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Commissioning and Operating Experience of the
Selby Steel Cord Belt Draft Conveyor

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COMMISSIONING AND OPERATING EXPERIENCE OF THE SELBY STEEL CORD BELT DRIFT CONVEYOR

The author of the Paper was Chief Engineer for this Project, with responsibility for the Engineering, Installation and Commissioning of the Conveyor. This Paper is a follow up to the Paper given at Beltcon 2, in which the design and conception of this Conveyor was described.

The Paper is split into three parts, the first describing the installation and commissioning of the first 5 kilometres. The second part describing the first belt extension, and finally the initial operating experience.

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1 Introduction

In my previous Paper, given at Beltcon 2, the requirement for the transportation of coal from the 5 mines, forming the Selby complex, to the surface plant at Gascoigne Wood, was described, and the solution in the form of the steel belt discussed. During the course of presentation of the Paper various slides were shown of the different sections and stages of construction.

The present paper is a follow up, describing:

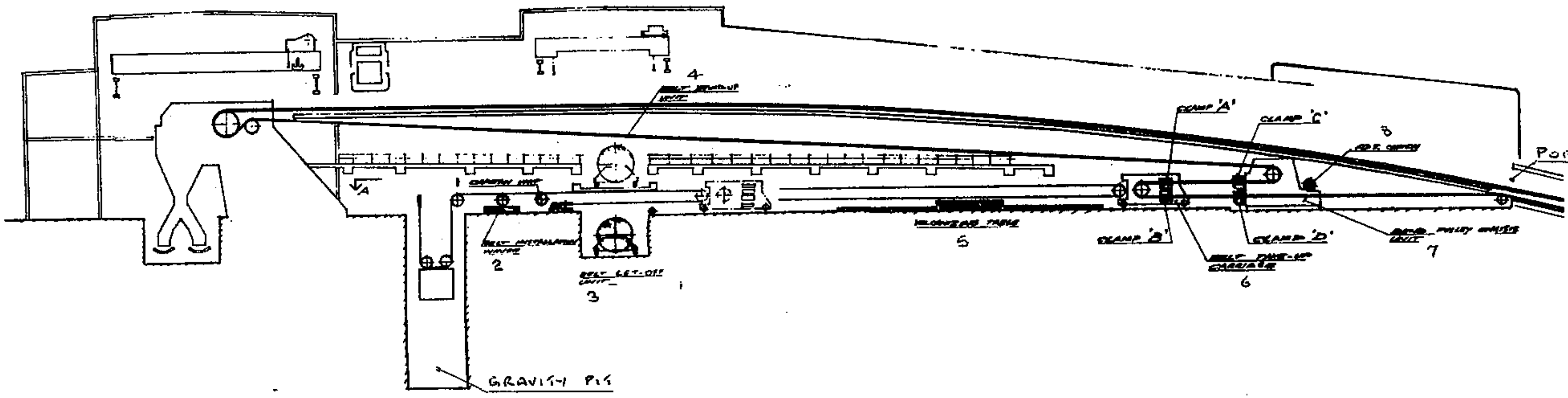
2 Commissioning of initial length.

3 The first extension.

4 The initial operating experience.

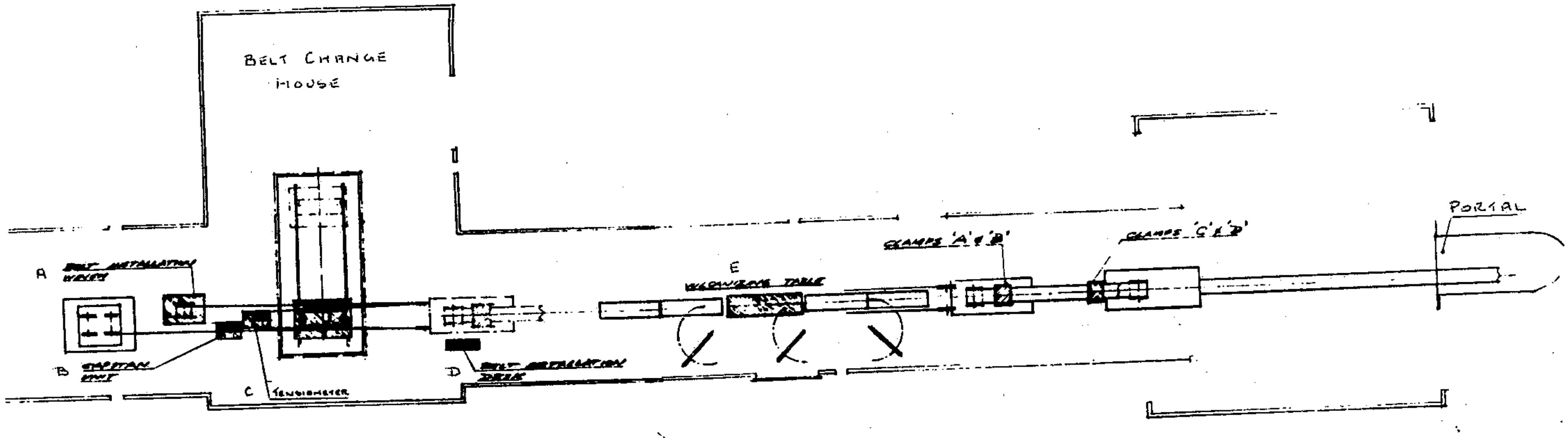
It is perhaps appropriate at this stage to recall some of the principal statistics of this conveyor:

Final Length	- 14930m
Total Lift	- 990m
Belt Speed	- up to 8,4m/sec fully variable
Belt Width	- 1300mm
Belt	- Steel cord ST7100
Tonnage	- 1828 TPH from tail end 3250 TPH from outbye feed points
Feed Points	- 11, each with feed accelerator conveyor
Installed Power	- 2x 5050kW DC Winder Motors
Drive Unit	- Single drum unlagged
Belt Cleaning	- High pressure wash and vacuum drying.



1 CAPSTAN UNIT
2 BELT INSTALLATION WINCH
3 BELT LET-OFF UNIT
4 BELT WIND-UP UNIT
5 VULCANIZING TABLE
6 BELT TAKE-UP CARRIAGE
7 BEND PULLEY CHASSIS UNIT
8 TEN TONNE WINCH

SURFACE ARRANGEMENT - SELBY



PLAN A–A

A - BELT INSTALLATION WINCH
B - CAPSTAN UNIT
C - TENSIOMETER
D - BELT INSTALLATION DESK
E - VULCANIZING TABLE

2 Commissioning of Initial Length

2.1 NCB Requirement

The first of the 5 mines to be brought into production was Wistow Colliery. The first longwall face at Wistow was programmed to start operating in the Spring of 1983, and coal to be fed onto the Steel Cord Belt via a bore hole slit, this being a temporary measure until the first Staple Bunker and permanent feed system could be installed.

The NCB requirement was, therefore, for a conveyor 5192m length, and to be fully operable to handle the initial production output, in the first part of 1983.

A further requirement was that the conveyor should handle the spoil from the driveage of the two spine roadways. The South Drift spine roadway was being driven by a full face tunnelling machine, and it was in this roadway that the steel cord belt was being installed. The North Drift spine roadway, in which the Cable Belt would be located, was being driven by a heading machine.

During the installation of the Steel Cord Belt, the spoil from the two driveages had to be conveyed to the surface in the North Drift, thus allowing installation to proceed unhindered, and also to permit materials to be taken in by loco, alongside the conveyor.

However, to allow installation of the Cable Belt to commence it was necessary to remove the spoil conveyor from the North Drift, and transfer all spoil onto the Steel Cord Belt, so again timing of completion was critical.

Finally, there was a requirement to extend the Steel Cord Belt to match the advance of the tunnelling machine.

In the original enquiry the NCB had programmed the installation as follows:

Initial commission at 5000m
Drive Spine Roadway until conveyor could be extended to 12500m.
Drive Spine Roadway until conveyor could be extended to final length.

Now these requirements led to a number of important considerations. Firstly, if the steel cord belt was to convey out the driveage spoil, a linking conveyor system would have to be installed, and extended, between the tail end of the steel cord belt and the tunnelling machine, and this could have been as long as 7500m.

When the steel cord belt conveyor had to be extended, this intermediate conveyor system would have had to be dismantled and removed, and an alternative system linked into the North Drift, to allow driveage of the South Drift to proceed.

Finally, during the time of the Steel Cord Belt extension from 5000m to 12500m, there would be no operating of this conveyor, and all production would have had to be switched to the North Drift.

The same problems would have been repeated during the final extension to 14930m.

In the design of the conveyor provision had been made for installing all the belting completely from the Surface Drive House. The surface plant included a Let-Off reel unit for new belt, a full vulcanising station, belt clamps, and a winch unit to allow belt to be lowered into the drift by traversing of the loop carriage. The tail end was wheel mounted, and ran on longitudinal floor girders, on which the conveyor structure was also mounted.

We discussed with the NCB the possibility of extending the conveyor in increments of one belt, to match the advance of the tunnelling machine. The tunnelling machine was planned to achieve an advance rate of 100m+ per week, and two weeks driveage was the equivalent of extending the conveyor by one belt length.

If this extension could be achieved over a weekend then loss of production time would be minimal and by providing an advancing overlap conveyor system between tunnelling machine and tail end of the steel cord belt conveyor, then any additional conveyor equipment would be eliminated. Such a system would give extreme flexibility, and leave the North Drift roadway clear of any switch over problems.

The decision was taken to proceed along these lines, and in order to achieve the turn round time required, the making of the belt joints was fully mechanised, including the use of a single operation guillotine to cut the belt, and a special cover stripping machine.

Belt clamps were remotely controlled, and of full hydraulic operation, and the tail end was fitted with an hydraulic self advancing mechanism. The full operation of cutting the belt, inserting a new length, extending the conveyor, and completing the joining of the belt and aligning of the conveyor is discussed under Section 3, and the whole operation was programmed to be completed in 72 hours.

2.2 Installation to First Commissioning Length

The main surface plant was completed, with the exception of the drive pulley, motors and switchgear, and belt washing and drying equipment. All belt installation equipment, clamps and vulcanisers were installed and commissioned prior to the start of belt and conveyor structure installation.

The first reel of belt, 440m long and weighing 38,72 tonnes, was lowered into the Let-Off Reel unit in the Belt Change House, and the Let-Off unit traversed across until the reel was located on the centre line of the conveyor, and was latched in position.

The tail end unit was located within the Portal, complete with its self advancing mechanism, and by a rope and winch system the belt was pulled through the loop take-up area, over the portal bend pulley, around the tail end unit, and up over the conveying idler sets on the gantry. It was then pulled around a temporary pulley located in-bye of the main drive pulley position, and then pulled back down over the gantry, overlapping itself.

This last length, overlapping on the gantry, would be the belt that would eventually form the return length from the drive, around the fixed loop pulley, and through to the loop take-up carriage, to complete the full belt loop.

This overlap length was then clamped off in the gantry area for the duration of the conveyor extension, up to the first commissioning length.

The procedure for belt installation was then introduced.

Clamp 'D' was closed and clamp 'B' opened, and by means of the main winch the loop carriage was moved to the out-bye end of the loop area. Clamp 'B' was then closed and clamp 'D' opened, so that the belt was now held via clamp 'B' (in the loop carriage), and the belt installation winch.

By putting the belt installation winch into the 'Render' position, and starting the advancing mechanism of the tail end, the tail end was moved in-bye with the loop carriage and belt following it.

As the tail end was advanced, a gang of men would install a line stand every 6 metres, on the longitudinal roadway girders, bolting it to the girders and fitting the 'V' return idler set and the troughing idler set. The tail end unit was provided with a hogging frame to lift the two runs of belt to provide access for the fitting of the top and bottom idler sets.

All operations were controlled from a Belt Installation Desk at the out-bye end of the loop take-up area, and the operator at the tail end. Both operators were in continuous communication with each other.

Strict regulations were laid down for the two operators, the one at the tail end being responsible for the starting and stopping of the advance of the tail end. In addition to the voice communication, a system of bell signals was introduced to indicate readiness to start operations, and to start or stop the operation.

With a 15 tonne tail end unit descending a 1 in 4 drift, followed by belt weighing 88kg/m run, there was a considerable load that had to be carefully controlled from both locations. It is indicative of the precautions taken, and the responsible attitude of the men involved, that throughout the whole period of installation there was only one very minor accident, with the man concerned back at work within two days.

When the loop carriage reached the in-bye end of the loop area, operations were stopped. Clamp 'D' would be applied, and proved to be 'on', and Clamp 'B' opened. The winch would then pull the loop carriage back to the out-bye end, Clamp 'B' be applied and proved 'on', and clamp 'D' opened, and extension operations continued.

This sequence of operations continued until the end of the belt was spotted at the out-bye end of the vulcaniser. At this point all extension operations ceased, and a new belt was introduced into the Let-Off unit, and the end of this new belt pulled through to the vulcaniser.

As explained earlier, the process of belt jointing had been highly mechanised for this project, introducing procedures never before undertaken in steel cord belt joint making.

Each joint was of 6m length and was of the Type 3 configuration, but specially modified. Each new belt was delivered from the Factory with pre-stripped covers, to eliminate cover stripping time at site. The vulcaniser comprised two single piece plattens, the lower permanently located between the loop carriage tracks, and the upper located to the side of the loop take-up area. The upper platten was provided with a pre-heat table.

Pre-formed back covers, with grooves to accept the steel cords, moulded to the exact splice layout, were built-up on the top platten, and pre-heated on an aluminium plate. Meantime the cords in the two ends of the belts were separated and stripped, and laid back over grooved guide rollers. Once pre-heated as required, the back cover and its aluminium plate was slid down onto the bottom platten. The steel cords were then cut to length by hydraulic shears, and laid into the pre-formed grooves, and the top cover placed in position.

By means of swinging arms and traversing rollers, the upper platten was then moved over the top of the lower platten, and by small hydraulic jacks lowered into position. The two plattens were then bolted together and hydraulically clamped to the required pressure, this pressure being automatically maintained throughout the vulcanising and curing process.

Both plattens were fitted with dual heating circuits so that should a failure in one occur during the vulcanising cycle, the other would maintain temperature. With such a large and important joint it was absolutely vital that the vulcanising and curing operations be undertaken under strict and precise control. To this end the temeprature at selected points of both plattens was continuously monitored, and a trace record kept of each temperature point.

At the end of the heating operation, the plattens and belt were allowed to cool, but again this was rigidly controlled. Each platten was fitted with a series of slots through which cooling air was drawn via a fan and ducting system. Again traces of all temperature points were monitored, thus at the end of the curing process not only had the operations been accurately controlled, but a detailed record of each joint was obtained for future reference.

The fan and ducting system for the cooling air, was designed to serve a dual purpose. All along the loop take-up area and the vulcaniser, gas monitors were permanently located, and these were set to automatically switch on the fan if fumes from the toxic fluids (used in the jointing process) started to build up and were detected, thus drawing the fumes away from the work area, to discharge to the outside of the building. This system would automatically override the cooling system if fumes were detected during the curing process.

By means of all this specialised equiment, and techniques developed by the Belt Manufacturer, it was possible to make factory quality joints to a very precise and repeatable design, and thus ensure that each and every joint had a rating of 90% or more of the breaking strength of the belt. This was of extreme importance on an installation of this size, and operating at a Safety Factory of 5 to 1.

In addition, the equipment and procedures allowed a joint to be made in 16 hours, and this was of special importance for future belt extension. The Belt Manufacturer's estimate for making this size of joint using conventional methods and equipment was in the order of 48 hours, so it can be seen that considerable gains had been achieved.

Whilst the belt joint was being made, the newly extended conveyor was aligned and levelled. Very considerable importance was attached to this as it was vitally important that the alignment and profile of both top and bottom belt, be as perfect as possible, and that all belt and idler resistances be kept to a minimum. In our design we had allowed for a resistance factor of no more than 0,015.

The Spine Roadway was being cut by a full face tunnelling machine, and therefore a floor had to be formed by a back fill. Despite compaction, such a floor was subject to settlement, and this was further aggravated by the passage of the 15 tonne tail end unit, that created further impaction through the roadway girders.

It was, therefore, necessary to survey the levels of each roadway girder at each line stand location, and to plot the results on a scaled graph. To achieve the accuracy required the graphical layout was a vertical scale of unity, and a longitudinal scale of 200 to 1. From this layout of the levels of the two roadway girders, a smooth, though gently undulating, conveyor line was established, and the distance between this line and each line stand location measured.

These figures were taken underground (each linestand was numbered from the surface), and the appropriate thickness of packs placed under each foot of each linestand to achieve the convyeor line required.

Having achieved the correct profile in a longitudinal direction it was now necessary to centralise and square each linestand and idler set, and very accurately level both top and bottom idler sets.

Due to the spine roadway following the lie of the coal seam, which was dipping to the North East, but at varying gradients, it was decided that it was not practicable to use a laser beam for the alignments. We therefore had to devise a system of surveying the run of the centre line of the spine roadway, and setting up of a very accurate line offset to the walkway side of the conveyor. From this line plumb lines were hung and moved in-bye to each linestand location.

A special alignment frame was mounted on the top of the troughing idler set, and straddling the belt, and a similar frame on the return idler set. From these, and the survey line, the linestand was centralised, and the stand and idler sets set square. Then each idler set was accurately levelled, using a spirit level set into each alignment frame, and the individual top and bottom sets shimmed and bolted in position.

Once these operations and the belt jointing was complete the next extension could be undertaken. All installation and alignments were carried out on day shift, with the conveyor structure and idler sets being taken underground on the backshift. The belt jointing was carried out on a continuous basis.

Like any new undertaking we had our operational problems The advancing mechanism of the tail end incorporated spring loaded 'on', hydraulic 'off', clamps that gripped the longitudinal girders, and which were connected to the tail end by hydraulic cylinders. The gripping medium was brake lining material, and initially the system worked well. However, we gradually got a build up of dirt and paint impregnating the brake linings so that they slipped. They also became damaged as we crossed joints in the roadway girders.

The units were temporarily replaced by a winch system, which slowed down operations, and were then re-installed with units incorporating steel liners fitted with a series of tungsten carbide tips. These liners cut through the dirt, and were not subject to damage at the roadway girder joints. So successful was the overall system, that once a full learning curve had been achieved by all teams, it was possible to extend the conveyor by 3 belt lengths per week, or 651 metres.

Whilst these extension operations were in progress, the drive pulley and its bearings were aligned and installed, this again requiring very special alignment techniques and equipment. To remind you of the size of the installation it required a 125 Tonne overhead crane to lower the drive pulley and bearings into position. The pulley and integral shafts (Single piece forging) weighed 90 tonnes and each bearing 15 tonnes.

This was followed by the fitting of the 13 tonne anti runback clutches, one to each side of the bearings, and then the fitting of the 35 tonne motor armatures onto the ends of the drive shaft, and the two DC Winder motors. Also all cabling installation, Main Switchroom, Cable Gallery, Reactor Room and transformer installations were in progress.

The whole project had to be very carefully programmed as we had to ensure correct interfacing with our own Sub-Contractors which were 10 or more in number, as well as interfacing with the NCB, the Civil Contractors and the Building Contractors.

Throughout the whole of the installation period we were successively taking over each section of foundations as they were completed, and carrying out our own installation. This frequently involved the buildings being constructed around us, cladding, building furnishing, cabling, painting etc all proceeding as we carried out installation.

Other than the installation of the gantry and rail layout for the rope haulage system, which was commissioned in April 1981, we were not scheduled to start conveyor installation until all the surface buildings were completed. However, the foundations and buildings were well behind schedule, and we re-arranged our programme to allow construction to proceed, and reach the point of belt installation whilst the foundations and buildings were being constructed.

It was only as a result of careful planning, co-ordination, and the willingness of all parties to compromise and adjust, that allowed the whole scheme to reach a successful completion.

Once the drive and snub pulleys had been installed, and the initial commissioning length reached, the belt that was overlapped on the gantry was released and pulled around the drive and snub pulleys, and into the loop take-up, and the final joint made.

The belt washing and drying equipment was installed, all cabling completed and the initial fill of the gantry weight box made to provide the requisite T2 tension for the start of operations.

All equipment was now ready for first commissioning.

2. Commissioning Of Initial Length

2.1 The Auxiliaries

Before running the belt it was necessary to commission all the auxiliary equipment. We had of course already commissioned and used the belt installation and vulcanising equipment.

The belt washing system was monitored, flows adjusted, and all safety devices checked for correct operation. We could not at this stage monitor the drying side until the belt was running.

The Gravity Weight box was raised and lowered in the 22m deep pit to check for freedom of operation, and correct tripping of travel limit switches. The Capstan unit was set to the correct operating levels, and the brake sequencing with the Belt Tensiometer checked.

Both the Main Bearings and the two anti-runback clutches required force feed oil lubrication from two separate packs. Like all other equipment these systems were fully monitored, and all essential auxiliaries had full duty-stand-bye units, so that the stand-bye would be automatically switched in, in the event of any problem with the primary equipment, without stopping the conveyor.

Equipment involved in duty stand-bye was :-
Filters for cooling air for DC Motors.
Fans for cooling air for D C Motors.
Belt Washing pumps.
Compressor Controls.
Vacuum pumps.
Lubrication systems for main bearings and clutches.
Capstan power pack supply.

All auxiliaries were started up in sequence and proved to be running satisfactorily before the conveyor belt could be started, and all this required full monitoring. All other monitoring equipment had to be proved safe, and the signalling and communications equipment over the full length of the conveyor and surface installations shown to be clear and operable.

The signalling and communications equipment was zoned throughout the length of the conveyor with a major zone at the surface, and others at 2,5 kilometre intervals. Each major zone was split into minor zones that allowed the pin pointing of a trip out to within a distance of 270m.

All pulley bearings, including those at the tail end, were fitted with Shock Pulse monitoring equipment, with a full display at the local control desk in the Main Switchgear Room. This desk also displayed the condition of the communications and signalling system, the exact location of any temperature fault, and monitoring of belt wander switches.

All principal functions, ie operating correctly or malfunctioning, were displayed on the GEC GEM 80.

Auxiliary commissioning was completed once all auxiliary drives were proved to be functioning correctly, and that correct displays were coming up on the Control Desk panels and the GEM 80.

Prior to pulling the belt around the drive pulley, to complete the belt loop, GEC had installed and cabled up the main drive motors, and the full drive system had been put through its paces, including running the motors over their full speed range. Fans and filters for the main motors checked, and the normal Winding Motor control gear procedures gone through, including the check programming of the GEM 80.

Whilst we could control and run the conveyor from the desk in the Main Switchgear Room, the system had to normally operate from the NCB's main Control Room. This involved feeding all sequence controls and condition monitoring via a high level data link to the NCB Main Computer and Control Room.

However, for initial commissioning it was decided to operate the conveyor manually from the main switchgear room.

2.2 Commissioning The Conveyor

For this operation we had men located at all principal pulley positions, including the tail end, and further men spaced out along the length of the conveyor.

Representatives of the Principal Sub-Contractors were also present, and monitoring their own specialised equipment. All personnel were located near to a commumications point, and could speak directly to the Control Desk or any other major point. In addition we had portable radios for the Senior Site Staff to communicate and give orders from any location within the Surface Plant.

All auxiliaries were sequence started and confirmed as functioning correctly by reference to the Control Desk, and staff reporting to Control.

The pre-start alarm was then signalled, flashing beacons already warning of auxiliaries running, and the pre-start alarm checked that it continued to sound until tail end pulley movement was detected by a monitor and signalled to the Control Desk.

For this initial run the belt was only operated at creep speed, and verbal reports taken from all observed locations. Only when it was reported from all locations that the belt was running clear and smoothly, and that the gravity weight and capstan unit had functioned correctly, was the conveyor run for any length of time.

Our programme was set-up to run initially at 10% of full belt speed for a full cycle, and if all systems and the belt were operating satisfactorily, we would then step up for a full cycle to 20% and on in 10% increments to full speed.

With something like 10½ kilometres of belt, at 10% of full speed one cycle of the belt took nearly 3½ hours, and this was more than enough time to check all areas for satisfactory running.

It is perhaps indicative of the care taken to align the idlers and pulleys throughout the length of the conveyor, that in the initial run we experienced no off-tracking of the belt, and in fact had only to adjust 3 or 4 horizontal rollers in travelling frames in the loop take-up area. This pattern remained throughout the full commissiong programme right up to 8,4 m/second belt speed.

As we had to work on a single shift the full speed range took just over two days to complete, as we also carried out stopping and re-starting sequences to check all functions as operating correctly.

In our designs we had taken special precautions to ensure that the high belt speeds involved would not create belt and idler resonance problems, which could have caused serious hammer of the belt to the detriment of idlers and supporting structure, as well as the belt itself.

It is interesting to note that no problems were observed over the full speed range, and this was particularly pleasing in respect of the carrying belt as we had no material on the belt, and this would normally have a considerable dampening effect.

Once these trials were completed, and several cycles at full speed had been obtained, the system was set to operate at a fixed speed of 3,5 m/sec, as this was the speed best suited for the initial running with the single feed point from Wistow Colliery. At this point the conveyor was switched via the high level data link to the main Control Room, and operated by the NCB.

A number of problems arose in the transmission through the data link, and also the signalling system created some problems in the zoning and at the various out stations. All problems were of a minor nature and invariably involved some minor adjustment, or replacement of a faulty card. Within a fairly short time the system was being controlled successfully from the NCB Control Room, and some material was fed onto the conveyor, and taken through the ROM Plant to help prove this area.

Although there had been some delays in the installation programme, mainly of an interfacing nature with other Main Contractors, it proved possible to make an offical Handover to the NCB on 27 June 1983.

Thereafter coal from the first production face at Wistow was conveyed to the ROM Plant at a rate which varied around 800 to 1000 TPH level. Spoil from the two roadway driveages was also fed onto the conveyor, now freeing the North Drift for the Cable Belt installation.

3 The First Extension

3.1 Preliminaries

The extension was planned to take place during the Pit shutdown for the annual holidays in August 1983. The extension was for a single length of belt to increase the commissioned length from 5192m to 5402m.

As the extension was being undertaken in a holiday period it was decided to carry out all operations on a day shift basis (with the exception of the belt splicing which had to be a continuous operation), as opposed to 24 hour continuous shifting for a weekend extension.

In order to monitor all operations, both those undertaken by the NCB and those by Anderson Strathclyde and its sub-contractors, it was decided by the NCB that teams of their Time & Motion Study personnel would be in attendance at all times, both at the Surface Works and at the tail end.

The outcome of these observations would be to assess the realism of the undertaking of a weekend extension in 72 hours, to see where problems could be eliminated, and where improvements could be made.

3.2 Initial Preparations

Prior to the start of operations a reel of new belt was placed in the Belt Let-Off Unit, and the unit traversed into position. Two vulcanising kits were delivered to site, and made ready. Belt clamps were checked and cleaned, including the related power packs, and the vulcanising area thoroughly cleaned.

Packs for placing under the feet of the linestands to achieve the required conveyor line, were obtained, the quantity and sizes being based on the experience gained during the initial installation length.

The belt joint to be removed was also decided upon. All joints when made had a joint number embossed on the side of the belt for recognition purposes, and all edges of joints were orange coloured for ease of identification.

It should be noted that the NCB decided that any extensions should not involve there being any more joints in the final length of conveyor than if the conveyor had been installed in a single installation. Thus at every extension an existing joint was to be removed.

3.3 Operations

The first step was for the NCB to take the conveyor off Central Control, and switch control to the Belt Installation Desk. From this position the belt can be run from creep speed up to 10% of full speed.

The belt was then run at 10% speed until the selected joint was brought into the loop take-up area. The belt was then run at creep speed to bring the joint to the outbye end of the vulcaniser where the belt cutter was located. The belt was stopped with the edge of the joint over the cutter base.

Belt Clamps 'C' and 'D' were then closed and proved to be 'on', and the belt support trolley moved to the in-bye end of the loop area. The gravity weight box was lowered to the bottom of the Gravity Pit by the Belt Installation Winch, and the Capstan unit locked off. The belt was then allowed to relax by releasing the loop carriage, so that the belt lay on top of the bottom half of the vulcaniser.

The Guillotine cutter was placed in position and connected to the power pack, and the belt cut. The Clamp 'B', in the loop carriage, was closed, and by connecting the carriage to the 10 tonne Winch the carriage and belt was pulled in-bye, overlapping the two cut ends of belt, until the out-bye end of the joint was over the cutter position. The belt was then cut and the old joint removed.

The end of belt in the loop carriage had then to be taken out of the way to allow the new belt to be joined to the existing belt, and for the extension to be undertaken. Mechanical fasteners were fitted to the cut end of the belt and the belt was then pulled manually through Clamp 'B' and the loop carriage. A rope and belt leader were pulled off the Belt Wind-Up unit and attached by the mechanical fasteners and a pin to the cut end of belt. By operating the drive on the Belt Wind-Up unit the end of belt was pulled up out of the way.

The end of belt lying on the vulcaniser now had to have its covers stripped, and for this operation the cover stripping machine was brought into operation for the first time. The unit is fully powered with a traversing rotary cutter, and removes one cover at a time in a single sheet.

Once both covers were removed the belt was prepared for jointing and the end of the new belt pulled off the Let-Off Unit and brought to the vulcaniser. A joint was then made in exactly the same manner as described in the Installation Section of this Paper. The whole process of cover stripping and jointing the belt was undertaken in 24 hours.

Whilst these surface operations were taking place, preparations were being made at the tail end. Firstly the NCB disconnected the feed conveyor to the tail end of the Steel Cord Belt, and moved this, and the overlapping bunker conveyor, in-bye by 210m to allow for the extension.

The NCB also connected up a trailing cable to the tail end unit, so that the power pack for the advancing mechanism could be operated. Meanwhile 210m of communication cable and relevant fittings were attached at the tail end, and the loose cable laid out on the top belt. This was essential so that during extension operations the operator at the tail end would always be in communication with the operator at the Belt Installation Desk.

Train loads of conveyor structure, idlers and linestand packs were made up in our Site Compound, and taken underground and off-loaded along the line of extension.

Once the belt joint had been completed and the tail end area readied, belt extension was undertaken in exactly the same manner as was described in the Installation Section of this Paper.

We did, however, run into a serious problem which caused quite a delay. After the tail end had been extended and we set up the survey equipment to check the line of the conveyor, it was found that the roadway girders were offset towards the centre of the roadway by about 100 to 120mm, and this turned out to be due to the floor level being below specification and causing the circular rings supporting the roadway, to limit the alignment of the girders.

It should be noted that the roadway girders were installed by the Tunnel Driveage Contractor, and were used for the mounting and advancing of the Bunker Conveyor System between the tunnelling machine and the tail end of the steel cord belt. It was a contractual agreement that the NCB would ensure that the roadway girders were levelled and aligned to within 25mm vertically and horizontally of the datum conveyor line.

To rectify the situation, we then had to lift and re-align the roadway girders, packing under these until the correct level and alignment had been achieved, and this with the full weight of the conveyor on the girders. Each 6m section, including belt, weighing over 1½ tonnes.

After this the preparations for aligning and levelling the top and bottom idler sets were put in hand, but a new operation had now to be introduced.

In a single belt extension we were cutting out a full joint and making two new ones. Compared to the initial installation of continuous jointing, we were, therefore, losing 13m of belt, and this had to be brought around the conveyor to maintain the loop carriage in its correct location when running the conveyor.

Therefore, in this exercise the tail end of the conveyor was extended until the tail end of the new belt was 13m from the vulcaniser, at which point tail end extension was stopped. The loop carriage, however, was continued to be moved in-bye till the end of the new belt was located at the out-bye end of the vulcaniser, the 13m of belt being lowered down the drift as slack belt. Clamp 'D' was then applied and proved to be 'on'.

The loop carriage was moved out-bye to leave the end of the new belt on the vulcaniser, and was then positioned 13m in-bye of its position prior to the start of the extension. The end of the old belt was recovered from the Belt Wind-Up unit and fed back around the loop carriage pulley and through Clamp 'B'.

Clamps 'A' and 'B' were closed and the loop carriage held on the installation winch whilst Clamp 'C' was opened. By operating the installation winch the loop carriage was pulled out-bye for 13m, pulling the 13m of slack belt through the system. This then brought the end of the old belt correctly over the vulcaniser for the making of the second joint.

In this operation the cover stripping machine was used to strip the covers from the old belt, and the second joint was made.

Once the belt joint was complete, and all alignments had been completed, and the communications and pull wire system correctly installed along the extended length, the conveyor was prepared for re-running. The Capstan brakes were released and the Gravity Weight box raised to its operating position, and the belt support trolleys re-located in the loop area. At the tail end the power supply was disconnected and the feed conveyor re-connected by the NCB.

With the conveyor still on local control at the Belt Installation desk the conveyor was run at 10% of speed to check correct running and alignment of the new section, and no adjustments were found to be necessary. It was then put back to remote control from the NCB Computer and Control Room.

3.4 Summary of Extension

As already mentioned, Time & Motion Study personnel monitored all operations, including those of the NCB. The programme suffered a number of delays, not the least being the need to lift and re-align the roadway girders. There were delays in getting men and materials underground at times, and we experienced some trouble with one of the belt clamp power packs.

Of particular interest was an electrical fault with one of the heating circuits of the vulcaniser. As a result of the fault the vulcanising and curing cycle became extended, but because of the monitoring and control equipment that we employed for this Project, it was possible to control the problem and finish up with a satisfactory joint.

On standard vulcanising equiment such a fault could easily have resulted in an unsatisfactory cure and thus a suspect joint. Therefore, it is of vital importance wherever a belt is being used with a low Safety Factor, to positively ensure that the vulcanising and monitoring equipment used will be suitable to guarantee a sound joint.

On major installations, Type 2 or Type 3 joints will be the norm. With the highest quality joint a rating of 90% of the breaking strength of the belt is the best that is likely to be achieved, and this has to be allied with a starting (breakaway) torque of some 120% of full load torque. In these circumstances, with a joint at the peak tension area, the operating safety factor is reduced by 25%. A belt with a working Safety Factor of 5 to 1 will have a joint Safety Factor at start-up of 3,75 to 1.

It will be seen, therefore, that the quality of the belt joint is of the utmost importance, and whilst the initial outlay in suitable equiment may be high, the long term benefits in a safely operating installation are considerable.

A detailed examination of the Time & Motion Study figures showed a number of areas where reduction in time could be achieved both by the NCB and the belt installation teams. Changes in certain operations were proposed, and modifications carried out to equipment which had suffered operational problems during the extension.

The Time & Motion Study people concluded that with all their recommendations being adopted a weekend belt extension could be achieved in 65 hours. Bearing in mind that all teams would be working 12 hour shifts, and minor problems are bound to arise, the author was of the opinion that the previously estimated time of 72 hours would be a more realistic figure.

4 The Initial Operating Experience

4.1 Initial Production Output

As referred to earlier, the NCB started production from Wistow Colliery, with the first longwall face A1. This output was fed from the Wistow bunkers via a bore hole slit, onto a short scraper conveyor, located across the Spine roadway, and then via a chute onto the first accelerator conveyor.

Spoil from the North Drift driveage was also fed on at this point, and spoil from the South Drift was fed onto the tail end of the conveyor.

At the head end of the conveyor the material feeds into a very large hopper chute, of others supply, that incorporates a two way 90° discharge onto one of two ROM conveyors. Coal and roadway spoil are then conveyed to separate locations in the ROM plant, and then to rapid train loading stations.

4.2 Operational Experience

In general the Conveyor ran extremely well, right from the start of the Take-Over. Like any major new installation it suffered from a number of teething problems, mainly associated with the electrical control and monitoring side. Our Site Staff were available at all times, and stand-by staff were arranged for the first few weeks of each of our main Sub-Contractors. Consequently, problems were dealt with in a very short space of time, and the NCB participated in any trouble shooting, thus gaining a detailed insight into the whole system.

Prior to the NCB taking over, we gave several teach-ins to the NCB personnel who would be operating the conveyor, these teach-ins being supported by specialist instruction from several of the Main Sub-Contractors. These teach-ins were additional to a very substantial Library of Operating & Maintenance Manuals, supplied in 3 sets to the NCB and covering all aspects of the conveyor. The Electrical side alone ran to some 11 Volumes.

One problem that showed up at an early stage was the failure of a very small number of both troughing and return idlers. These were scattered throughout the conveyor, and initially were a complete puzzle, as the belt was only running at 42% of full speed.

Due to the very high loadings and the required life expectancy of the idlers, we had used spherical roller bearings in the rollers, and we quickly discovered the cause of the problem. Less than 1% of the rollers had been assembled with all the tolerances on the limit, and in assembly this had created an end pre-load on one of the bearings. In running, the bearing concerned heated up, and this in a number of cases led to the roller being replaced.

However, some rollers initially heated up and then lost temperature, and thereafter operated satisfactorily. We concluded that in these cases the initial temperature rise had allowed relative movement to take place axially thus relieving the pre-load.

We immediately Shock Pulse monitored all remaining idler rollers in our compound, and found a small number that might be suspect. These were removed for examination and rectification.

Thereafter the problem disappeared and the conveyor idlers operated perfectly, including those used in the first extension, and which had been monitored prior to installation.

During the early design stage we had carried out extensive fatigue life tests on the idlers, at full load and full belt speed, in a specially built test rig, and not once did we experience this end loading problem. The NCB also tested a number of rollers at their Research Centre, and these all passed the test with flying colours.

Nobody to our knowledge has previously used spherical roller bearings in welded idler assemblies, and it emphasises the fact that pre-production testing may be extensively undertaken, and yet a minor problem does not show up until after the production stage.

One very important feature of this conveyor was the design with a low resistance factor of 0,015. We were therefore very interested to obtain resistance readings with the conveyor operational. However, this could only be done with the conveyor empty as the NCB feed arrangement did not include any weigh equipment that would have permitted accurate loadings to be taken.

At the start of operating the conveyor we obtained figures that indicated an overall resistance factor of 0,022, but as the conveyor ran-in subsequent figures reduced until in August 1983 we were recording readings of 0,0169. Since we could expect this figure to be less with a loaded belt, and since all the drive, cleaning, tensioning and pulley resistances at both head and tail end already existed, we could reasonably expect a reduction in the figures as the conveyor was extended towards full length.

The figures were most encouraging, and clearly showed that the efforts spent on accurately aligning the conveyor and idlers, the care taken in the profiling, particularly at the brow section, had all paid off, and that the idler rollers were performing as expected.

It may be worth noting that with an operating tension of 184 tonnes, and a starting tension of 195 tonnes in the brow area, when the conveyor is at full length, had demanded very careful design of this curve. The belt had to have good load support, and the stresses in the steel cords had to be evenly distributed across the belt to avoid localised overstressing. We designed for a 450m radius with idlers pitched every metre, and a troughing angle from start of the curve to the head end of 17½°. Every idler in the curve, during installation, was surveyed for level, and then shimmed so that the centre roller of each set was within 1mm of the true radius.

Some operational problems occurred with the discharge chute in respect of the operating doors on the two way discharge legs, and on one or two occasions led to the filling up of the chute and flooding of the Fines Conveyor that carried the dirt scraped from the belt into the chute.

The Contractor who supplied the chute, and the first phase of the ROM Plant, quickly solved the problem and the whole system continued to operate to everyone's satisfaction.

The Belt Washing System functioned well, and in particular the belt drying worked perfectly, the belt returning down the drift in a completely clean and dry condition.

The conveyor continued to perform well until after the August extension, and then a catastrophe befell Wistow Colliery. The NCB had been achieving the sort of production levels that had been planned, and which more than justified the money expended on this major project, when the first Production Face was seriously flooded, and initially had to be abandoned.

It was some weeks before the flooding was brought under control, the face recovered and production restarted.

However, the end product was virtually a slurry. It was so bad that on the 1 in 4 drift section the material ran backwards, and when it met a slightly drier section of material coming up the belt, flooded over the sides. This rapidly built up under the conveyor throughout the drift and gantry section, but of more serious concern, was carried back at the spillage areas on the return belt, leading to a swamping of the tail end unit.

As this situation was going to continue for some time, due to the continued ingress of water at Wistow, it became necessary to fit ploughs to the bottom belt to prevent the slurry being carried back to the tail end.

The NCB introduced a screw conveyor to feed the slurry ploughed off the bottom belt back onto the top belt.

In the ROM plant conveyors were brought to a standstill due to the flooding of this slurry at transfer points, and it was only because of the twin conveyor system in the ROM plant that the overall system continued to operate.

It was during this period that the belt washing system came into its own. The mechanical cleaners were largely swamped, but consistently the belt emerged from the belt washing and drying system completely clean and dry. Not once did the conveyor have to be stopped due to the slurry problem.

In operating the conveyor from the NCB Main Control Room, once initial problems with the high level data link had been resolved, the system worked extremely well. At this stage the computer did not vary the belt speed to suit the load, as only one feed point was in operation, and the speed was left on a single setting. At some future point as the additional feed points come on stream, and the Staple Bunkers and feed systems are installed, the full advantage of the variable speed system will be brought into effect, and this and the output from the individual feed points will be controlled by the computer.

4.3 Implication of the Industrial Problem

At the time of writing this Paper the conveyor should have been some 11 kilometres in length, however it is actually still only 5,4 kilometres long.

Before a further extension could take place the National Union of Miners had instituted an overtime ban. This meant no holiday or weekend working, and consequently no extensions could be undertaken.

Production of coal continued, as did driveage in the North Spine roadway. However, the tunnelling machine in the South Drift met a fault and driveage was brought to a standstill until this fault could be negotiated. Whilst this created a problem for the NCB they did at least not have to worry about the gap that would have developed between the tail end of the conveyor and the driveage feed system, had roadway driveage proceeded normally.

The slurry problem had largely disappeared and the conveyor continued to operate in a satisfactory manner despite the limitations of main tenance imposed by the overtime ban.

This state of affairs continued until March 1984, when the NUM called an all out strike, which stopped all mining operations at Selby, and lasted until March 1985.

During this period of time the auxiliaries were cleaned and checked over, and run from time to time to keep everything in operational condition. It also proved possible to run the conveyor for a short period of time on two occasions.

Towards the end of the strike some remedial work was able to be done underground due to a number of miners returning to work. A section of the roadway was found to be misaligned due to floor heave, and this section of the conveyor had to be re-aligned using the system adopted for installation alignments.

On restart, following the end of the strike, the conveyor was put back into operation and was running well, and operating virtually round the clock.

At the time of writing this Paper (May 1985), a further extension is being planned, including another feed point, and two longwall faces at Wistow are now operational. However, a water problem has re-appeared at both faces, and a very wet product is being conveyed, although not as serious as on the previous occasion.

I hope that by the time this Paper is presented I can bring you up to date with the progress of this conveyor.

4.4 Conclusion

Considerable new ground was broken with the conception of this conveyor. It incorporated many completely new and previously untried features and items of equipment.

It incorporated a drive pulley of completely novel design, involving the largest forging undertaken by the British Steel Corporation at their Sheffield Works. DC Winder motors larger than those previously built, including the armatures being mounted directly on the ends of the drive pulley shaft. Also a complex monitoring and control system.

Anti-runback units larger than anything designed or built in the world, and a complete new concept in belt washing and drying.

A tension system combining the best of take-up features, namely a gravity unit operating in conjunction with an hydraulic constant torque system and tensiometer.

A very new form of conveyor structure utilising idlers of special design, and idler pitches of 6m. Combined with a variable speed system that not only allows a very smooth and soft start, extending to some 4 to 5 minutes, but the facility to creep the belt only a few millimetres at a time for belt installation or maintenance purposes, or run right up to a speed of 8,4m/second.

A unique belt installation system with completely novel features including remotely controlled hydraulic clamps built especially for the project, and a unique system of belt joint making and vulcanising equipment. The type of joint developed had never been used anywhere else in the world.

Much of this belt installation equiment and the feature of single belt extensions, resulted from detailed discussions with the NCB's Engineers, also the acceptance in the first place by the Board's Engineers to proceed with such a proposal for a single flight conveyor breaking so many new concepts in belt speed, control and Safety Factors.

The fact that the conveyor operated from the word go in such an effective manner is a tribute to the Board's Engineers and all the various companies involved in this major project. It has opened up new possibilities and concepts for the future of loose bulk material transportation.
