and the low speed of operation, and were consequently operating under unprecedented conditions. As with the tail pulley bearings, it is possible that transient loads had contributed to the failure, but after intensive study of the problem various improvements were made to the design and manufacture of the bearings, as follows:

- roller material specification enhanced

- case hardening, rather than through hardening of the rollers was practised

- roller end profile modified to eliminate high point stresses

- lubricant specification improved, with improved temperature monitoring and control.

The bearings have been trouble free since these modifications were introduced.

Other problems which have occurred have been belt-related. Although overband magnets and sacrificial accelerator conveyors are employed, longitudinal belt damage has occurred on a number of occasions as a result mainly of roadway repair work. The continuing nature of the problem gives added impetus to the development of reliable belt tear detection equipment.

4. CONCLUDING REMARKS

British Coal now has considerable experience of operating high duty conveyors, and will continue to extend this experience as the mining strategy continues the change to fewer units producing larger outputs of coal.

In particular, the Selby complex is now in full operation and is approaching its projected output level. At this level, reliability of the coal clearance system is paramount as the cost of lost production if the Gascoigne Wood outlet is halted exceeds £1.5 M per day.

The coal clearance system has enabled some substantial performance figures to be achieved in the Selby complex:

65,450 t saleable in one week from one face at Wistow;
108,700 t saleable in one week total output from Wistow;
254,283 t saleable in one week total output from the Group;
309 t per manshift coalface productivity at Stillingfleet;
30.0 t per manshift overall productivity at Stillingfleet;
and 12.9 t per manshift overall productivity in the Group.

Performances of this nature can only be achieved if continuing emphasis is given to the need for the highest standards of installation, testing, commissioning and continuing in-service inspection and maintenance.

The conveyor specification should include all available means of condition monitoring, although this does not eliminate the need for the incorporation of other protective features by design, eg the use of overband magnets to prevent belt damage, and the use of controlled run up and rundown to minimise transient loads.

Significant financial outlay is required for high duty conveying systems, and only by building in reliability by the means stated above, and by ensuring high volume low cost production, can justification be given for provision of the capital.

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Table 1 Steel Cord Belt Conveyors in Operation Underground in British Coal Mines - Summer 1991 (excluding Selby Complex)

Colliery	Length m	Gradient	Power kW	Belt Width mm	Belt Speed m/s	Belt Type	Capacity t/h
Daw Mill	1300	25%	900	1050	3.5	FR2700	800
Daw Mill	957	25%	900	1050	3.5	FR2700	800
Grimethorpe	2754	25%	5000	1200	5.3	FR7000	2000
Harworth	1870*	level	900	1350	2.8	FR2200	1200
Ollerton	1684	18%	1500	1200	3.3	FR4000	1000
Welbeck	1680	18%	900	1050	2.7	FR3000	800

* Present length. To be extended.

Table 2 Underground Steel Cord Belt Conveyors within Selby Group

The conveyors in this table are distributed as follows: Riccall - 1; Whitemoor - 1; Stillingfleet - 2; North Selby - 2.

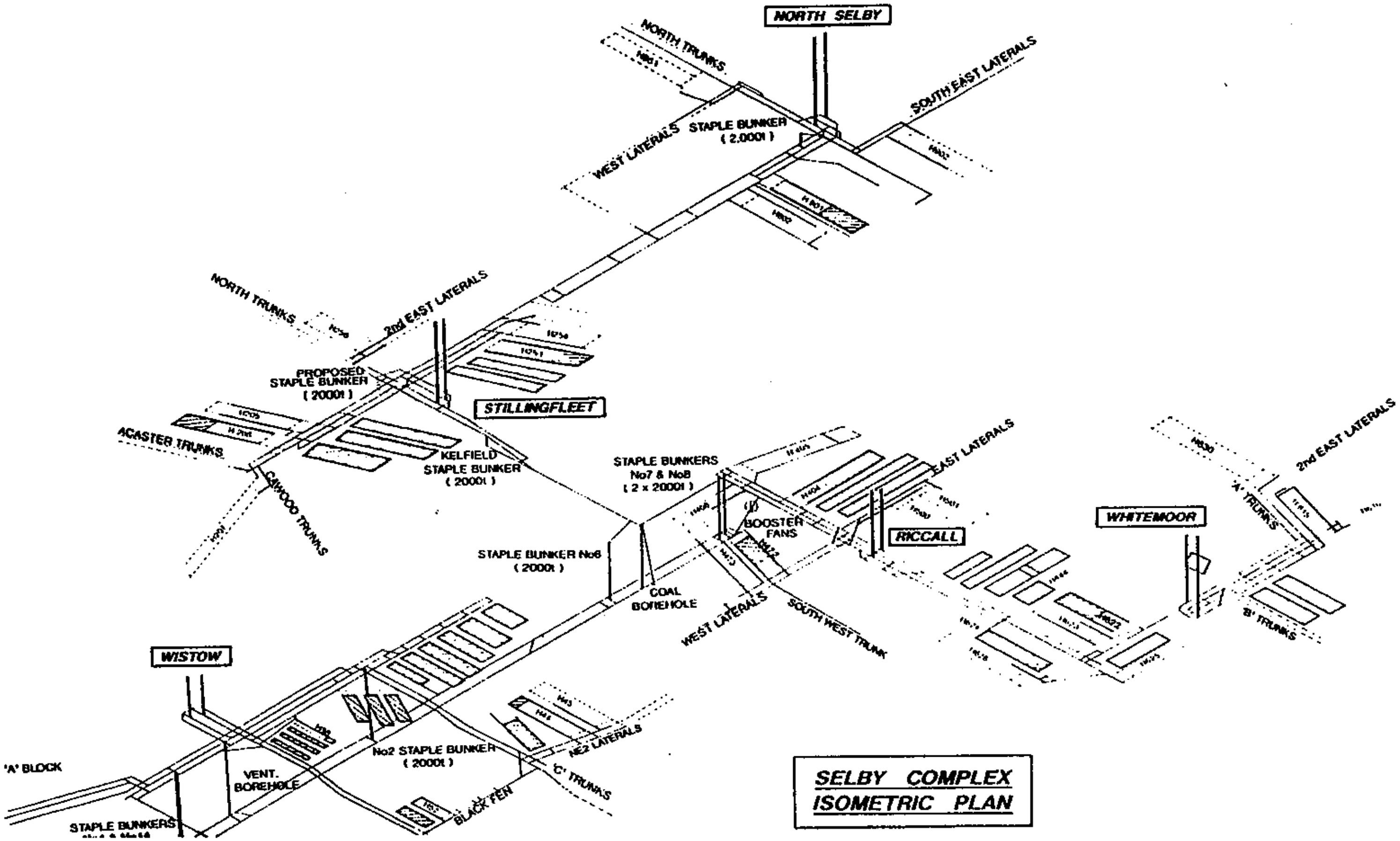
Length	- up to 4350 m
Lift	- up to 180 m
Speed	- 4.0 m/s
Capacity	- 2000 t/h
Belt type	- BTR FR2200 steel cord
Belt width	- 1350 mm
Belt construction	- 17.3 mm thickness, comprising 5.3 mm dia cords and 6 mm top and bottom covers
Belt factor of safety	- 7 to 1
Drive	- 1 or 2 x 750 kW 6.6 kV 1480 rev/min induction motors: Fluidrive 66 GST scoop trim fluid couplings: bevel helical gearbox. 1000 mm dia drive pulleys, 800 mm dia snub pulleys
Idler sets	- top: 1.375 m pitch, 168 mm dia, 3 roll 25° trough, roof slung - bottom: 2.7 m pitch, 168 mm dia, 2 roll 10° V
Tensioning	- loop take-up with rapid response electric winch and load cell
Main contractors	- Huwood (FKI Babcock) or Gullick Dobson (FSW).

Table 3 Gascoigne Wood South Spine Tunnel Steel Cord Belt Conveyor

Length	-	12232 m (14930 m as designed)
Lift	-	805 m (990 m as designed)
Speed	-	Infinitely variable 0-8.4 m/s
Capacity	-	2500 t/h uniformly distributed from tail end, or 3250 t/h loaded at Wistow staple bunker (5 km from drive)
Feed points	-	8 off, between 5-12 km from drive
Belt type	-	BTR FR6950 steel cord
Belt width	-	1300 mm
Belt construction	-	28.1 mm thickness, comprising 13.1 mm dia cords and 7.5 mm top and bottom covers
Belt factor of safety	-	4.8 to 1
Drive	-	Direct drive twin 'E' frame DC winder motors 5050 kW each: 2670 mm dia drive drum and 1600 mm dia drive shaft in single piece 90 t weight forging: 1500 mm dia bend, snub and tail pulleys
Idler sets	-	top: 168 mm dia, 3 roll 30° trough
	-	bottom: 168 mm dia, 2 roll V
	-	spacing: 6 m, decreasing near tail end to 2 m
Tensioning	-	150 t gravity weight at drive end
Main contractors	-	Anderson Strathclyde PLC and REI (France).

Table 4 Gascoigne Wood North Spine Tunnel Cable Belt Conveyor

Length	- 9650 m (14923 m as designed)
Lift	- 685 m (990 m as designed)
Speed	- Infinitely variable 0-7.6 m/s
Capacity	- 2800 t/h loaded at Wistow staple bunker, reducing to 1830 t/h uniformly distributed from tail end (as designed)
Belt type	- Cable Belt proprietary neoprene with inbuilt lateral steel straps
Belt width	- 1050 mm
Cables	- 57 mm dia 6 x 19 round strand, 3.1 factor of safety
Drive	- Direct drive twin 'D' frame DC winder motors 4375 kW each: 6700 mm dia drive wheels
Line pulleys	- 3.95 m pitch top, 7.9 m pitch bottom 'polyrim' pulleys
Tensioning	- Tension drift at tail end, plus differential gears in drive
Main contractor	- Cable Belt Limited.



SELBY COMPLEX
ISOMETRIC PLAN

Figure 1 Selby Complex Isometric Plan

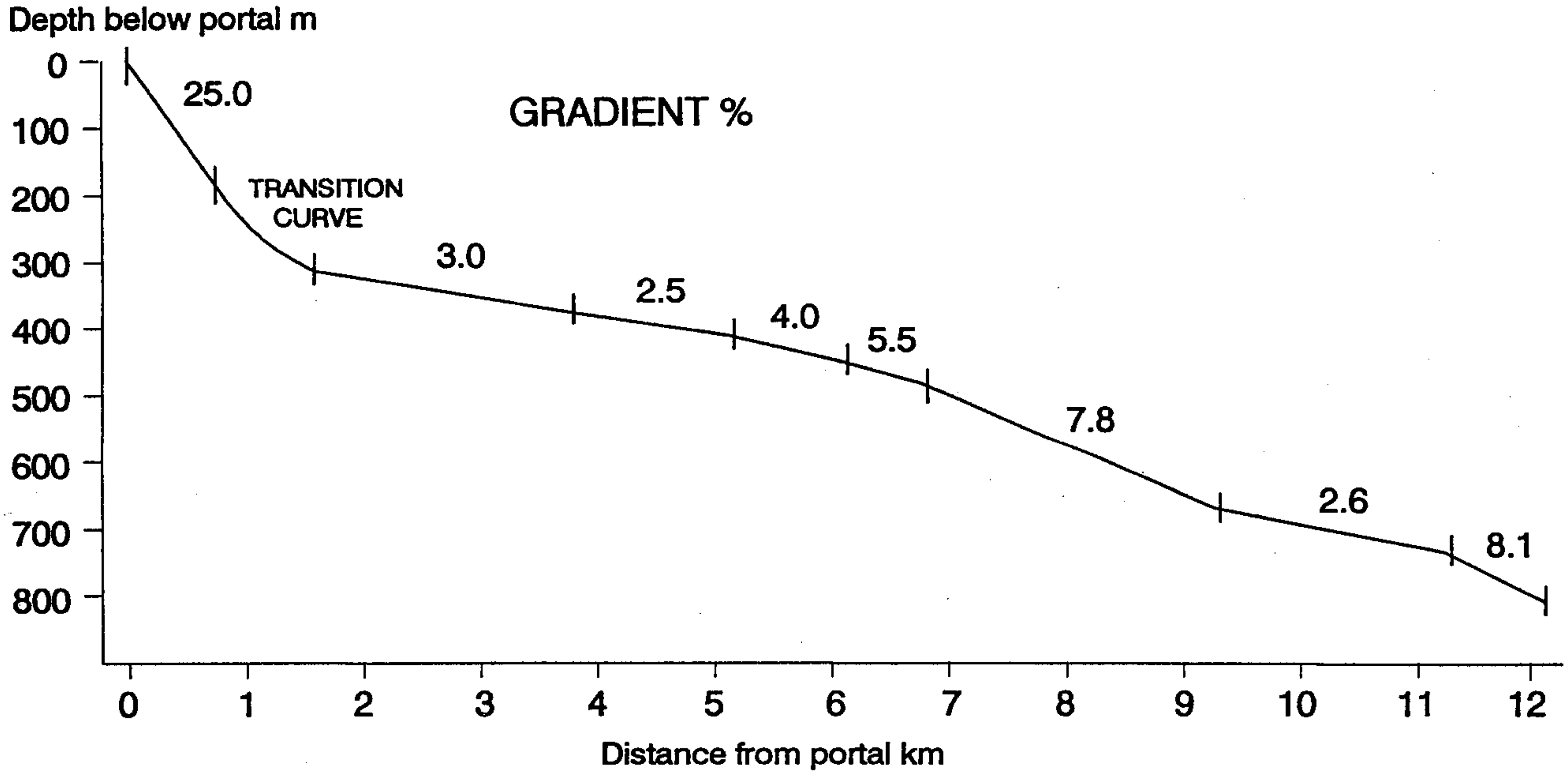
Figure 2 Gascoigne Wood Spine Tunnel Gradient Profile

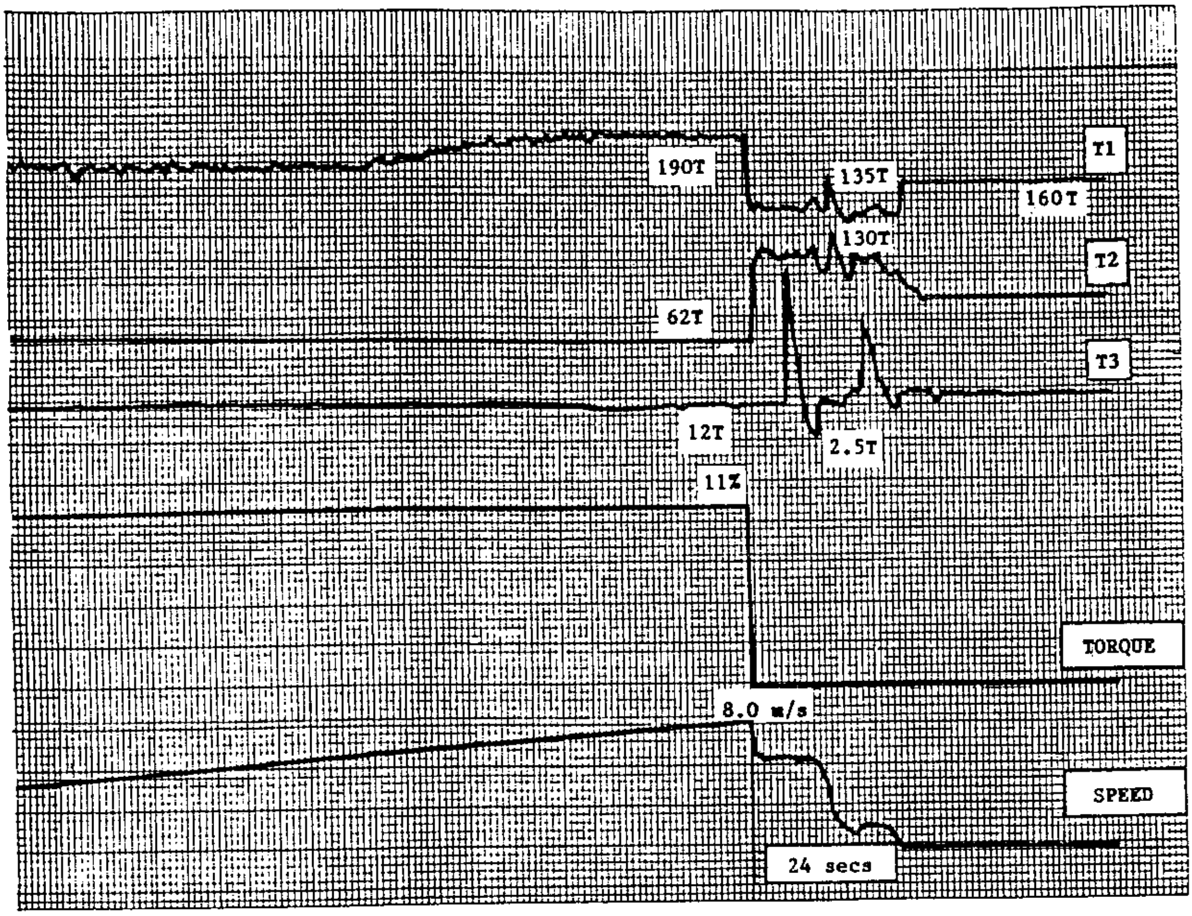
Figure 3 Effect of Powered Run Down on Tensions in Steel Cord Spine Conveyor

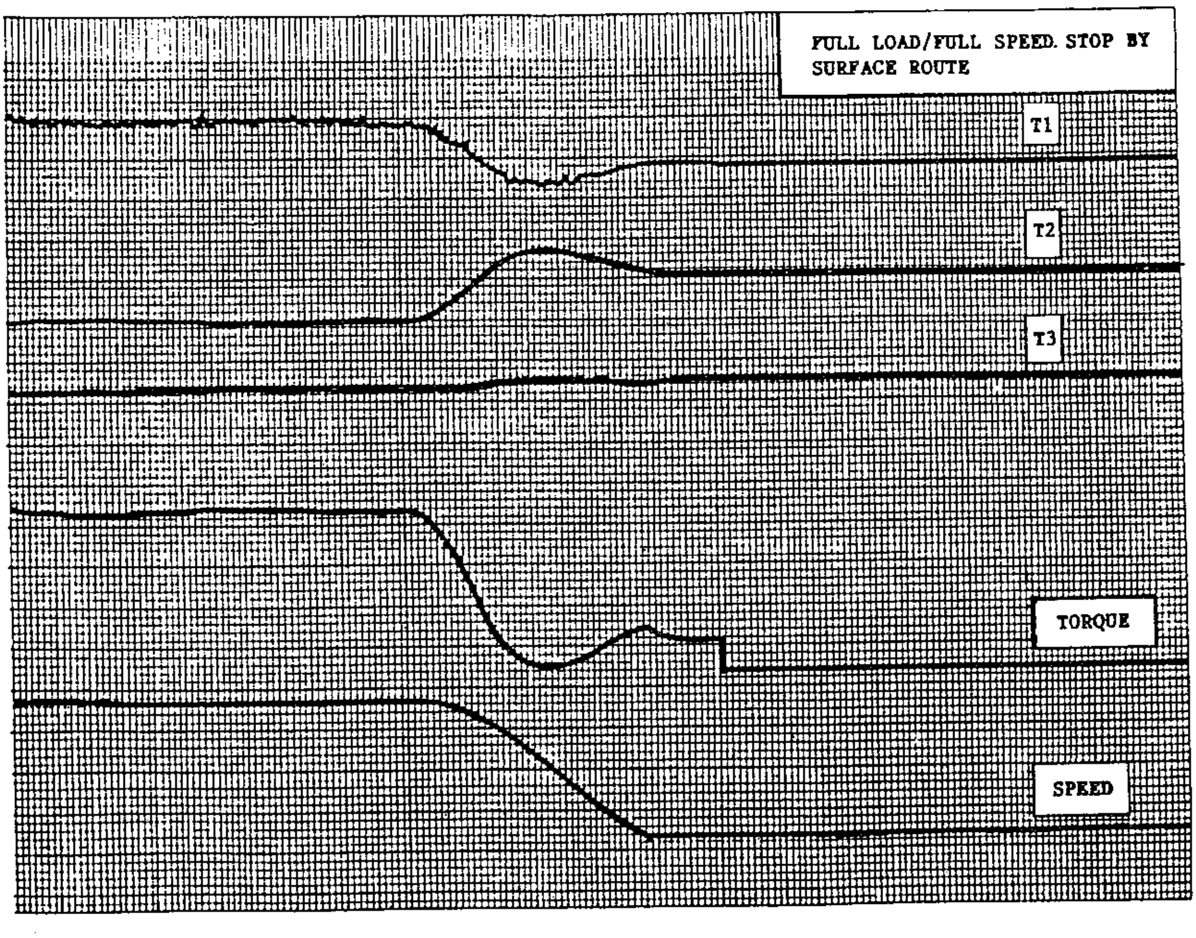
- upper graph: power trip

- lower graph: powered run down

GASCOIGNE WOOD SPINE TUNNEL GRADIENT PROFILE




190T
135T
160T
T1
130T
T2
62T
T3
12T
2.5T
11%
TORQUE
8.0 m/s
SPEED
24 secs


FULL LOAD/FULL SPEED. STOP BY SURFACE ROUTE
T1
T2
T3
TORQUE
SPEED

FORM C

INTERNATIONAL MATERIALS HANDLING CONFERENCE

PRESENTATION AIDS

The Eskom Auditorium is very well equipped, however it will assist the organisers if you could tick those items below which are required for your paper. This will ensure that the equipment is made available timeously.

The 35mm carousel slide projector has spare magazines and the organisers will load these in the order the slides have been arranged by you, if required.

(a)	35mm Carousel Slide Projector	✓
(b)	Overhead Projector	
(c)	Video - VHS	
	Video - Beta	
	Video - Load Band Umactic	
(d)	P C Data Projector (IBM Compatible)	
(e)	Flip Charts	

Signature .... **Date:** 5th July 1991

Name in Block Letters ....ALAN KIRK....................