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Practical and Operating Aspects of the Richards Bay Coal Terminal

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SYNOPSIS

TITLE OF PAPER: PRACTICAL AND OPERATING ASPECTS OF THE RICHARDS BAY COAL TERMINAL (CASE STUDY).

The paper deals with the experience of a large modern coal exporting terminal with regard to some of its belt conveyor items, most particular idler and conveyor belting. The presentation concentrates on the experience from a practical and operational view point and discusses some of the more interesting and unusual aspects of the terminals findings in these areas and outlines what the impact or development of these findings may be. The paper does not discuss the technicalities of the investigations carried out but rather seeks to show the practical and operational actions which can or are taken by a large user in his own right in areas of some import to him.

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PRACTICAL AND OPERATING ASPECTS OF THE RICHARDS BAY COAL TERMINAL

1.0 INTRODUCTION

Richards Bay Coal Terminal is situated on the Mhlatuze delta at Richards Bay, a town some 200 kilometres North of Durban, in what is perhaps most commonly known as Zululand. The local environs are picturesque and the area is also of some cultural and historical interest, being better known for its nature reserves, game parks and coastal facilities. South Africa has a long tradition of the exporting of coal originally as ship's bunker fuel : this had generally been limited by port facilities and handling techniques. In response to the international growing demand recognised in the early 1970's for coal as a power station fuel and for steel making the port of Richards Bay, the Coal Terminal and associated rail infrastructure was developed. The Coal Terminal was commissioned in mid 1976 with an initial intended throughput capacity in the order of 12 million tons of coal per annum (Mtpa). Subsequent expansion phases, commissioned in late 1978 and 1980, raised the intended throughput to the order of 20 Mtpa and 44 Mtpa respectively. Additional expansion phases are available to raise the Coal Terminal, as an integrated terminal, in various stages to a throughput of about 100 Mtpa.

Although Richards Bay Coal Terminal makes no particular claims in this field it is believed that it is one of the largest and most modern coal exporting facilities in the world.

The Coal Terminal in keeping with most other modern technology dependent operations in whatever field has many problems relating to its practice and operations : these may range from industrial relations aspects, through heavy mechanical engineering to computerisation. This presentation attempts to discuss from a users view point some practical considerations especially in relation to the Coal Terminal belt conveyors.

2.0 SCOPE OF PRESENTATION

It is intended to consider the Coal Terminal's practical and operating experience with regard to the following belt conveyor items:

- idlers,
- conveyor belting.
- pulleys.

It is perhaps important to retain perspective of the importance of these items to the Coal Terminal to record the following statistic:

Coal Terminal site area	about	105 Hectares
Conveyor belt length	about	45 kilometres
Idlers rolls in use	about	125 000 rolls

The Coal Terminal belt conveyors are arranged in such a way, and its operating practice is such that, multiple routes generally exist to any stockpiled coal. Control of such routes is by a computerised control system which can provide preferred routing.

3.0 GENERAL RBCT CONVEYOR PARAMETERS

In general the principal and majority of belt conveyors at the Coal Terminal comply with the following parameters.

Belt width	1,8m	2,2m
Belt speed	5,3 m/s	5,9 m/s
Belt construction Poly Ply EP	1250/5	Poly Ply EP 1250/5
Capacity - coal	6000 TPH	10 000 TPH
Idlers	3 equal in line : 152mm roll diameter : Fixed frame	
Roll gauge length	642mm	799mm
Troughing angle	45°	45°

As can be seen from the foregoing the Coal Terminal belts are relatively wide with, in keeping with modern practice, rather high belt speeds. In general it is believed that the Coal Terminal's belts are amongst the largest and fastest in the Southern hemisphere if not in the world.

4.0 IDLERS

4.1 TROUGHING IDLERS

Troughing idlers and rolls because of the length of belt conveyors in use at the Coal Terminal and the importance of their availability are a major maintenance item of expenditure. Thus to some extent investigations into idler rolls have been continuous with the development and expansion of the Coal Terminal. During the last phase of coal terminal expansion because of some dissatisfaction with the performance (or projected performance) of the idler rolls particular importance was placed on their selection and design. In general selection was based on widely accepted design criteria with an implied failure rate of about 5% per annum. This lead to the selection of idler rolls with the following principal parameters:

- 32mm taper roller bearing,
- 6,2mm tubing wall thickness.

Soon after the introduction of these idler rolls it became apparent that the idler roll failure rate would exceed that implied in the design criteria of 5% and that in fact the Coal Terminal faced a potential major problem.

4.1.1 CHARACTERISATION OF IDLER ROLL FAILURE

Investigation into the idler roll failure characterised the failure as one in which:

- the wing rolls predominantly failed,
- conveyors without environment protection i.e. where covered gantry section, 'dog house' sheeting etc did not exist, reflected a higher incidence of failure.

The former of these was rather suprising as the equal in line configuration of the idler ensured that the wing roll only carried about 1/4 of the load of the most heavily laden roll, the centre roll. With regard to the latter it was initially thought that environmental considerations contributed to the rolls demise. Further investigation revealed however, that environmental protection was not a factor but rather another characteristic of these belt conveyors : that these belt conveyors carried moving trippers and thus portions of the belt conveyor length ran empty during running.

Consequently it was determined that the idler rolls which predominantly failed were those which ran lightly laden.

4.1.2 FINDINGS OF INVESTIGATION INTO CAUSES OF IDLER ROLL FAILURE

The investigation into the idler roll failure revealed two rather unusual findings. Over and above the usual problems imposed upon the idler roll by economic, design and manufacturing constraints and the execution of these, there were other significant factors which contribute to the idler roll demise. These were:

- out of balance considerations of idler roll
- idler roll end cap rigidity.

(I) Out of Balance Considerations

With belt conveyors moving with the speed of those of the Coal Terminal, out of balance of idler rolls seems to contribute most significantly to idler roll failure. It is believed that this problem is not particular to or compounded by the use of taper roll bearings but is equally true for any bearing selection.

(ii) Idler Roll end Cap Rigidity

The Coal Terminal's access conditions are often such to necessitate a fair measure of rehandling and ultimate hand transportation. Unfortunately the Coal Terminal rolls are relatively heavy and awkward. These two factors tend to result in the idler rolls being dropped or receiving blows to the end cap or exposed shafting.

The following graph Figure I shows the rigidity of some commercially available idler roll end caps. As can be seen considerable variation in idler end cap rigidity exists between manufacturers.

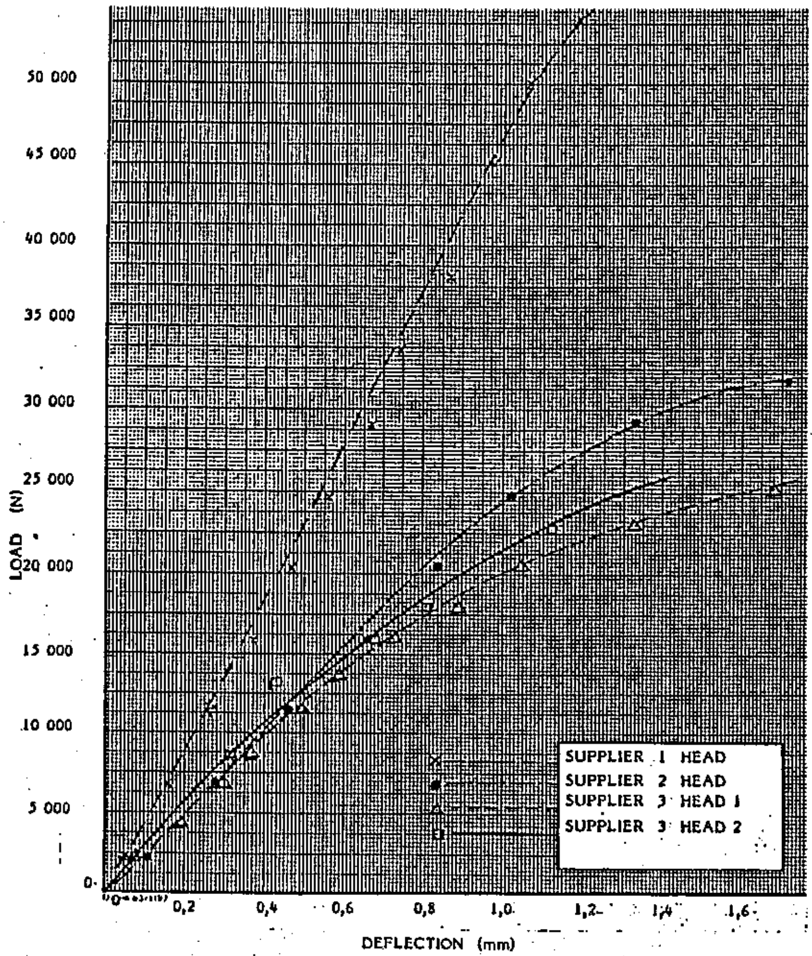

FIG. 1 - Load deflection curves for idler roll end caps.

Whilst the effect of lack of rigidity may be most critical to idler rolls using taper roller bearings, where careless handling may result in loss of preload to the bearing, there is equal evidence of its significance for other 'bearinged' idler rolls. Figure Fig. 2 shows displaced retaining circlip and damaged circlip groove from an idler roll using a deep groove ball bearing.

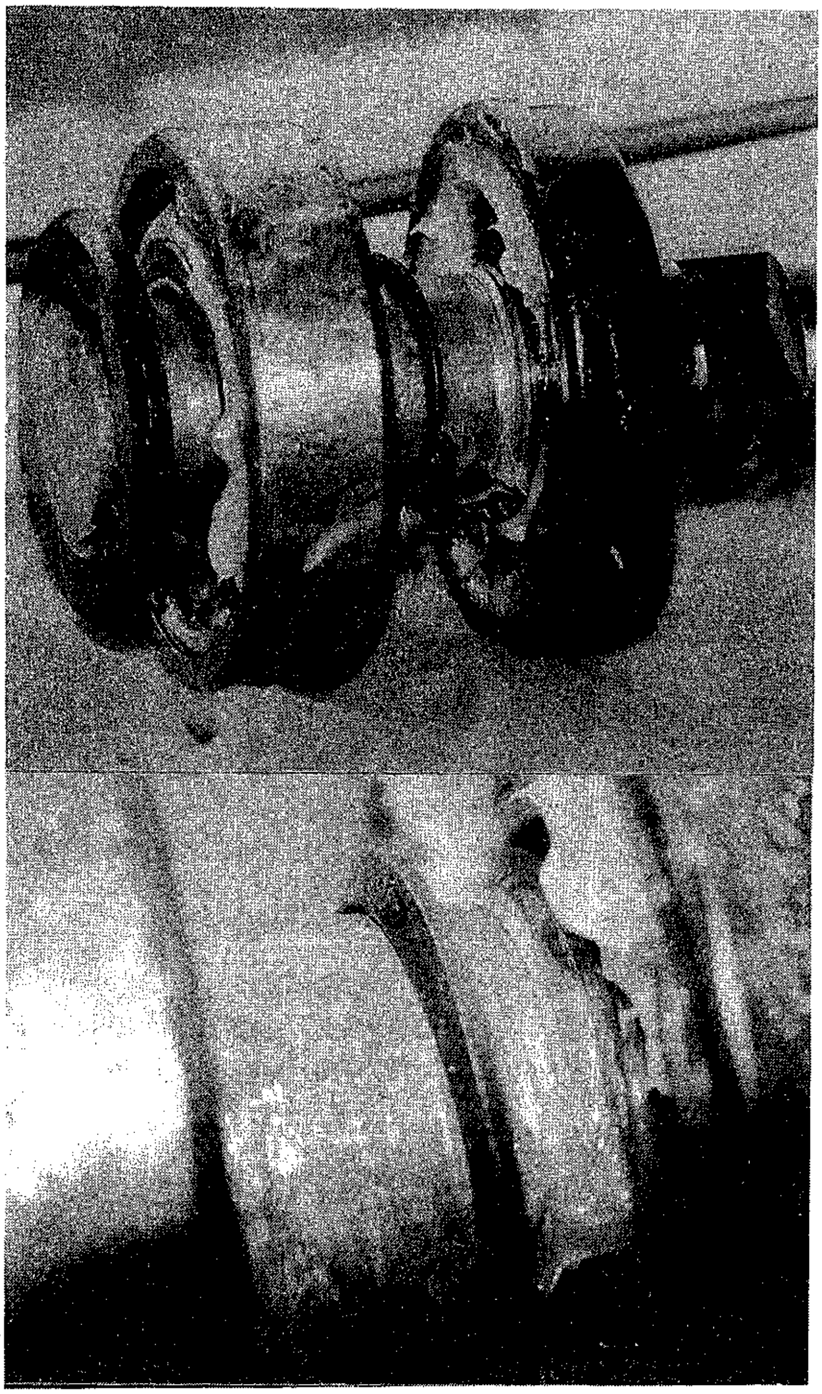

FIG. 2 - Photograph of deep groove ball bearing idler showing displaced retaining circlip and damaged circlip groove.

4.1.3 IMPLICATION OF FINDINGS

The implications of the findings to the Coal Terminal with regard to these rather unusual findings are several, some of them of necessity rather long term. They are:

- limitation of tubing to South African Bureau of Standards specification 657 for idler rolls for use under the Coal Terminal conditions. This will result in time in the Coal Terminal seeking idler rolls with:
  - very low order TIR,
  - very high order balance,
  - improved resistance to abrasion and corrosion.
- importance of idler roll end cap rigidity,
- improvements in package and transportation of idler rolls. This is likely to encompass:
  - idler roll end cap protection,
  - protection to corrosion protected surfaces.

4.2 IMPACT IDLERS

Although the material handled by the Coal Terminal is all -50mm (the majority being in fact -38mm) at loading points, points of impact etc., the Coal Terminal has adhered to the practice of using fixed frame idlers with rubber disc type impact idler rolls. Periodically from these impact idler beds have occurred belt fires of lesser or greater import : impact idler rolls used at the Coal Terminal are:

30 or 35mm deep groove ball bearing,
32mm taper roller bearing,

idler beds and/or fires being indiscriminately distributed between types. The typical scenario for a belt fire is that fire has occurred shortly after a running belt conveyor has been stopped : the fire is associated with a siezed impact idler with/or without the association of spillage existing in the vacinity, normally present on deck or spill plates.

The gaunt after effect of such a belt fire are shown following in Figure 3.

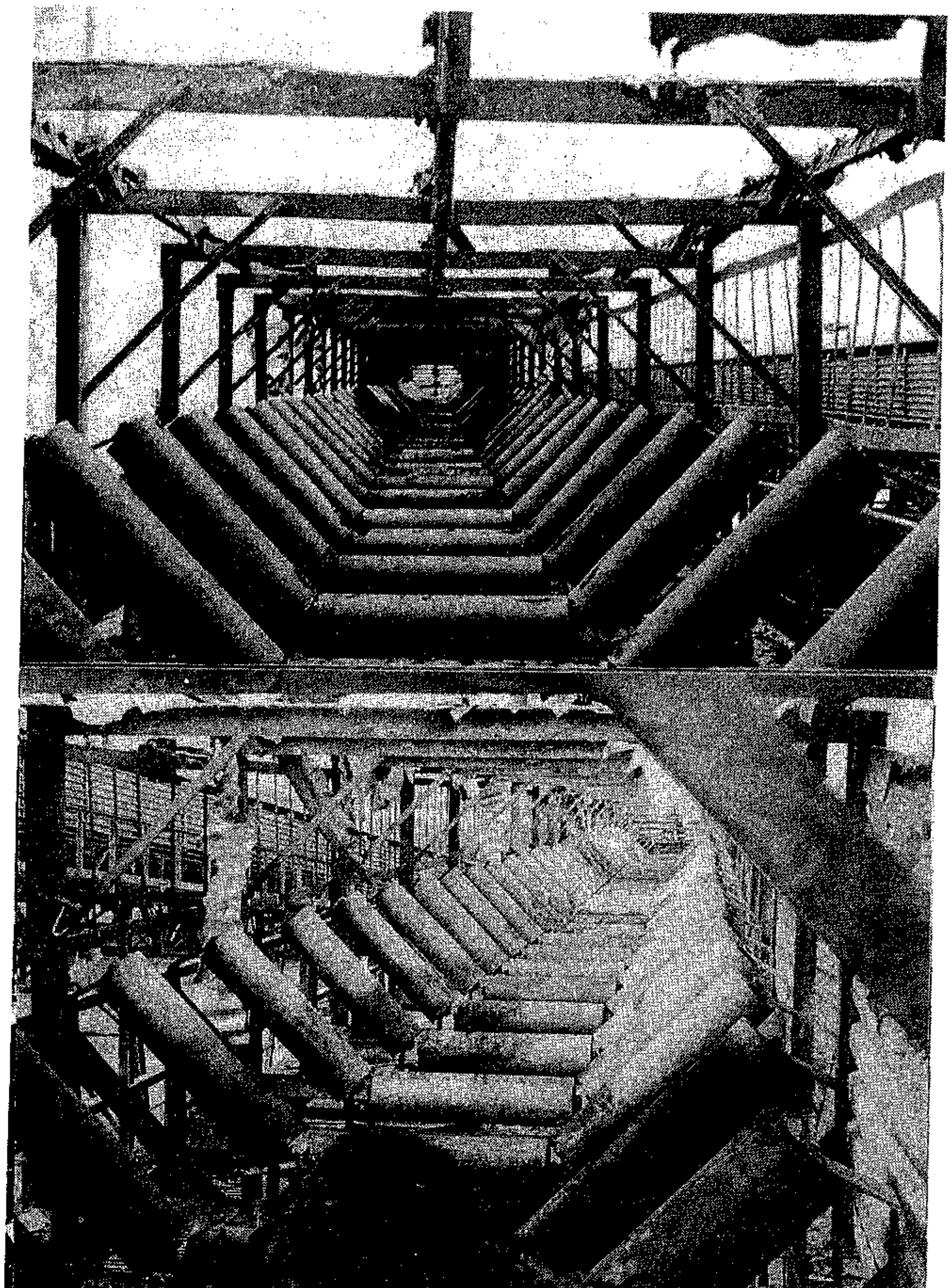

FIG. 3 - Aftermath of fire on gantry section conveyor.

4.2.1 FINDINGS INTO INVESTIGATION INTO CAUSES OF IMPACT ROLL FAILURE

It is obviously difficult to undertake definitive investigations into idler rolls which have been subject to fire and in general no clear cut mode of failure could be defined. From the investigation it did appear that from a practical view point physical replacement of idler rolls was a major difficulty due to the physical configuration of the loading area, idler spacing, loading skirts, spill boards etc. It would seem reasonable that if items are difficult to replace, replacement may be tardy or neglected.

4.2.2 IMPLICATION OF FINDINGS

The main implications of the findings to the Coal Terminal are likely to be twofold and these will attempt to address the practical limitations of the situation. These are:

- use of heavier duty bearing, probably spherical roller type of generous proportions,
- use of readily demountable or 'collapsible' impact idlers and this may encompass
  - garland type impact idlers,
  - 'collapsible' fixed impact idlers ; in this case however, special care will be required to be exercised in design and material construction due to the Coal Terminal's difficult corrosive environment.

4.3 TESTING OF IDLERS

Because of the importance of idlers to the Coal Terminal, the Coal Terminal maintains a number of test beds of troughing idlers on both 1,8m and 2,2m belt conveyor lines. These test beds presently have a combined length of about 300m : an individual test bed occupying approximately 30m length i.e. about 30 idlers or about 90 idler rolls.

A major problem with such a classical test practice is simple:

- even the worst idler roll lasts about a year, only a fraction of its intended life.

Regretfully the Coal Terminal in keeping with most other undertakings does not have a 'history' or a 'lead' of multiple numbers of years for its decision making. At best it would seem that the Coal Terminal might have a 1 year 'lead' upon which to base its decisions. In this context it is perhaps pertinent to remember the Coal Terminal's scale of procurement in this field : in its last major expansion phase the Coal Terminal's procurement of idlers covered 53000 idler rolls with a value of about R2,5 million. Further the testing carried out by RSA idler suppliers is not designed for operating conditions life determination and it is the Coal Terminal's experience that to accede to a design on the basis of 'sound engineering practice' without testing is fraught with risk. Consequently there is some urgent need for an 'accelerated' testing technique.

It would seem from investigation that the most promising line for any accelerated testing technique would be by use of a bearing analyser. The Coal Terminal presently has such an instrument on order and although a number of practical matters (many of them associated with the Coal Terminal's operating parameters) will require resolution, it is hoped to have the instrument operational in the field within a few months.

5.0 CONVEYOR BELTING

As has been indicated earlier the Coal Terminal has approximately 45 Kms of conveyor belting in its belt conveyor lines. Up to the last phase of expansion the majority of this conveyor belting was of imported origin from major European suppliers : the last phase of expansion however, made use of locally produced RSA conveyor belting. This procurement of conveyor belt (of EP 1250/5 class and 1,8m or 2,2m width) was for approximately 27 Kms.

Shortly after the commencement of operation of the last expansion phase problems were experienced with some of the conveyor belt. This was principally in the form of transverse cracks which appeared in both top and bottom covers distributed across the entire surface of the belt : in at least one case these cracks were established to have penetrated through to the carcass of the belt sufficient for it to be decided by the Coal Terminal to change the conveyor belt. As a result a series of investigations were instituted and these were ultimately extended to include other aspects related to conveyor belting e.g. splices, which at some time had proved troublesome to the Coal Terminal.

5.1 DYNAMIC TESTING OF CONVEYOR BELTS

The drawing following Fig. 4 shows a dynamic testing rig for conveyor belts. It should be emphasised that this is a full scale testing rig capable of high or low tension testing. It is broadly based on the reasonable premises that conveyor belt failures will occur as a basis of :

- number of flexures (or cycles),
- tension characteristics of the conveyor belt configuration.

The principle features of the dynamic test rig are as follows:

Belt width	up to 2,2m max
Belt speed	5,1 m/s
Belt tension	up to 471 KNM max
Belt test length	13,2m
Belt cycles	23 per minute (250 000 cycles = 181 hours).

Testing took place over a 6 month period under various operating tension and conditions with a variety of belts. In general the testing was inconclusive and conveyor belt conditions similar to those found in the field were not generated during testing. With the assistance of separate laboratory testing it was however proven that those conveyor belts with least stretch showed failure of the splice before those that were more flexible.

5.2 EXAMINATION OF CONVEYOR BELTING IN USE

Observations of conveyor belting in use on several conveyors indicated a number of faults. Further examination of samples of these conveyor belts, during which the covers and plies were stripped revealed two different types of fault. These were :

- Faults associated with the conveyor belt manufacturing process,
- Faults associated with conveyor belting design or fabric faults.

(i) Faults Associated with the Conveyor Belt Manufacturing Process

These included:

- fabric folds in warp direction,
- folds in fabric associated with one or more plies at varying angle to warp direction,
- faulty longitudinal joints where fabric ran apart, in places up to 25mm and others where there was overlap to the same extent,

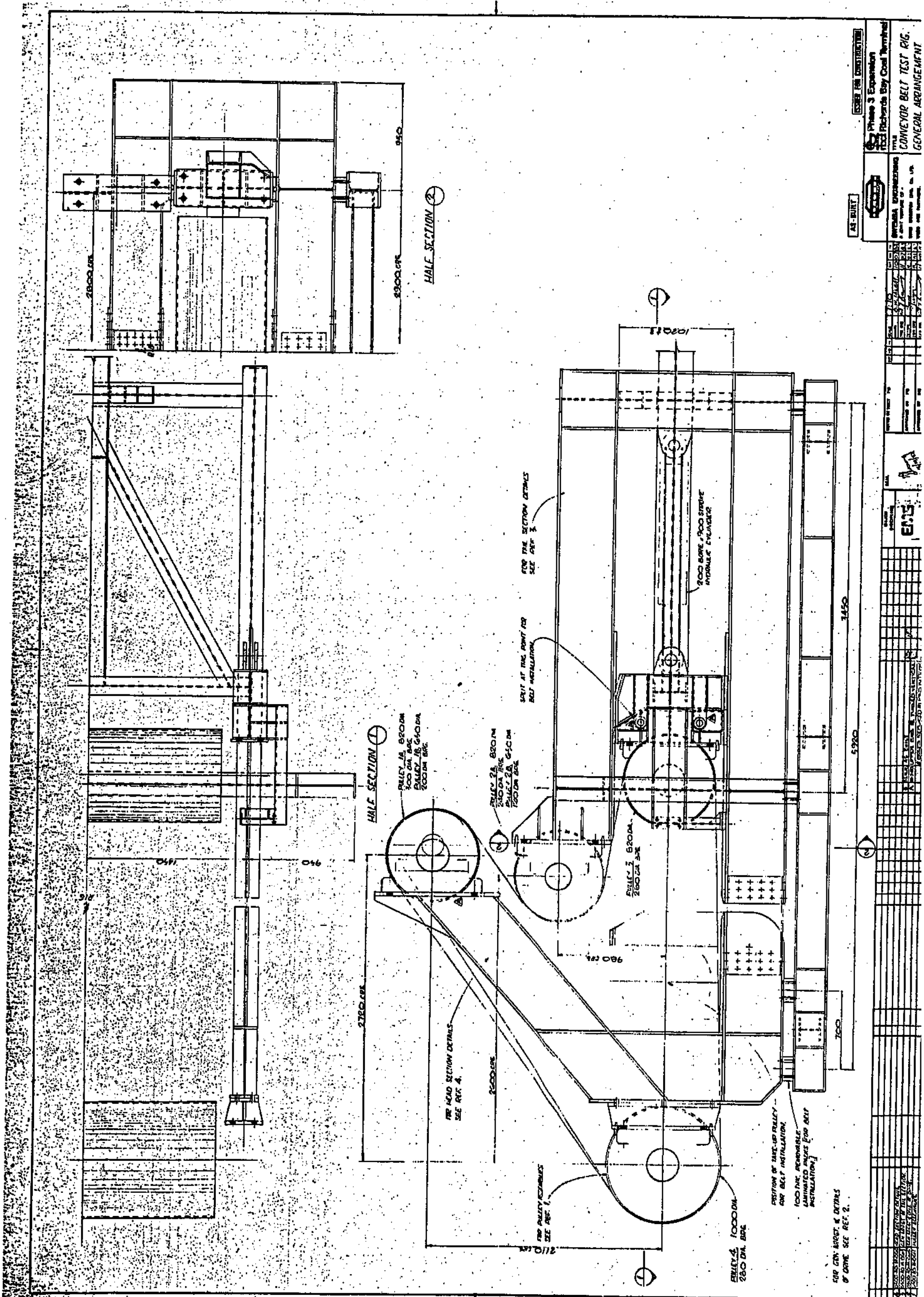
Phase 3 Expansion
Richards Bay Coal Terminal
CONVEYOR BELT TEST RIG.
GENERAL ARRANGEMENT
HALF SECTION 1
HALF SECTION 2
200 BORE x 900 STROKE HYDRAULIC CYLINDER
FOR TAIL SECTION DETAILS SEE REF 3.
FOR HEAD SECTION DETAILS SEE REF. 4.
FOR GEN. ARRGT. & DETAILS OF DRIVE SEE REF. 2.

FIG. 4

- longitudinal joints in adjacent plies within 100mm of each other,
- uneven thicknesses of rubber between plies and between adjacent layers,
- corrugations in full fabric thickness running parallel to warp,
- waves in full fabric thickness running parallel to weft,
- loose lengths of yarn left between plies,
- ribs on one cover corresponding to depressions in opposite cover due to folds of fabric in weft direction,
- fabric showing weft thread displacement,
- rubber covers showing indentations and disfiguration which appear to have resulted from dirty press platens.

(ii) Faults Associated with Belt Design or Fabric Faults

These included:

- Transverse cracks through the cover and into the fabric, occurring mainly towards the edge of the belting but in some cases also showing in the centre,
- breakages in a number of adjacent warp threads and breakages at intervals down the line of individual warp yarns.

Fig. 5 shows an example of a typical fault uncovered.

Although the above faults were observed it was found difficult in practice to quantify their occurence. Similarly it was difficult to relate the faults observed significantly with the conveyor belt failures experienced in the field.

5.3 SPLICES

Of equal concern to the Coal Terminal is the splicing of conveyor belts as it is the Coal Terminal's experience that in dynamic applications the splice will normally be replaced 2 or 3 times within the life of the conveyor belt. Should the splicing technique be ineffectual the incidence of splice failure drastically increases with corresponding interruption to operations.

At various times the Coal Terminal has used 3 types of splice. These are:

- cold splice,
- accelerated cold splice,
- hot splice (vulcanised).

In general under the Coal Terminal's operating conditions it would seem that cold or accelerated cold splices are to be preferred. Hot splicing despite the advantage of a shorter splice length and potentially higher strength is critical with regard to curing and process temperatures and these are difficult to maintain over and above practical operational difficulties.

In practice there appears to be little difference in performances of a cold or accelerated cold splice. It is important to bear in mind some of the climatic difficulties under which splicing must take place : the Coal Terminal with its coastal environments has its fair share of sunlight, high humidity conditions and precipitation. It is necessary to protect the applied adhesive from direct sunlight in order to control its drying time : similarly with regard to high humidity or precipitation (rain), although authoritive recommendations are scant, it is known that the adhesive hardener is hydroscopic, and that any surface moisture should be removed from the adhesive.

It should be noted that with regard to high humidity and precipitation that a positive advantage exists for the hot splice (vulcanised) method. Modern vulcanising press design is also going a long way to neutralise other disadvantages of this method.

All of the Coal Terminal's splices however performed,are of the butt type. A typical poly-ply belt splice is shown following in Fig.6

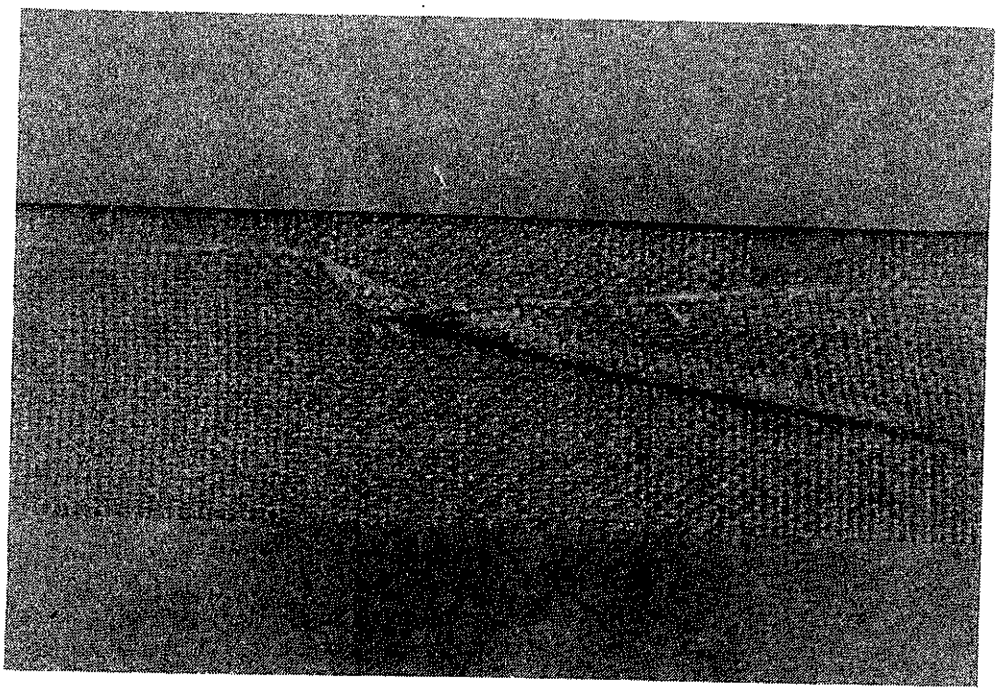

FIG.5 - Cover stripped to show a fold and overlap in carcass.

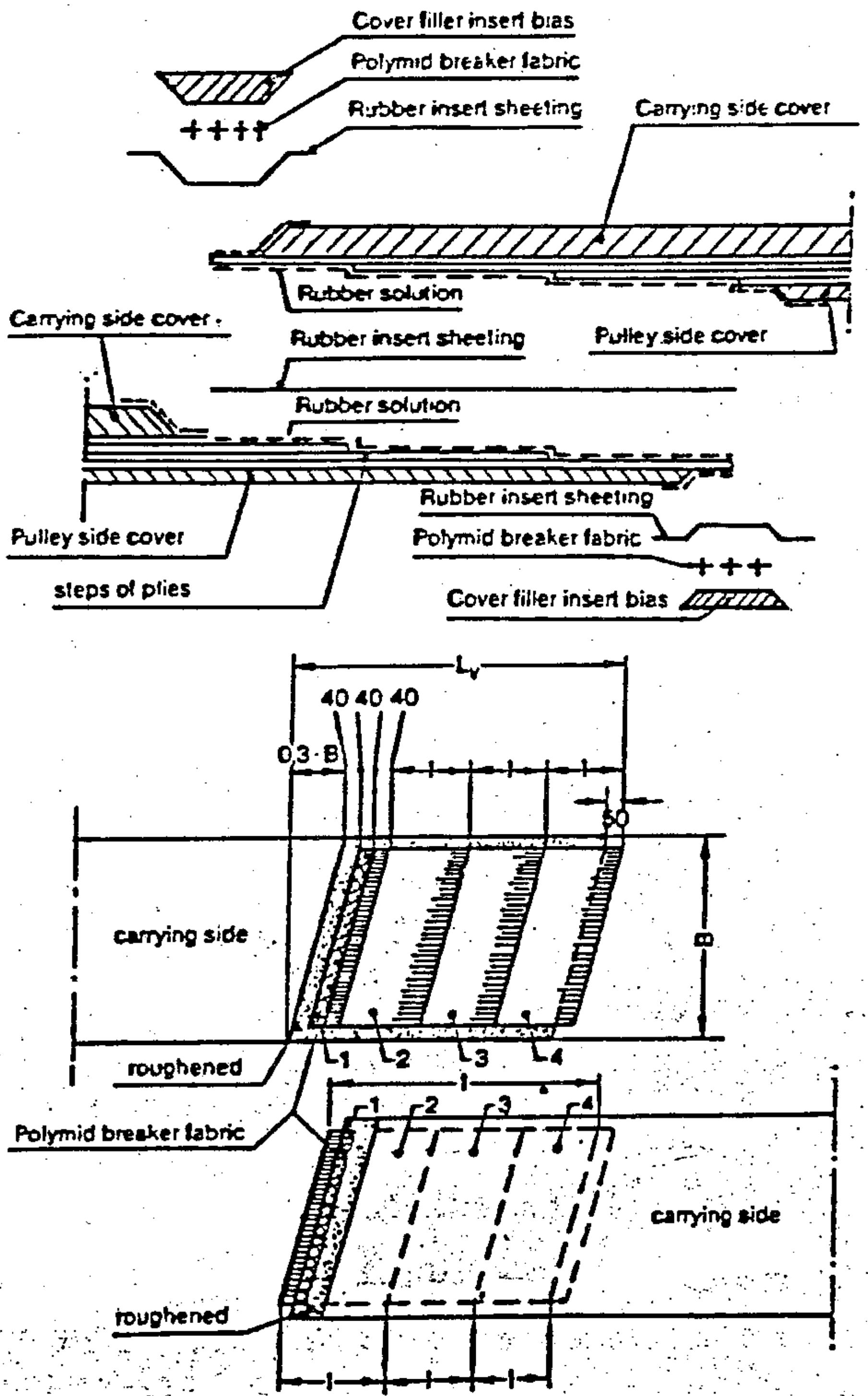

FIG. 6 - Typical splice of a poly-ply belt.

5.3.1 FINDINGS OF INVESTIGATION INTO SPLICE FAILURES

From investigation it does appear that a major cause of splice failure is due to the high shear stress between the plies in the adhesive layer. These stresses are determined to a large extent by conveyor belt deformation which in turn may be referred to the number and nature of flexures of the conveyor belt.

Perhaps relatedly the rubber layer thickness between plies affect the intensity of the shear stress distribution in the rubber layer. Some of the Coal Terminal's splice failures especially with heavily tensioned conveyor belts have been due to carcass cracking in the splice area. Again at least in part this may be referred to the number and nature of flexures of the conveyor belt.

5.4 IMPLICATION OF FINDINGS

As with many investigations, the Coal Terminal's finding were not conclusive and no clear single cause emerged as a sole factor but rather the accumulative effect of many. The main implications of the findings to the Coal Terminal are primarily three fold. These are:

- design of conveyor belt lines so that conveyor belt flexures are minimised. This may involve
  - design of conveyor configuration,
  - the use of larger diameter pulleys.
- improved quality assurance aspects of conveyor belt supply. This will range over many areas and will include
  - supply to conveyor belt manufacturer of all conveyor design constraints,
  - careful specification of all aspects of conveyor belting design,
  - careful quality control of conveyor belt manufacturing process,
  - testing of conveyor belting,
- to monitor development in modern hot splice (vulcanising) presses.

6.0 PULLEYS

The Coal Terminal has approximately 750 pulleys in use in its conveyor belt lines. These pulleys have been supplied by a variety of suppliers with each expansion phase and some are of imported origin. In general the Coal Terminal has experienced few problems with its pulleys. The procurement of pulleys has almost always taken place against a strict specification which over and above requiring design and manufacture in accordance with good engineering practice has also included rigid quality assurance requirements. Design requirements of the pulleys in general makes allowances for:

- operational life expectancy,
- belt tensions during normal operation, acceleration and deceleration,
- fatigue failure.

In general during major expansion phase procurement, pulleys are furnished lagged or unlagged depending upon their requirements however, during replacement procurement due to standardisation constraints the tendency is for all pulley shells to be supplied lagged. Some problems are experienced by the Coal Terminal with pulley lagging : these are principally :

- wear, or rate of wear,
- loss of traction between pulley and conveyor belt, resulting in slippage, under inclement weather conditions (rain).

In order that perspective can be given to the latter, it should be realised that the Coal Terminal and its plant is capable of operations in wind speeds up to 80Kph (a condition not frequently exceeded) : the most common cause of suspension of operations at the Coal Terminal is rain,due to the slurrying of the product coal (with associated handling problems) and/or under speed of the belt conveyors.

The problem of slippage should also be seen against the Coal Terminal's conditions of high linear speed of the conveyor belt and the high rotational speed of the pulleys.

Presently the Coal Terminal's pulleys are lagged with a natural rubber to British Standard (BS) CP3003 or South African Bureau of Standard specification (SABS) 1198, with a variety of thicknesses and patterns depending upon application. In general lagging hardness is in the range of shore hardness 60° - 70° on drive pulleys and 50° - 60° on driven pulleys.

Presently the Coal Terminal is investigating what can be done to ameliorate the present position and such investigation is still in a somewhat tentative and early stage. It is presumably reasonable that lagging life and tractive capability are to some extent paradoxical requirements; however, it would seem from early investigations that pulley lagging is an area where major improvements are achievable and to be expected in the future.

7.0 ACKNOWLEDGEMENTS

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