

DEVELOPMENT OF COAL RAILWAYS IN QUEENSLAND

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ABSTRACT

Queensland Railways has, over the past two decades, developed Australia's largest transport system for the export of coal. This development is traced, with special emphasis being placed on improvements in productivity which have been achieved, through the introduction of new technology, processes and improved work practices, as a result of research activities.

Earlier improvements included upgrading of the track and rollingstock standards and capacity, the introduction of remotely controlled locomotives which have allowed a doubling of train length, and centralised traffic control. More recent changes have included the introduction of electrification and two man crews on trains.

Current research and development in relation to coal railways is reviewed, and areas for future research are discussed.

COAL RAILWAYS IN QUEENSLAND

1. INTRODUCTION

Queensland Railways entered the coal heavy haul railway industry on a large scale with the opening of the Moura Short Line in 1967. This was soon followed by development of the Blackwater system in 1968, the Goonyella system from 1972, and the Newlands Railway from 1984. The total coal hauled on these systems now exceeds 60 million net tonnes per year.

This paper discusses how research and development activities across the entire range of railway technology, operations and management has assisted in developing Australia's largest transport system for the export of coal.

2. THE TRANSPORT TASK IN PERSPECTIVE

The significance of the transport task carried out by Queensland Railways in the haulage of export coal can be gauged by an examination of the export levels of coal from the world's major exporting countries. Table 1 indicates that Australia is the world's largest exporter of coal.

TABLE 1. EXPORTS FROM THE WORLD'S
LARGEST COAL EXPORTING COUNTRIES

(million tonnes for calendar year 1986)

| | |
|--------------|------|
| Australia | 92.2 |
| U.S.A. | 77.5 |
| South Africa | 45.5 |
| Poland | 34.4 |
| Canada | 25.9 |
| U.S.S.R. | 25.4 |
| China | 9.9 |
| Columbia | 5.6 |

Source : Australian Coal Report (1987), Coal Marketing Manual.

Coal exports from Australia are generated from only two Australian states, Queensland and New South Wales. Table 2 indicates that, since 1984/85, Queensland has established itself as Australia's leading state in the export of coal. The bulk of this exported coal from Queensland has been transported from mines to ports by Queensland Railways.

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TABLE 2. COAL EXPORTS FROM QUEENSLAND
AND NEW SOUTH WALES ('000 tonnes)

| Financial Year | Exports from | | TOTAL |
|-------------------|--------------|-----------------|---------|
| | Queensland | New South Wales | |
| 83/84 | 33 095 | 33 427 | 66 522 |
| 84/85 | 45 504 | 38 296 | 83 800 |
| 85/86 | 50 797 | 39 087 | 89 884 |
| 86/87 | 53 525 | 42 189 | 95 714 |
| 87/88 | 58 422 | 43 778 | 102 200 |

Source : Australian Coal Report (1987) Coal Marketing Manual.

Within Queensland Railways, there are five major coal exporting systems, developed over the last twenty years, which collectively contribute to the substantial overall export task. Table 3 indicates these systems, the associated export ports, and the relative tonnages exported through each system. These systems are also shown by location in Figure 1.

TABLE 3. MAJOR COAL EXPORTING
SYSTEMS WITHIN QUEENSLAND RAILWAYS

| System | Export Port | Export Tonnage |
|--------------|-------------------|---------------------------|
| | | 1987/88 ('000 tonnes) |
| West Moreton | Fisherman Islands | 2,071 |
| Moura | Barney Point) | 3,099 |
| | Auckland Point) | |
| | Clinton) | |
| Blackwater | Clinton | 12,704 |
| Goonyella | Hay Point | 18,216 |
| | Dalrymple | 15,074 |
| Newlands | Abbot Point | 5,449 |
| TOTAL | | 56,613 |

Source : Queensland Railways Commodity Statistics

3. TECHNOLOGICAL INNOVATIONS

The development of heavy haul coal railways in Queensland has seen the introduction of major innovations in technology by which railways have achieved significant productivity increases in utilisation of staff and equipment. Three of these will now be briefly discussed.

3.1 Centralised Traffic Control

Centralised Traffic Control (C.T.C.) was first installed on the Moura system, from Moura Mine to South Gladstone, and later installed on the Goonyella - Hay Point system. Centralised Traffic Control, in which train controllers, operating from a central control point, control the operations of trains by directly operating signals and points, has eliminated the need to retain staff at stations, and has provided the railways with the capability to keep trains moving by eliminating unnecessary station stops, thereby achieving greater line capacity.

3.2 'Locotrol' Operations

'Locotrol' is a trade name for a remote multiple unit operation system by radio control, which was developed by NASA in the U.S.A. It was evaluated by Queensland Railways officers and selected for application on the Goonyella system.

The Goonyella Line was originally planned to operate with design trains made up of three multiple-unit Diesel Electric Locomotives hauling 74 wagons each of 71 tonnes gross weight and each carrying 57 net tonnes of coal. As the tonnage to be carried on the line increased, with the opening of new mines, it became necessary to either increase train size or to duplicate track and/or insert additional crossing loops. (Goldston, 1982)

It was decided that, by using the 'Locotrol' concept, the train size could be doubled. A train consist made up of 6 locomotives and 148 wagons for a gross train load of 10,500 tonnes became the norm, effectively halving the number of trains required to carry a given quantity of coal.

3.3 Electrification

The electrification of Queensland's coal railways has seen a significant introduction of new technology, not only in the motive power area, but in a number of related areas. This major change has necessitated the need for research to develop new systems to operate the railways in an efficient manner. Much of this research has been of a technical nature, and this will be discussed elsewhere in this paper. Figure 2 is a schematic representation of Queensland's electrified coal railways.

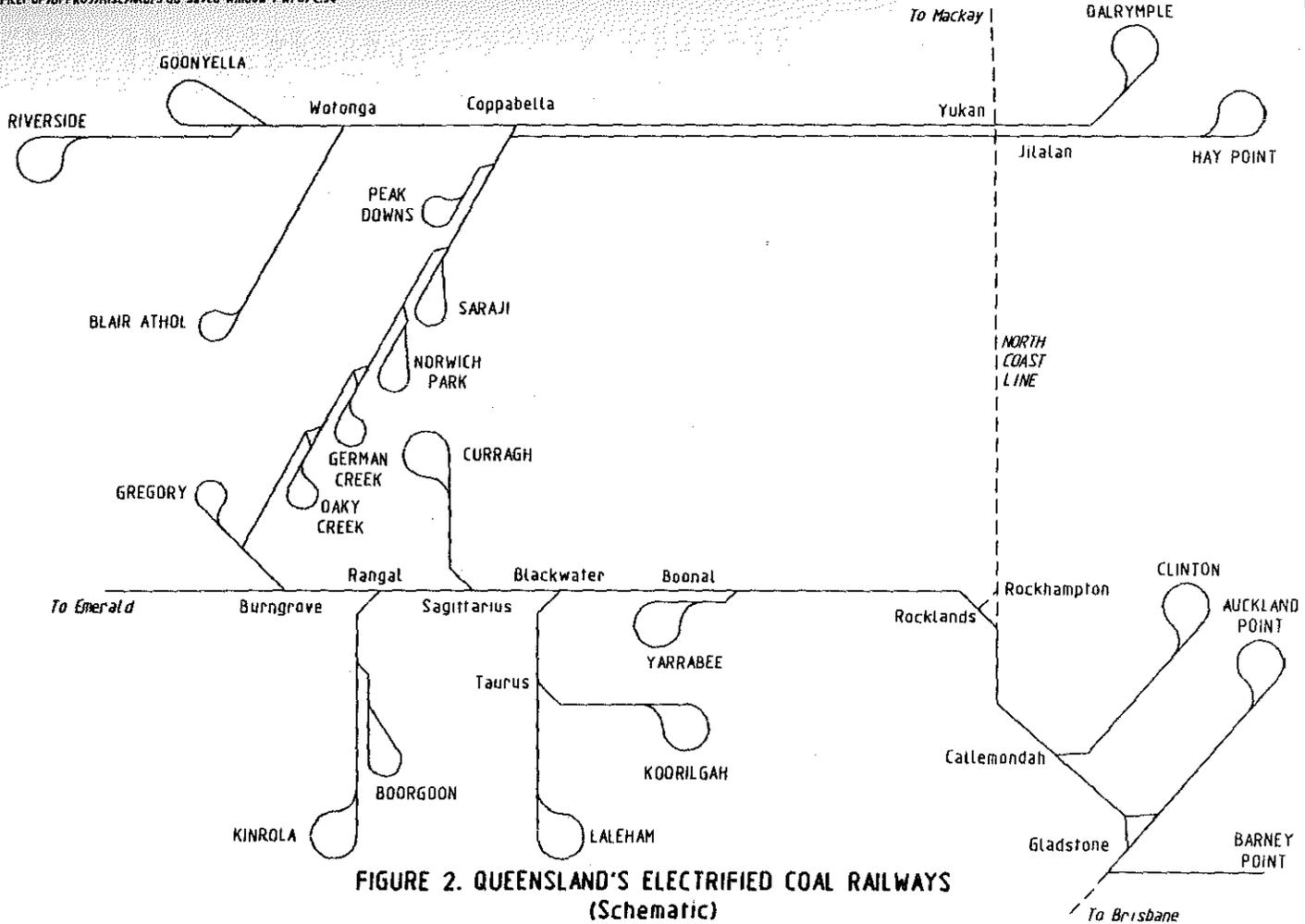


FIGURE 2. QUEENSLAND'S ELECTRIFIED COAL RAILWAYS (Schematic)

The introduction of new, more powerful electric locomotives has allowed Queensland Railways to reduce its fleet of Diesel Electric locomotives, some of which were at the end of their economic life.

Major benefits arising from electrification of the coal railways include :-

- . A reduction in energy costs.
- . Reduced locomotive maintenance.
- . Reduced turnaround times, and better utilisation of rollingstock.
- . Reduced crew costs.
- . Use of an indigenous energy resource instead of an imported resource.
- . Introduction of two man crews.

4. TECHNICAL RESEARCH AND DEVELOPMENT

Railways are highly dependent on the effective application of technology for successful performance. It is not surprising, therefore, that much of the research effort within the organization has been directed in the technical areas. There has, however, been an increasing emphasis within the railways, on research into overall management and utilisation of resources. Whether the research has been of a technical, operational or management nature, the overriding consideration has been towards improving the commercial performance of the organization.

Significant research and development in the technical areas are as follows.

4.1 Civil Engineering

Concrete Sleepers

Queensland has, up to the 1960s, had a sufficient supply of hardwood timbers to meet the needs of railways for timber sleepers. However, in the mid-1960s, the supply of suitable timber was recognised as finite. This situation was exacerbated by a generally poor return to sleeper suppliers, the loss of suitable labour for sleeper cutters and attraction of more financially viable business opportunities, for example the growth of landscaping activities in residential and industrial markets.

A major concern was the deteriorating quality of timber. Whereas, in the 1940s and 1950s, sleeper working life was estimated at 20 years, surveys conducted in the 1970s indicated a life of current sleepers closer to 10 years. Current timber supplies for sleepers are now estimated available only for 10 years.

A series of research activities to seek suitable alternative and economic supplies was undertaken. These include the use of pretreated timber sleepers, steel sleepers and finally prestressed concrete sleepers (P.C.S.).

The C.S.I.R.O. has been deeply involved since 1961 in evaluating the life of pretreated timber sleepers in Queensland Railways. Significant improvement in the life of timber, giving a life of 25 years, can be obtained by dipping the sleeper into a bath of oil-based preservative or by chemical pressure treatment of the timber. This does not solve the problem of a diminishing timber supply, and the free market choice enjoyed by suppliers. In addition, the rigid standard of dimensions and quality of timber sleeper, essential ingredients in maintaining heavy haul railways, are very difficult to meet.

Steel sleepers have been used in Queensland Railways since 1888 on the Normanton-Croydon Railway. Most of the original are still intact. However, there has been a general reluctance to use steel sleepers in heavy haul railways, because of the difficulty in packing ballast securely around the sleeper itself. Whereas sharp rock ballast particles are capable of penetrating timber and concrete surfaces to provide a force resistant to movement, this is less evident with the steel sleeper. In addition, problems with maintaining a suitable fastening between rail and sleepers have existed. The lighter weight of the steel sleepers is also seen as a drawback.

Much of the research conducted in railways has centred around using concrete sleepers. Generally, the cost of producing the P.C.S. and equipping it with suitable fasteners has precluded the universal use of this type. However, its inherent durability of a 45 year life and the fact that concrete manufacturers have produced a competitively priced product, forced Queensland Railways to reassess its use when the decision was made to duplicate the first 145 km of the Goonyella Railway.

All these factors were taken into account to justify use of the P.C.S. on economic grounds. In general, the belief is held that the P.C.S. has produced a much safer track structure, with a longer economic life and which generates significant reductions in operating costs. In addition, railways have moved away from an industry with diminishing sources of supply and subject to the constant vigilance of conservationists. Queensland Railways started using P.C.S. in limited quantities in 1982.

A considerable amount of research (Muller, 1985 and 1986) has been carried out by Queensland Railways to ensure the servicability of prestressed concrete sleepers, to overcome problems encountered by other rail systems in using such sleepers. This has resulted in the development of P.C.S. which would remain servicable under the most adverse operating conditions likely to be encountered by Queensland Railways.

One of the disadvantages of the concrete sleeper is the weight factor, 4 P.C.S.s weigh one tonne in comparison with 13 timber sleepers to the tonne. The advent of the concrete sleeper has precipitated a whole new range of mechanised rail machinery to ease the burden of installation by minimising the labour-intensive function.

Wheel/Rail Interaction

In the late 1970s rail shelling, a subsurface fatigue failure of the rail metal in the gauge corner region of the rail head, became a serious problem on the Goonyella export coal railway. This heavy haul railway at that time was operating Locotrol trains of 148 wagons and six diesel electric locomotives with a maximum axle load of 18 tonnes. Train consists amounted to approximately 10,500 gross tonnes and operated at a speed of 60 km/h.

The first instances of rail shelling were reported in June, 1973 after about 12 million gross tonnes of traffic on the line. The annual traffic volume had increased to 21 million gross tonnes by July, 1979, and the extent of rail shelling and wheel wear mirrored this exponential increase in coal hauled. Incipient rail shells were rapidly growing into deep seated cleavages with an inherent risk of rail breakage and derailment. A rail replacement programme was being used to treat the problem. However, rerailling gangs were not able to keep ahead of the problem and technical investigations to research the cause and derive a solution were undertaken.

Early in the investigation it became clear that the subsurface cracks resulted from excessive shear stresses under the zone of wheel/rail contact. Modification of this zone of contact was necessary to treat the cause. Consequently a range of modified wheel tread profiles were investigated to determine if a more appropriate wheel shape could be developed from Queensland Railways' traditional cylindrical wheel running on vertical rail.

Computer simulation runs were undertaken to examine the contact band, rail contact stress, and vehicle tracking performance for a range of wheel profiles. A new wheel profile was adopted that reduced contact stresses on the existing vertical rail profile. It was also recommended that the rail network should adopt rails that are inclined at 1 in 20 towards the gauge side, in order to further improve wheel/rail contact which would be necessary as tonnages and axle loads increased in the future. The result was that rail shelling was significantly reduced and today rail replacements due to rail shelling are now at a low level.

The success of this exercise in reducing rail stresses through wheel profile optimisation, and the work performed by B.H.P.'s Melbourne Research Laboratories on the heavy haul railways in Western Australia, demonstrated the potential of practical engineering rail research. The success has not only been in solving technical

problems but also in reducing maintenance costs through extended material life and has enabled increased utilisation of the system.

Follow-up research has now been undertaken in the Queensland Railways under the direction of the Railways of Australia Technology Development and Application Committee.

A further refined wheel profile has now been developed that has demonstrated an increase in wheel life through reduced wheel wear of over 3 times. This represents a considerable economic benefit to the System. Studies have also been completed into improved rail profiles by the use of on-track machinery to plane or grind the rails to an optimum profile. Optimum rail profiles have been developed that reduce curving forces by about 20 per cent with corresponding reductions in rail wear and further improvement in wheel life. The wear improvement in moderate to sharp curves is particularly noteworthy where the modified rail profile and the wheel/rail contact helps to steer the rollingstock around the curves. On straight track the design profiles help to centre the wheel sets and minimise flanging which in turn reduces tractive energy consumption. (Hagaman, 1989)

Maintenance Windows

As the tonnage carried by coal railways increased, the number and frequency of trains increased, and the amount of time available for track maintenance has reduced. Increasing tonnages, however, require an increased maintenance effort, resulting in conflicting demands for access to the track. The increasing use of mechanised maintenance equipment because of the heavy track structure, also dictates that such equipment be allowed reasonable periods of access to the track for maintenance purposes.

A review of options for track maintenance of single line coal carrying railways was conducted by Hartigan, Cochrane and Nibloe (1983), and following this and other investigations, the concept of maintenance windows, whereby maintenance equipment would be allowed access to the track for maintenance purposes for predetermined periods, was established.

In duplicated sections of track, crossovers have been installed, together with bidirectional signalling, to allow maintenance machinery to work, while permitting trains to operate temporarily over single line sections. In this way, the conflicting demands of traffic haulage and maintenance activities are met without undue detrimental effect to either.

Development of Rail Track Equipment

Many of the productivity improvements in both construction and maintenance phases in railways have stemmed from the research and development initiated by the manufacturing companies which service

the industry. Notable advances in track laying equipment, track welding techniques, rail grinding and planing machinery and ballast tamping machinery are now in the process of being installed in Queensland Railways.

Rail Rectification

The need to reprofile the rail head to minimise wheel rail interaction has already been discussed. The solution to reprofile the rail head has only been made possible by the introduction of two machines : the SBM 140 PLASSER Rail Planing Machine and the LORAM 32 Stone Rail Grinding Machine. The first has been used to camber the rail head to the 1 in 20 grade, tending to leave a coarse finish. The second, fitted with 32 stone grinders, is the finisher profiling the head within finer tolerances.

The Planer unit produces large cuts of "swarf", spent metal which has to be collected for removal. The Grinder is hazardous in that it sets fire to the surrounding country, so an essential piece of ancillary equipment is a fire engine. Both items have proved to be economically justifiable.

Ballast Rehabilitation

The haulage of coal causes severe problems with respect to spillage and the natural drainage of the porous ballast track subsurface becomes clogged with fallen coal. During wet weather, silting and water between rails tends to interfere with signalling systems and earthing return currents in the rails. This has major impacts on track stability and operational safety of the total system. This also requires ballasting and track lifting regularly, a process which, with electric traction, has finite limitations with respect to the clearance between the overhead catenary and the pantograph.

Several methods to eliminate these problems are under investigation. Our engineers are favouring the use of a system which not only cleans and reclaims the existing ballast, but also restores the fouled track to an acceptable operational standard. In addition, a spoiled ballast disposal system is needed together with a system of inserting geotextile fabric to stabilize poor formations. Research is now in progress to design suitable equipment for this task.

Track Laying Machine

Perhaps the most significant improvement in rail construction is the advent of the Track Laying Machine. The unit is self contained, designed in reaction to the need, perceived by railways, to construct new or relay old track with reduced labour input and cost. The unit can either construct new track or replace existing track using either timber or concrete sleepers.

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The unit requires a minimum of 10km of track to lay to be economically efficient because it is attended by 90-100 personnel and takes up to two weeks to relocate. Depending on the task and track time window available to it, the unit in its relay mode can replace 0.5km in a 5 hour period and up to 3km in an 8 hour construction mode. The estimated savings in construction approach 50,000/km, in comparison with the older semi-mechanised methods.

4.2 Mechanical Engineering

Wagon Design Research

To overcome cracking problems in the wagon body, particularly the aluminium bottom discharge wagon, has required a good deal of research using a finite element analysis computer model. This model replicates the stresses generated at key points in the body at various stages of the transport task. These stresses occur during mine loading operation, during haulage of the loaded and empty wagon and during unloading. For existing wagons, suitable modifications have been evolved, notably the retrofitting of a 360mm diameter tensioned steel bar in the form of a centre sill in the plane of the coupling links. (Fullelove, 1989) This should produce a noticeable improvement in the life of the wagon. The original wagons were designed as a monocoque body structure without the centre sill, and have developed severe body cracks.

Much of the knowledge and research information input into in the design of the new steel 90 tonne wagon has come from the ongoing research both in the field of railway design and metal use. The advent of 12% chromium 3CR12 steel, which is suitable for railway rollingstock use, has taken the comparison between aluminium and steel on a new course. With steel, corrosion is no longer a major problem and with the higher, physical properties of steel, it is expected that the cracking problems of aluminium designs can be overcome.

The latest design, bottom discharge steel wagon comprises a centre sill, of rolled steel, in the line of the couplings. In addition, special consideration has been given to the "flowability" of coal from the wagon body and hopper doors. Queensland Railways has recently commissioned the University of Wollongong to investigate the flow characteristics of its latest wagon to ensure that the body design does not impede the coal flow from the wagon. (Illawara Technology Centre, 1988) The centre sill which passes through the door openings is specially covered with an "A" cap of steel to ensure flowability is not impeded. Other modifications in the body have been incorporated to ensure that material flows are on a first in first out pattern, that there are no dead regions in the body to consolidate the load, and that flow out is uniformly controlled so that the feed density goes on independent of the head of the wagon body. Figure 3 shows features of the 90 tonne wagon. The wagon will visit different mines with coal of varying densities demonstrating a

HEAVY DUTY AUTOMATIC COUPLERS - NO BUFFERS
 NO TRANSITION COUPLINGS
 FOUR PAIRS OF BOTTOM DISCHARGE DOORS
 - PNEUMATICALLY OR MANUALLY OPERATED

3CR12 STEEL BODY WITH STEEL UNDERFRAME END UNITS
 RUBBER FRICTION DRAFT GEAR -
 CARDWELL WESTINGHOUSE MARK R500
 CONTINUOUS LOAD SENSING CHANGE OVER VALVE FITTED

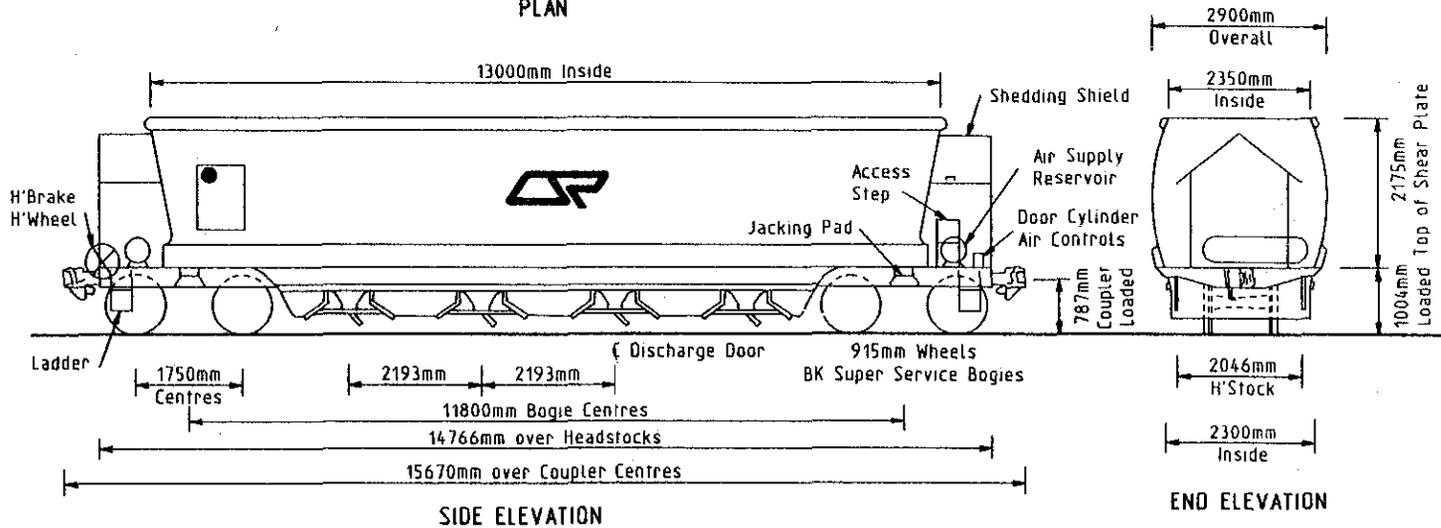
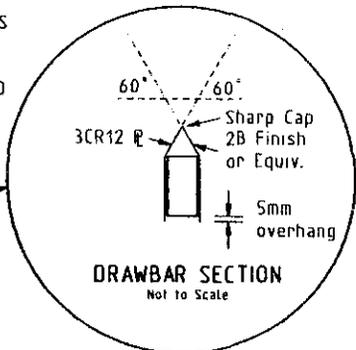
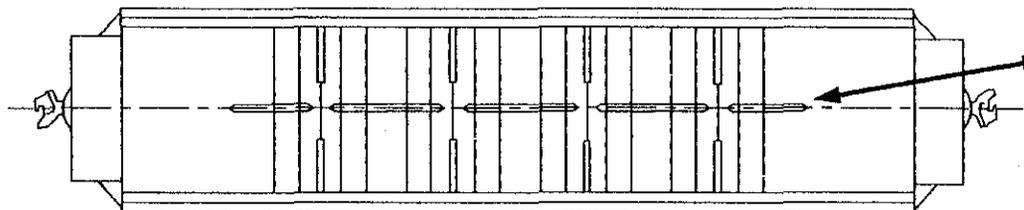


FIGURE 3. 90t COAL HOPPER WAGON CLASS "VSNB"

range of flow rates. Factors which influence the flow include the percentage of fine particles in the coal, the size of particle, the length of storage on stockpile, rainfall and coal moisture content. It is likely in the future the design characteristics of the body will be specified to include factors which take into account the coal flowability range to be encountered.

Other features in the wagon design include investigation into the bogie type. The importance of the bogie cannot be overemphasised for several reasons. All heavy freight trains in Queensland operate at a maximum speed of 60 km/h, but there is a feeling that the increases in speed may be warranted. Another important aspect is the use of the so-called self-steering bogie, in which, contrary to the standard three piece freight bogie, the two axles can move in line with the track curve alignment and independently of each other. The self-steering bogie is widely used, particularly in South Africa, and is reputed to greatly reduce train resistance at the wheel rail contact area and hence improve energy consumption. It also reduces hunting and rail wheel wear.

The use of this bogie is currently under investigation in Queensland. By its very nature, the self-steering bogie is very suitable for heavy traffic lines with a high percentage of curved track. Generally new lines in Queensland are constructed to minimise curvature and maximise radius, and the applicability of the self-steering bogie is being examined to determine its suitability, particularly as this bogie is more expensive and heavier than the type in current use.

Systematic Attention of Wagons

Traditionally, rail wagons have been repaired as failures have occurred, and regular maintenance activities on wagons have been undertaken when wagon wheels needed reprofiling. However, as wagon wheel life has increased with improved materials and wheel/rail profiles, the intervals between regular maintenance activities on wagons has increased. The removal of an individual wagon from a long train is time consuming and often inconvenient. Repairs to wagons undergoing random failures has proved to be too disruptive to the efficient running of coal trains.

In order to reduce the number of coal wagons out of service, a process called Systematic Attention to coal wagons was introduced at Jilalan workshops on the Goonyella system in January, 1986. This was later extended to the Callemondah workshops. Under this system, all coal wagons in the fleet are inspected in a 16 week cycle. This attention requires that the wagons are subjected to a routine system of checks and repairs, usually a half train consist is removed from traffic at a time. Any minor faults are repaired on the spot, and if major repairs are necessary, the wagon is despatched to a major workshops.

Other routine inspections are carried out to ensure that major defects of wagons in service are detected. A roll-by inspection is carried out on all trains on each trip (one side only is inspected with the second side checked on the next trip). A Terminal examination is carried out once per week as the locomotives are being serviced.

The Systematic Attention of Wagons has been effective in increasing the availability of wagons. There has also been a marked improvement in wagon door operation, derailments due to wagon defects have been reduced, fewer wagons are being taken out of service for repair and shunting operations are reduced accordingly.

4.3 Electrical Engineering

Electric Load Study

Research into the electrical loads for Queensland's electrified railways was initiated in order to establish a strategy for electrical energy usage which minimised electrical energy costs. Trade-offs which impact on other areas, such as rollingstock fleet size, operating patterns, costs and tonnage throughput are also being examined. The results of this research will be available shortly and are expected to have impacts on operational strategies to be adopted on the electrified coal railways.

Harmonic Current in Electric Traction Systems

Electrification of the Central Queensland coal railways raised concerns about the problems which would be caused by the thyristor controlled locomotive load on the supply system. These include increased negative sequence current presence in the 3-phase supply system and significantly large harmonic distortion levels injected back into the supply system. Harmonics in the supply system can cause :-

- Telephone interference and noise.
- Motor overheating.
- Malfunction of protection, metering and electronic control equipment.
- Capacitor and cable overloading.

In order to meet the requirements of the Australian Standards to limit the adverse effects mentioned above, Queensland Railways arranged for corrective measures utilising Static Var Compensators (SVC) at nine sites and harmonic filters at all 13 substations on the electrified coal lines.

When electric train operations commenced, it was observed that harmonic filters began failing at an alarming rate. Queensland Railways has carried out intensive investigation into the causes for

the failure of the harmonic filters, resulting in an improved design for harmonic filters. (Hamoud and Griffiths, 1989) New harmonic filters have now been installed which are working satisfactorily. An additional benefit for the research undertaken by Queensland Railways is that there is now a much better understanding of the factors to be considered in design of harmonic filters for electric traction systems, and there is the ability to share this expertise with other railways contemplating electrification.

Track and Overhead Inspection and Recording Vehicle

Following an extensive review of track and overhead recording vehicles available in Australia and Overseas, Queensland Railways has undertaken the development of a vehicle which combines the measurement of both track and overhead wiring parameters in the one vehicle. It is understood that Queensland Railways is the first railway system in the world to develop such a vehicle, as other railway systems have separate vehicles for recording track and overhead wiring parameters.

The importance of the track inspection system is to identify areas where contact between the pantograph and the overhead catenary system is likely to be lost because of vertical and horizontal track misalignments.

The Inspection and Recording Vehicle will record the alignment and level errors in track, and will measure the height, stagger and displacement from track centreline of the overhead wiring, as well as identifying locations where longitudinal accelerations of the pantograph will occur.

Features of the vehicle will include :-

- . On-board computers for measuring and recording track and overhead wiring.
- . Radar systems for establishing locations of overhead wiring masts.
- . A colour video recording system to record visual images of both the track and trackside features as well as the pantograph/contact wire interaction.
- . Desktop microphones to allow operators to record audio signals onto the corresponding video recording.
- . The provision of four Event Terminals which will allow operators to input up to 20 different types of Event, such as speed boards or kilometre posts.
- . The provision of two Transponder Detectors, for detection and identification of transponders in track.

The Track and Overhead Inspection and Recording Vehicle should allow this system to more effectively maintain its track and overhead wiring to the required standards.

Fault Locators

In conjunction with the Main Line Electrification Project, Queensland Railways has installed return current fault locators, to allow faults in the traction power feed to be located rapidly. On the Central Queensland coal lines, fault locators are coupled with motorised isolators, double track and bidirectional Centralised Traffic Control signalling, to considerably reduce the impact of any electrical faults in the traction power feed and to minimise disruptions to train running.

Using the experience gained from the operation of fault locators on the electrified coal lines, and based on its own research, Queensland Railways has developed a second generation fault locator for installation in the Brisbane-Gladstone section of the Main Line Electrification Project (Snape and Griffiths, 1989). These fault locators can be produced at a lower cost and have improved accuracy, as well as being able to integrate better with modern supervisory equipment.

4.4 Signalling and Telecommunications Engineering

Jointless Track Circuits

Jointless Track Circuits were developed to cope with the effects of main line electrification on signalling systems; in particular, to ensure that inductive and conductive interference resulting from high levels of traction current in close proximity would not pose a threat to the safe operation of signalling systems. (Whisson, 1989)

In the case of track circuits, the integrity of a signalling system depends on low powered electrical circuits in the rails themselves. Considerable investigation was conducted to establish the safe limits required. The maximum length of a d.c. track circuit was limited to 380 metres and one rail was required for the traction return current. Since it was desired to use both rails for traction return current wherever possible, jointless track circuits were introduced to achieve this requirement. There is an added ability to pick up broken rails. These could, however, only be operated up to distances of 650 metres. In longer single line sections, jointless track circuits would prove to be very expensive and an alternative system to determine the occupancy or otherwise of single block sections, using axle counters, was developed.

Axle Counters

In some remote single line sections, a cheaper alternative to jointless track circuits was investigated as a means to establish the occupancy or otherwise of single line block sections.

The use of axle counter systems, together with vital telemetry links operating over telecommunications bearers between stations, was adopted as a viable alternative.

Two systems, from different manufacturers were installed. Fifteen sets of equipment from one supplier were installed on the Goonyella Line, and nine sets of equipment from another supplier were installed on the branch lines west of Rockhampton and on part of the Central Line. Apart from some early problems, both systems now operate very reliably.

Hot Wheel Detectors and Dragging Equipment Detectors

Hot wheel detectors have been installed to provide advance warning of excessive heating of wheels on rollingstock, which if undetected, could lead to wheel failure and major derailment of coal trains.

Dragging Equipment Detectors have been installed to allow early detection of derailed vehicles or dragging equipment. This will help to minimise major track and rollingstock damage in the event of a derailed vehicle. The Dragging Equipment Detectors in Queensland Railways are operated in a unique way, linked through the C.T.C. and radio systems to the Control Centre.

Optical Fibre Cable

In order to meet electrification and immunisation requirements, it has been necessary to replace high maintenance, failure-prone open aerial communications and signalling telemetry transmission systems with microwave communications links and optical fibre underground cables.

Although these systems have a high initial cost, they have a very high reliability and are able to be used for many communications, information and data transfer applications for minimal additional cost. The high reliability of the systems also reduces the incidence of failure of the signalling and communications systems and improved the overall reliability of the transport system.

Automatic Train Protection (ATP)

An Automatic Train Protection (ATP) system is currently being introduced as part of the electrification of the main North Coast Line between Brisbane and Rockhampton. (Whisson, 1989) - A major

requirement in selection of a suitable system was that it should already be operating successfully on an existing railway. It was decided to adopt a system developed for use on Swedish Railways, but with the following modifications from a signalling viewpoint :-

- .. Queensland Railways signalling aspects were different;
- .. Lower speeds on Queensland Railways turnouts;
- .. Beacon information had to be extracted from the signalling control relays and not the signal lamp transformers.

5. OPERATIONAL DEVELOPMENTS

The development of coal railways in Queensland has seen the introduction of features which have sought to maximise the efficiency of the train operations. Research and development in the operational area have included the following aspects.

Balloon Loops

The introduction of balloon loops for loading and unloading operations has permitted the rapid loading and unloading of trains without the need for shunting or marshalling operations. Turnaround time is thereby minimised, with a consequent saving in rollingstock capital requirements. Another aspect, apart from reducing turnaround time, is the care needed to design the grade of the loop near the loadout station. Down grades for the loaded train require constant brake applications. Brake noise and the need to concentrate over long periods has a very debilitating influence on the locomotive crew.

Duplication and Capacity Expansion

As new mines have developed, the number of trains on the coal lines has increased. In order to increase the capacity of what were basically single line railways, additional crossing loops were constructed and, in sections of heavy tonnage, duplication of sections was carried out. Crossovers have been installed at strategic locations in conjunction with bidirectional signalling to facilitate maintenance activities whilst not unduly disrupting train operations.

Optimum Train Consists

The introduction of electrification in the Blackwater and Goonyella railway systems has resulted in train consists being amended following the change in motive power. Fewer electric locomotives are needed to haul a given number of wagons in a train. Investigations were carried out to determine the optimum train consists for each system following electrification. Aspects included were such considerations as costs of extension of crossing loop lengths,

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frequency of trains, port capacity, train operating costs and locomotive fleet requirements..

Port Capacity

Progressive increases in tonnages carried, particularly to the Ports of Hay Point, Dalrymple and Clinton, has required a closer inspection of the capacity limits imposed by unloading arrangements at these ports. Queensland Railways is currently carrying out research, together with the various port operators, to examine options for increasing port capacity as tonnages increase. A range of options is available, including improved operational arrangements, track layouts, upgrading loader and unloader capacity, duplication of unloaders and amendments to train consists.

6. INDUSTRIAL RESEARCH

Queensland Railways has, since 1983, introduced the concept of industrial relations research, to identify areas of activity where improvements in work practices can achieve increased productivity. This has been discussed in some detail by Kane and Fernandez (1988).

Significant advances in the operation of coal trains include the following:

Two Man Crews

Early coal trains were operated with crews made up of a Driver, a Fireman and Guard. With improvements in technology, such as C.T.C. and improved braking systems, the role of the Guard has diminished. After negotiations with the relevant unions, the introduction of two man crews, made up of a Driver and Driver's Assistant, was progressively implemented into coal train operations from 1988.

Working Through Depots

A work practice which was a legacy from the days of steam locomotive operation was a union policy rule that train crews were not to be worked through depots on either side of their home depot. After negotiations with the unions, this constraint was abolished, with substantial cost savings. With the introduction of electrification, turnaround times were improved to such an extent that it was possible, in the case of the Blackwater system, to operate a train on a round trip from mine to port and back with only three sets of crews, compared to five sets of crews when not working through depots was the norm.

Driver Only Operation

A further reduction in the size of train crews, currently under examination within Queensland Railways, is the concept of trains being run with a driver only. This type of train operation is being

investigated on all trains and locomotives, with the exception of 'Locotrol' trains and Brisbane suburban electric trains. It is expected that driver only operation will be progressively introduced across the Queensland Railways network as signalling and locomotive modifications are carried out.

7. AREAS FOR FURTHER INVESTIGATION

As tonnages exported increase, the rail networks involved in the export of coal will expand. Areas for further research will cover a wide range of activities, and could include :-

- . Potential for interlinking of rail networks to maximise flexibility of operations.
- . The concept of the type of maintenance windows to be used when high tonnages are carried.
- . Mechanised maintenance of overhead wiring.
- . Increased computerisation of operational activities, such as computerised train scheduling and crew rostering.
- . Examination of the trade-offs involved in duplication of track sections or upgrading track structure on single line sections.
- . Duplication of existing ports or the establishment of new ports.
- . Increased automation of loading and unloading operations.

8. CONCLUSIONS

Queensland, over the last twenty years, has assumed the role of Australia's largest coal exporting state. Queensland Railways has played a major part in the achievement of this position through development of the coal carrying railways.

An extensive program of research and development has allowed Queensland Railways to remain competitive internationally, and has allowed Queensland's coal exporters to win new markets. The research and development effort is an ongoing one and, although it is substantially technically oriented, it has been sufficiently broad to encompass the operational, industrial and management areas.

The overriding objective of Queensland Railways in this area of export coal operations is to transport coal at the lowest overall cost, in order to allow Queensland to retain its competitive edge in the coal export markets.

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