REPORT ON AN

ACCIDENT

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MOURA NO. 4

UNDERGROUND MINE

on

WEDNESDAY, 16TH JULY, 1986

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of *"The Coal Mining Act, 1925-1981"*

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BEFORE: Mr K.P.**LYNN,** B.A. LL.B., S.M., Mining Warden

Mr John **MAITLAND,**
General President, Australasian Coal and Shale
Employees' Federation.

Mr Howard **JONES**, B.Sc., O.B.E.,
Retired Mining Engineer

Mr Keith **Ross**, B.E.
Managing Director of Coal Resources of Queensland Pty. Ltd.

Dr Bevan A. **KATHAGE**, B.E. (Qld) Ph.D.,
Senior Mining Engineer, Denham Coal Management Pty. Ltd.

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APPEARANCES

* Mr F.J. **CLAIR**, of Counsel
Instructed by Mr R. Boiston of Crown Solicitor's Office, Brisbane.
To assist the Inquiry.

* Mr A.J. **MacSPORRAN**, of Counsel
Instructed by Mr G. Dickson of the Crown Solicitor's Office, Brisbane.
For the Queensland Department of Mines and the Central Queensland Mine Rescue Brigade and their officers.

* Mr G.W. **OSBORNE**, of Counsel
Instructed by Messrs. Quinlan, Miller and Treston of Brisbane.
For the next of kin of C.S. Friske and P.D. Laing (until day 7) and
Instructed by Messrs. Palmer, Fowler and Associates, Ipswich.
For the remainder of the next of kin.

* Mr P.H. **MORRISON**, of Counsel
Instructed by Messrs. Thynne & Macartney of Brisbane.
For Thiess Dampier Mitsui Coal Pty. Ltd., the owners of Moura No. 4 Underground Mine, and for company personnel D.Fowler, L.F. Cumner and G.A. Mason.

* Mr J.G. **CROWLEY**, Q.C. with him Mr R. M. Bourke of Counsel.
Instructed by Messrs. Morris, Fletcher and Cross of Brisbane as town agests for Messrs. Curwood and Derkenne of Sydney.
For commonwealth Industrial Gases Limited.

* Mr P. **AMBROSE,** of Counsel
Instructed by Messrs. Quinlan Miller and Treston of Brisbane.
For the next of kin of C.S. Friske and P.D. Laing (from day 7).

SUMMARY

At about 11:05 a.m. on 16th July, 1986 an explosion in Moura No. 4 Underground Mine in Central Queensland. The 12 miners who were extracting pillars in the Main Dips Section were killed. Their bodies were recovered on 23rd July, 1986 after an extensive recovery operation.

The Inquiry into the fatal accident was held in Rockhampton conducted before the Mining Warden and four persons having practical mining knowledge. The Inquiry commenced on 9th february, 1987 and closed on 27th February 1987. Evidence presented to the Inquiry showed that the upper part of the seven metre thick seam was being worked and that the strata between the seam worked and the seam approximately sixty metres above it consists mainly of massive bands of sandstone. The seam was described by witnesses as “fairly gassy”.

The Inquiry found that the mine was well ventilted and stone dusted and return airways were continuously monitored for carbon monoxide and methane. Methane detecting instruments were also available to the section’s deputies.

The Inquiry found that a roof fall had occurred in the goaf and that the wind blast from the fall blew a mixture of methane, air and coal dust into the working area. An explosive atmosphere developed in the working area and in particular around the deputy’s flame safety lamp.

An ignition occurred creating a violent explosion which caused extensive damage throughout the section. The explosion was quenched by the presence of a water barrier in the belt roadway and substantial quantities of water in swilleys in other roadways. Some eight possible sources of ignition were considered. The Inquiry considered that the flame safety lamp, although properly assembled, was the most likely source of ignition.

A number of recommendations were made by the members of the Inquiry, the most important of these being that flame safety lamps be prohibited from use in underground coal mines in Queensland subject to limited exceptions.

THE OCCURRENCE

At about 11:05 a.m. on 16th July, 1986 an explosion occurred in Moura No. 4 Underground Mine in which twelve men died. Another eight men were underground at the time. The twelve miners who died comprised the entire team extracting coal from pillars in the Main Dips Section. The names of the deceased miners are contained in Appendix “A”. The other eight were working elsewhere.

Observers on the surface saw a large dust cloud emerge from the mine portals. There was an interruption to power underground and almost immediately damage was reported to the ventilation fan.

The extraction method employed at the mine included controlled caving of the roof and observers at first assumed that a massive roof fall which had been anticipated had caused a severe wind blast to emanate from the mine.

Immediately after the dust cloud was observed on the surface rescue attempts commenced. Men were sent underground who observed that conditions were very dusty and that a strange smell was present.

The eight survivors safely evacuated themselves from the mine. Ruscue teams were sent down to assist the men still in the mine.

A mines inspector who was presnt that day discovered a high concentration of carbon monoxide at the mine portals while inspecting temporary repairs being carried out to the fan.

All men were withdrawn from the area of the fan at 12:26 p.m. The rescue team that penetrated furthest underground was halted by blast debris and poor visibility. The team found that carbon monoxide levels were high and the methane level was climbing and it was obvious that more that a fall had occurred. All men were withdrawn from the mine by 1:30p.m.

Next day, 17th July, 1986, at 10:32 p.m. conditions permitted an inspection underground and a rescue team operating within severe time constraints sighted the bodies of most of the dead miners. The positions of the machines and the bodies of the dead men suggested that immediately prior to the explosion a fall was anticipated and that an orderly withdrawal was initiated. During the withdrawal a young miner may have been pinned beneath a shuttle car. The explosion may have occurred as he was being assisted. The body of the Deputy, who carried a flame safety lamp, was close by him. Further attempts to reach the Main Dips Section were made but conditions did not permit recovery of the bodies until after the injection of nitrogen vapour. All bodies were recovered on Wednesday 23rd July, 1986. After dealing with a subsequent fire the ventilation was restored on Monday 28th July, 1986. Post-mortem examinations revealed that the men had all died quickly.

INTRODUCTION

THE INQUIRY

Pursuant to Section 74 of the *Coal Mining Act 1925-1981* an Inquiry into the nature and cause of the accident was convened at Rockhampton before the Mining Warden for the Mount Morgan Mining District who selected to assist him the following four persons having practical knowledge and skill in the mining industry, who were not connected with the coal mine where the accident occurred:-

* Mr John Maitland
  General President, Australasian Coal and Shale Employees' Federation.

* Mr Howard Jones, B.Sc., O.B.E.
  Retired Mining Engineer.

* Mr Keith Ross, B.E.
  Managing Director of Coal Resources of Queensland Pty. Ltd.

* Dr Bevan A. Kathage, B.E. (Qld) Ph.D.
  Senior Mining Engineer, Denham Coal Management Pty. Ltd.

The Inquiry opened on the 9th February, 1987 and closed on the 27th February, 1987, sitting each week day apart fom the 23rd February, 1987.

In all thirty-six (36) witnesses, who are listed in Appendix "B", were examined and a total of sixty-five (65) exhibits were tendered. These are described in Appendix "C". The transcript of evidence comprises 1,215 pages.

The Moura No. 4 Underground Mine was worked under Special Coal Mining Leases Nos. 125, 141 and 169 all of which were renewed on 11th April, 1978 for terms which expire on 1st April, 1999 and Special Coal Mining Lease No. 361 which was granted on 3rd June, 1976 and approved to commence on 1st March, 1973 for a term which expires on 28th February 1994.

GENERAL DESCRIPTION OF THE MINE

1. LOCATION:

Moura is a predominantly mining community located about 450km north west of Brisbane and 150km south west of Rockhampton in the State of Queensland.

Coal mining by open cut and underground methods has been established in the area for about the last 25 years.

All mining operations in the area are controlled by one company— Thiess Dampier Mitsui Pty. Ltd. (herinafter referred to as T.D.M.).

All mines are located east of the township with No. 4 Mine about 7km from the town. The mines are serviced by a fully equipped branch of the Central Queensland Mines Rescue Brigade situated in the township.

2. GEOLOGY:

The coal seams at Moura contain medium to high volatile, low ash, bituminous coking coal.

The six seams in the lease area dip to the west at about 7 degrees from the subcrop.

The No. 4 Mine extracts the C seam beneath the upper non-mined A and B seams which are approximately 75m and 60m respectively above it. The underlying D seam—40m below C seam, is extracted in No.2 underground mine.

The C seam is approximately 7m thick consisting of:—

(I) an upper 3m section of good coal;
(ii) a middle split of variable thickness up to 1m of poor quality coal; and
(iii) a lower 3m section of good coal.

The strata between C and B seams consists mainly of bands of massive sandstone.

Within the No. 4 mine area, the seam is not intruded by dykes or sills.

Reverse faulting occurs in the seam. These faults, of which the P2¼ Fault is an example, are associated with rolls in the seam.

The C seam makes some water but is not regarded as a wet seam.

3. MINING METHOD:

Mining has always been carried out by continuous miner units.

The mining equipment installed in the affected section of the mine—the Main Dips— consisted of a Joy 12 CM continuous miner which filled either of two Joy 15 SC electric shuttle cars. These cars delivered the coal through a “grizzly” at the boot end onto a 1,050mm. conveyor belt system.

Diesel powered, rubber tyred vehicles conveyed men and materials to and from the surface to the mining sections.

Electric power was reticulated underground at 6,600 volts to section substations which transformed it to 415 and 1,000 volts for the coal cutting equipment.

Compressed air was also reticulated underground to power face and outbye stone dusting units and also hand held face roof bolting equipment.

Standard roof support during development was by roof bolts with some timber roof to floor supports. During extraction additional timber roof to floor supports were used to protect men and equipment.

A crib room was located in each section. First aid equipment was stored in or near this site. Amongst the first aid equipment stored in the Main dips Section was a cylinder containing Entonox which is administered to alleviate pain suffered by a severely injured workman.

4. VENTILATION

The mine is ventilated by a Fox centrifugal fan sited on the surface at the return airway portal. This fan was set to deliver 118m³ per second against a pressure of .473 Kpa.

Permanent stoppings between intake and return directed the air to the last open cut through where brattice sheets were used to direct the air to the working place.

The company installed a MAIHAK Type 4N.1 Carbon Monoxide and Methane infrared analyser to monitor six points in the mine through a tube bundle system. The recorded results were examined daily, the peaks noted and management advised.

In addition the company installed methane monitors on each continuous miner which were set to trip the power to the machine at a concentration of 2% methane or above.

The section deputies had available to them a variety of instruments for detecting methane and included: —

(1) Flame safety lamps;
(2) Sieger automatic fire damp detectors; and
(3) Auer 502 methanometers.

The last ventilation survey carried out on 24th June, 1986 showed 28m³/sec flowing in No. 5 Heading and 34m³/sec in No. 1 Heading of the Main Dips. Methane concentrations were 0.2% and 0.3% respectively.

On the morning of the accident, the face ventilation as shown on Plans Appendices “D” and “E” was reported to be very good with the majority of the air directed over the continuous miner into the No. 1 Heading return. Air quantities flowing would have been similar to those recorded in the ventilation survey.

5. STONE DUSTING:

The standard of stone dusting was shown to be satisfactory as evidenced by the results of the regular tests taken.

In addition to compressed air dusters installed at strategic points throughout the mine, smaller units were used on the return air side of the continuous miner. This type of unit was installed and operative on the shift during which the incident occurred.

A water barrier was installed in the belt heading between 23 and 24 Cut Through as required by *“The Coal Mining Act 1925-1981”.* It was in good condition prior to the event.

6. MANAGEMENT:

The management of the Moura No. 4 mine at the time of the incident was:

Mr R. MacKinnon	General Manager
Mr G. Smith	Area Operations Manager
Mr L. Cumner	Deputy Operations Manager (Acting Mine Manager)
Mr D. Fowler	Mine Manager (on Leave)
Mr G. Mason	Undermanager
Mr W. Greaves	Mine Electrician
Mr T. Faber	Mine Mechanical Engineer

Besides in-house technical services provided by Mine Planning Engineer, Mr M. Caffery, and Underground Geologist Mr I. Poppitt, the company could draw on the services of the Australian Coal Industry Research Laboratory (ACIRL) at Rockhampton and the Superintendent of the Moura Mines Rescue Station, Mr D. Kerr.

Mines Department officials responsible for the Moura Mine included: —

Mr G. Hardie	Chief Inspector of Coal Mines
Mr D. Wilson	Senior Inspector—Rockhampton
Mr J. Brady	Mines Inspector
Mr A.McMaster	Electrical Inspector
Mr A. Hepburn	Principal Mechanical Inspector

Miners Union officials were:

Mr W. Allison	District Union Inspector
Mr M. Best	District Union Inspector

7. MINE DEVELOPMENT:

No. 4 mine commenced in February, 1978 by driveage of three portals from the toe of an abandoned highwall in the top 3m of the seam. The portals provided:

(1) a men and materials entry;
(2) a belt conveyor entry; and
(3) a main return airway where the man fan was located.

As shown on Plan Appendix "D" an additional return was added after the entries had been driven one pillar. This layout provided for the two intakes (supply and conveyor belt roads) to be flanked by single returns.

Mining proceeded using continuous miners and shuttle cars and a number of panels were formed and extracted. Both total extraction of the top split and partial extraction of the total seam involving lifting of bottoms were practised successfully.

A further set of entries—"Acky's Portals" —were developed to improve access to the southern section of the mine—the 3 South Panel. These entries served as additional intakes.

Deterioration in seam quality in advance of the main development caused management to change direction and develop the Main Dips Section. This proceeded until between 22 and 23 Cut Throughs a previously undetected fault described by some as the P2¼ Fault was encountered. This fault was only penetrated with great difficulty. In all headings but the supply road, swilleys were cut in the soft floor and these filled with water. In the supply road the roof fell to a height of about 8m and a major steel structure was erected to protect persons travelling underneath. This became known as the "Taj Mahal".

On the western side of the fault, a marked increase in the virgin seam gas content was noted with values in excess of 7m³ of methane per tonne of coal being recorded.

Mainly because of gas emission problems development proceeded slowly and mining was suspended in late 1983 with the faces advanced to 28 Cut Through line. A methane drainage programme commenced in December, 1983 to test techniques for degassing the seam 50m in advance of the standing faces.

This programme continued despite the loss of some holes until mining recommenced in January, 1986.

Development continued until April when 30 Cut Through was formed between 1 and 3 Headings at a depth of about 190m to seam.

Prediction of a possible geological structure similar to the P2¼ Fault just in advance of the faces together with the prospect of development into the non-drained area had caused management to decide to commence extraction of the formed pillars.

The first plan of extraction called for a single split through the formed pillars and lifting of bottoms to the floor of the seam. Thickening of the middle band in the mining area caused a major decrease in the quality of the coal mined by this method. Market requirements forced management to modify the method of extraction.

The second plan of extraction called for two splits to be driven through the 50m by 30m pillars to a height of 2.3m and then lifting floor coal to the top of the seam split before partially extracting the fenders formed.

This method proved unsuccessful. Irregular sized stooks were left which neither fully supported the roof nor permitted full goaf caving. As a result, abutment pressures increased as evidenced by the rib spalling and floor heave that occurred in the panel. Concern over the method of extraction was expressed by the District Union Inspector on 5th June, 1986.

In May, 1986, T.D.M. acquired the surface property over the panel. This removed a major constraint on management who, until then, had to design and operate an extraction system that would prevent surface subsidence.

With the above constraint removed and weighting apparent in the panel where no major goaf fall had occurred, management decided on a system of total extraction of the formed pillars in the upper part of the seam. It was decided that:

(1) extraction would be carried out on a two shift basis;
(2) three splits would be driven through the pillars and the fenders thus formed totally extracted; and
(3) progress would be closely monitored during the trial period of two weeks.

This commenced on 30th June, 1986 by extraction of the large fenders inbye 27 Cut Through 1A to 2 Headings.

Total extraction continued without major problems until 16th July. During this period, concern was expressed by Mines Inspector J. Brady of the mining practices adopted by one of the crews during his inspection on 7th July. He

detailed his concerns to the crew and requested, in particular that addition roof to floor supports be erected. He proposed to return to the mine on 16th July to repeat his safety instructions to the other crew—Deputy K. Keyworth's crew.

Regular inspections of the working areas and goaf were conducted by Mine Planning Engineer Mr M. Caffery, and Underground Geologist, Mr I. Poppitt. The conditions during Caffery's last visit on 15th July are summarised below:

(1) 3 to 4m fall consisting of 0.5m thick plates of coarse sandstone outbye 28 Cut Through 1-3 Head ings;
(2) 4 to 5m fall 28 Cut Through 3-4 Headings for 20 to 30m along a joint line;
(3) roof heavy 27-26 Cut Throughs 1A-2 Headings where last of a pillar was being extracted;
(4) noticeable weight on goaf edge inbye 3 Heading with rib spall evident in 27 Cut Through;
(5) tension cracks in 4 Heading running outbye to 26 Cut Through; and
(6) considerable floor heave in 27 Cut Through 1-2 Headings.

The above observations confirmed the belief that a goaf fall would shortly occur in the area of total extraction 26-27 Cut Throughs 1A-2 Headings, and this would relieve the abutment loadings being experienced by the pillars.

THE CIRCUMSTANCES IN THE MINE IMMEDIATELY BEFORE THE EXPLOSION

AFTERNOON SHIFT TUESDAY, 15TH JULY, 1986

This production shift completed extraction of the fender inbye 26 Cut Through 1-2 Headings. The continuous miner was flitted to 27 Cut Through 3 Heading and the place prepared for production from the wide fender inbye 27 Cut Through 2-3 Headings.

Shift Deputy, E.C. Strong, commented on the weight being taken by the supports and bed separation occurring inbye 26 Cut Through 1A-2 Headings where both pillars had been totally extracted. This was to be expected and indicated that a fall would occur soon.

NIGHT SHIFT WEDNESDAY, 16TH JULY, 1986.

During this non-production shift between the preceding and following production shifts, the Main Dips Section was inspected twice by Deputy J.W. Blyton. He reported that the goaf was very quiet and despite thorough tests along the goaf edge no inflammable gas was detected.

DAY SHIFT WEDNESDAY, 16TH JULY, 1986

Prior to commencement of shift, Acting Manager L. Cumner (Manager D.Fowler was on annual leave) met with Undermanager G. Mason and Deputy K. Keyworth to discuss the extraction of the wide fender inbye 27 Cut Through 2-3 Headings. They decided to take a strip off the outbye side of the fender, supporting the roof as this was done. The stated reason for this was to reduce the width of the fender so it could be more easily lifted off by the miner starting from the inbye end.

The production crew proceeded underground at about 6:40 a.m. together with the men assigned to maintenance of the other continuous miner section in 3 South Panel.

At about 8:15 a.m., Undermanager G. Mason, proceeded underground to the Main Dips Section where he remained until about 10:15 a.m. when he returned to the surface to meet Inspector J. Brady. During this period mining continued without incident and the crew were in high spirits. Mason inspected the goaf edge and believed a fall was going to occur on that day shift due to the nipping of props in the goaf.

At about 10:30 a.m., W. Greaves, the mine electrician, monitored the trend of the gas readings on the MAIHAK instrument and found nothing abnormal.

The entire belt conveyor system was travelled and inspected by the belt patrolman C. Bayles, and junior miner W. Foden. They found the system to be in very good condition and operating normally. They completed their inspection at 8:30 a.m., returned to the surface for “smoko” and then proceeded underground again to clear up spillage at Dip 2 and Dip 1 boot ends.

G.Ziebell, transport driver, visited the Main Dips Section at least three times during the morning. He stated that the face area was normal and no-one made any adverse comments.

J. Dullahide, supplyman (an experienced miner operator in pillars), also made three trips to the Main Dips Section during the morning to replace empty supply trays with full ones. He also relocated trays in the face area. He noted nothing of concern during his visits to the face area which, it is estimated, he left for the last time about 13 minutes prior to ignition.

THE EXPLOSION AND THE IMMEDIATE AFTERMATH

At about 11:05 a.m. a thick cloud of dark grey dust was observed rising above the spoilpile near the vicinity of the main ventilating fan serving No. 4 underground mine. At the same time the electical power supply to the mine was interrupted. Within minutes an inspection of the vetilating fan revealed substantial damage to the fan ducting, the internal baffles being blown some 25 metres.

In the absence of the Acting Manager Mr Cumner, Mr P. Reed, Manager of Moura No.2 Mine, assumed control. He immediately activated the Mine's emergency procedure and called for assistance from the Moura Rescue Brigade, Moura No. 2 Mine and the Moura Ambulance Brigade.

Some 20 men were underground at the time of the incident—12 in the Main Dips Section, five in 3 South Section and three working on access roads. The five men in 3 South were advised by telephone to make their way to the surface via Acky's portal where they would be met by a deputy and an experienced miner. The other three men working on access roads were out of contact but they made their way to the surface.

Mr mason, the Under Manager at No. 4 Mine apparently made arrangements for Mr Duncan, the No. 2 mine Under Manager and Mr Ziebell to re-enter the Mine via the supply road so that they could undertake a general inspection and assist the men who were leaving the mine. At about the same time, Mr Caddell the mine deputy for 3 South and Mr Dullahide entered the mine to proceed to 3 South to render assistence. At about 11.35 a.m. Caddell met the men from 3 South and after telephoning the surface control they were instructed to return to the surface. On arriving at about 11.55 a.m. Caddell reported to Reed and was instructed to return to 3 South to retrieve "oxygen" self rescuers. He did this with Dullahide and returned to the surface at 12.55 p.m. Duncan and Ziebell had returned at 12.10 p.m.

At 12.05 p.m. the first rescue team captained by N. Pickering was instructed to proceed inbye towards the Main Dips Section to search for survivors. Bayles, who had made his own way to the surface after the incident was instructed to drive the vehicle containing the rescue team. Meanwhile Duncan and Ziebell were debriefed by Cumner and Brady. Both reported that visibility was very poor, the air being "very heavy with dust and having and unusual smell". Brady formed the opinion that both men were exhibiting signs of carbon monoxide poisoning, and arrangements were made for oxygen to be administered. Until this time the general view was that a wind blast had occurred following a fall in the Main Dips Section. Cumner and Brady then made an inspection of the fan and the immediate return. This was made with a readily available Draeger multi tube detector and carbon monoxide in excess of 700ppm. was detected. Following this inspection, all men were withdrawn from the cut where the main fan was located. This was about 12.25 p.m.

The second rescue team under the captaincy of L. Graham was ready at 12.15 p.m. and they were instructed to check all ventilation appliances and the quality of the atmosphere. Shortly after 12.25 p.m. Graham reported from near No. 8 cut through. He reported visibility of about 20 metres, in excess of 700ppm. carbon monoxide, nil methane. After reporting, Graham was instructed to explore further inbye.

At 1 00 p.m. Pickering and his team reported from the inbye end of the Dip 2 conveyor. He reported that his team had advanced as far as the "Taj Mahal" which they found completely destroyed. While Pickering was making his report Graham and his team arrived. Visibility was reported as nil. carbon monoxide in excess of 700 ppm. and 2.2% methane. Both teams were ordered to withdraw immediately—the time being 1.07 p.m.

At about this time Brady and Ziebell entered the fan portal and carbon monoxide in excess of 3,000 ppm. was detected.

Both rescue teams returned to the surface at about 1.30 p.m. and were debriefed by Mr D. Kerr, the Moura Rescue Station Superintendent.

THE RECOVERY OPERATION

Immediately after the debriefing of rescue teams 1 and 2. Messrs. Cumner, Brady, Reed and Kerr and Sergeant Black of the Moura Police held a meeting to assess all available information.

It was then presumed that an ignition of gas and/or coal dust had occurred and there were grave doubts about the safety of the twelve men. The possibility of a second explosion caused the suspension of further rescue attempts until an accurate assessment of the mine atmosphere could be completed.

1. THE RECOVERY OF PERSONNEL:

Arrangements had been made to bring a gas chromatograph and chemists from the Safety in Mines, Testing and Research Station, Redbank near Brisbane. However, they were not expected on site for some time.

Meanwhile, an infrared analyser and oxygen meter belonging to the Mines Rescue Brigade were installed to analyse samples from the mine.

Initial recordings from the main fan drift:

C0 + 5,000 ppm (5,000 ppm.is upper limit of instrument)
CH4 1.7%
02 18%

In addition, drilling of a bore hole was commenced to intersect the Main Dips Section at 27 Cut Through 4 Heading to gain additional air samples.

The gas chromatograph arrived on site at 7:30 p.m. with the first results being available to the control centre shortly after 10:00 p.m. Further readings were taken and analysed including readings from the bottom of the bore hole which was completed at 4:00 a.m. on 17th July.

Upon the control team being satisfied from the trend of the readings that the mine atmosphere was not explosive, rescue team 3 entered the mine at 9:33 a.m. on the 17th July, to explore the workings. Teams 4 and 5 continued exploration and team 6 later confirmed that an explosion had taken place, that all lives had been lost and that extensive damage had occurred to the ventilation system. This team located all but two of the bodies of the missing miners in the area of the Main Dips Section. Many difficulties were experienced during this period, including difficulties with poor visibility and blast debris. The rescue attempts were hampered by fluctuating conditions in the mine caused by changes in atmospheric pressure. These changes caused emission of methane from the sealed 4 South panel and increased the level of methane in the Main Dips when the atmospheric pressure fell. Because of these conditions rescue operations had to be halted and it was not possible to recover the bodies from the mine at that time.

On Friday 18th July, rescue teams 7 and 8, continued exploration and recovery work, while other labour, under the control of the Mines Rescue Brigade Superintendent, commenced temporary repairs to the overcasts and damaged stoppings.

However, these operations ceased when it became evident that an active fire was present inbye 19 Cut Through.

A decision was made to suspend further recovery until a more reliable sample point could be established at 25 Cut Through 1 Heading.

On Saturday 19th July, flooding and inertisation of the Main Dips Section were considered. The option of flooding the section was rejected because it would destroy possible evidence of the occurrence. Action was taken to expedite the arrival of the New South Wales Mines Rescue Service “Mineshield” inertisation equipment and operators from Newcaste, New South Wales— a distance of approximately 1,400 km.

The “Mineshield” equipment consisted of a 40 tonne liquid nitrogen “Mother Tanker” and vaporising unit which converts the liquid nitrogen into gas.

Additional bore hole drilling was commenced to facilitate further sampling, water injection into the goaf and nitrogen injection into the workings.

Drilling and monitoring was continued throughout the remainder of that day.

At approximately 8:00 a.m., Sunday 20th July, the “Mineshield” equipment, technical personnel and four tankers containing a total of 64 tonnes of liquid nitrogen arrived on site. However, the propane gas tanker which contained fuel for the vaporising unit was delayed.

Attempts were made to inject liquid nitrogen directly down two bore holes. These attempts proved unsuccessful as back pressure in the bore holes caused the liquid nitrogen to force its way back to the surface via cracks in the subsoil. This eventually froze the ground and blocked the bore hole.

Water injection was also proving difficult through blockages in the uncased bore holes.

Both operations were abandoned and recovery of the blocked holes by reaming and casing was commenced in anticipation of the nitrogen vapourising unit becoming operational and the arrival of further quantities of liquid nitrogen.

Bore hole recovery and mine atmosphere sampling continued into Monday 21st July, when sample results determined at 10:00 a.m. from bore holes, indicated the mine atmosphere about the Main Dips Section was not explosive. Further samples 1 hour later provided similar information.

As a result, rescue team 9 accompanied by a District Union Inspector, The Mines Rescue Superintendent and the Government Mines Inspector entered the mine. During this inspection concern arose about the accuracy of sample results received up to that time because a thick bluish smoke and a “fire stink” were detected. These signs indicated the existence of an active fire inbye of 22 Cut Through.

Further exploration attempts were suspended and attempts were made to inject nitrogen gas. The first significant injection rate of 5 tonnes per hour was achieved at approximately 6:00 p.m.

This rate was increased gradually to 14 tonnes per hour at 8:00 p.m. causing the oxygen levels to be slightly reduced. However, this rate could not be maintained due to the difficulties of getting sufficient nitrogen to the site. It was evident that the natural ventilation flow in the unsealed panel was diluting the nitrogen and it was calculated that to reduce the atmosphere to 12% oxygen would require an injection rate of 18 tonnes per hour which could not be guaranteed.

On Tuesday, 22nd July, water injection to the goaf area was recommenced to reduce the area to be inertised by nitrogen.

Rescue teams 10 and 11 entered the mine to locate the source of smoke and to erect brattice seals to reduce the quantity of air flow in the panel. Whilst these teams were underground, the nitorgen injection rate was set at 10 tonnes per hour.

In 24 Cut Through between 2 and 3 Headings a large area of smouldering floor coal as well as evidence of burnt out props was discovered. A new sample tube point was established inbye and all roads were sealed by brattice.

Drilling of a bore hole was commenced directly over the heating to allow the injection of nitrogen vapour into the area.

On Wednesday, 23rd July, at 8:20 a.m., the hole was completed and nitrogen, at the rate of 3 tonnes per hour, was pumped through the drill stem. With sufficient quantities of nitrogen on site and additional supplies in transit, it was decided to attempt to recover the bodies.

The nitrogen injection rate was increased and five rescue teams were prepared for the recovery operation. By 1:00 p.m., oxygen levels had been reduced sufficiently to allow the operation to commence. Rescue teams 12, 13, 14, 15 and 16 were to prepare and remove the bodies to the fresh air base.

Physical conditions were extremely arduous with high temperature and humidity, very poor visibility and extensive blast debris. However, in spite of these conditions all of the bodies which had been previously located were recovered together with the two bodies which had not previously been located. One of these, being that of a young miner named Hull, was located wedged beneath the outbye section of Shuttle Car No. 31.

The last of the bodies was transported to the surface by 5:15 p.m. The “mineshield” equipment was shut down at approximately 5:30 p.m.

It appeared that inertisation of the sealed area had been successful in that the oxygen level had remained outside the explosive range.

2. THE RECOVERY OF THE MINE:

The next priority was to re-establish the Main Dips Section by extinguishing the fire at 24 Cut Through, rebuilding stoppings between intake and return roadways, clearing roadways and re-ventilating the workings.

During Thursday, 24th July and Friday, 25th July, preparations were made to inject fly ash to cover the heating. The first truck load was injected by 6:00 p.m. on the 25th, and continued during the remainder of the night.

On Saturday, 26th July, rescue teams 17, 18 and 19 entered the mine at 8:00 a.m., their main objective being to inspect the workings outbye the seals, to double brattice all seals and to erect a suitable air block in the seal in 4 Heading.

By 10:00 a.m., on Sunday 27th July, a total of 200 tonnes of fly ash had been injected and nitrogen injection continued at the rate of 2 tonnes per hour.

Rescue team 20 entered the sealed area and established that fly ash had completely covered the heated zone and that there was no evidence of residual “hot spots”.

Rescue team 21 continued to erect stoppings between intake and return roadways.

On Monday 28th July, rescue team 22 completed erection of remaining stoppings between intake and return roadways. This completed the work necessary to provide a ventilation circuit.

Rescue team 23 made a thorough inspection of all roadways inbye of the seals to ensure that no previouly undetected “hot spots” were present and that it was safe to re-ventilate the area.

Shortly after 12 noon, the outbye stoppings were closed and the five seals opened which allowed re-ventilation of the section. All men were withdrawn to the surface immediately.

The injection of nitrogen vapour continued at a rate of 4 tonnes per hour until approximately 4:00 p.m. when sample results indicated that the atmosphere had returned to normal.

This completed the recovery operation which involved some 35 Mines Rescue Brigade personnel in the 23 teams used.

INVESTIGATION

The investigation was carried out under the control of officers of the Queensland Mines Department.

Organisation of onsite activities was controlled by Rockhampton based Inspector J. Brady. The scope of investigation carried out by Mr Brady included—

1. Collection and sifting of every possible source of evidence from the site of the explosion and the im mediate vicinity.

2. Obtaining of statements from all witnesses who may have been able to shed light on the circum stances leading up to the explosion.

3. Procurement and impounding of all records and other items of evidence which may have been rele vant to the investigation.

Mr Brady acknowledged in his evidence the complete co-operation of T.D.M. in achieving his objectives.

Detailed scientific examination of particular items of evidence such as the flame safety lamp were sought and subsequently co-ordinated by the Chief Inspector of Coal Mines, Mr G. Hardie.

A number of experts were able to give evidence of their investigations and conclusions. These included—

Dr A. Ansford

Government Pathologist who carried out post mortem examinations of the bodies of the victims.

Messrs. A. Hepburn and A. McMaster

Mines Department Inspectors at Rockhampton who were responsible for examining mechanical and electrical equipment which had been in use in the Main Dips Section at the time of the explosion.

Mr T.G. Hislop

Senior Inspector Electrical Testing at the Safety in Mines, Testing and Research Station, Redbank. (SIMTARS)

Mr I. Poppitt

Geologist with T.D.M. who examined the fallen goaf area after the explosion and carried out a series of experiments in order to assess the incendivity of Moura sandstone, and its propensity to ignite methane.

Dr A. Joyce

Principal Operator in Geochempet Services, who gave evidence on the petrological nature of Moura sandstone.

Mr P. Green.

Geologist with the Geological Survey of Queensland who also gave evidence as to the petrological nature of Moura sandstone.

Mr R.H.M. Thomas

Technologist in the Department of Mechanical Engineering of the Capricornia Institute of Advanced Education, who gave details of examination of a damaged Entonox cylinder found near the site of the disaster.

Dr P. Golledge

Director of the Safety in Mines, Testing and Research Station, Redbank, who with the aid of vido explained a series of experiments carried out to investigate the possibility of the flame safety lamp being the source of ignition.

Mr S. Bell

Senior Chemist at Safety in Mines, Testing and Research Station, Redbank, who was responsible for sampling and analysis of roadway dust after the explosion and the plotting of variations in D.A.F.V. values.

Dr A.J. Hargreaves

Senior Engineering Consultant who gave evidence as to the possible source of fuel for the explosion.

Dr A.R. Green

Senior Projects Officer (Combustion), Londonderry Occupational Safety Centre, Department of Industrial Relations, New South Wales Government, who studied evidence related to the path of heat and pressure resulting from the explosion.

A written report was also received from Dr A.F.Roberts, Health and Safety Executive from Buxton, United Kingdom.

The Inquiry received evidence not only from the abovenamed experts but also from employees of T.D.M., both management and miners, rescue personnel, Mines Department Inspectorate, Union Representatives and Police.

DISCUSSION OF EVIDENCE—THE NATURE AND CAUSE OF THE EXPLOSION

The thrust of the investigation and subsequent evidence given to the Inquiry was primarily to provide answers to the following questions:

1. What were the events which took place in the panel between the time Undermanager G.Mason left to travel to the surface and the time at which the explosion occurred?

2. What was the source of the fuel which ignited to cause the explosion?

3. What was the source of ignition of the explosion?

1. EVENTS PRIOR TO THE EXPLOSION:

The “C” seam in the Main Dips Section of Moura No. 4 mine was described by the witnesses, including Dr Hargreaves as a “fairly gassy” seam. It was suggested during evidence that the seam contained about 7m³ of methane gas per tonne of coal. There had been difficulties caused by gas emissions during development of the section and this was one of the factors which had led to a decision in December 1983 to cease development and to carry out a programme of methane drainage.

Mr Fowler’s evidence states that a decision was taken in late 1985 to recommence development inbye of 28 Cut Through to assess the effect of the methane drainage. After forming 30 Cut Through withdrawal was commenced from the Section by partially extracting the pillar coal.

There was clear evidence that there were no problems associated with methane emissions once withdrawal of the panel had commenced in early 1986. The quantity and standard of ventilation in the section was shown to have been satisfactory and in excess of that required to meet all normal circumstances which may be encountered.

There were three separate plans devised and submitted to Inspector Brady of the Mines Department covering the method of extraction of pillar coal in the section. The first two plans entailed methods of partial extraction with pillars being split and fenders being punched.

It is clear from evidence submitted that neither of these plans for partial extraction was strictly followed and substantially smaller remnant pillars were left than had been planned.

Concern was expressed to management by both Inpsector Brady and District Union Inspector W.Allison, that the submitted plans were not being followed. Their concern was related primarily to the risk of the continuous miner operator being struck by a localised roof fall when he progressed beyond the last line of support when extracting coal. Their other concern was that robbing of coal from the designed pillars would lead to increased abutment pressure in the working areas and consequent strata support difficulties. These are genuine concerns which should be addressed but in the opinion of the members of the Inquiry they bear no direct relevance to the cause of the explosion.

Following onsite meetings on June 23, 1986 between Management, Miners’ Union representatives and workmen, it was agreed that a system of total extraction of the upper part of the seam should be commenced and the following day a letter was forwarded to Inspector Brady to advise him of this decision and to seek his agreement. Mr Brady signified his agreement to the changes.

The evidence of all witnesses who spoke to the crew on the day of the disaster indicates that they held no concern regarding the conditions in the panel. They were aware of the likelihood of a large goaf fall which would be considered normal under these circumstances.

It has been established that a goaf fall took place during the interval between the time of Mr Dullahide leaving the section and the explosion occurring. Both Mr Brady and Mr Poppitt observed that the upper surface of the fall in 27 Cut Through between 1 and 2 Headings was covered in carbon black or soot as was the roof above that fall. These facts show that there was some flame in the void after that fall.

It has also been established that there was an orderly withdrawal of the continuous miner and the men from the face shortly prior to the goaf fall. At sometime towards the end of this withdrawal it appears that Mr Hull was struck by the car prior to the explosion and injured but not killed. The positioning of seven other victims’ bodies in close proximity to that of Mr Hull supports a view that they were attempting to assist him.
The position of bodies of the other four men and the finding of an Entonox cylinder and a lifting jack away from where they would normally be is consistent with their obtaining further assistance to recover Mr Hull.

SOURCE OF FUEL

The opinions of Drs Golledge, Hargreaves and Green are unanimous that the explosion was initiated in an atmosphere of methane and coal dust.

The presence of coal dust can be readily explained by the preceding goaf fall. Although the Dip section was well stone dusted there would have been sufficient coal dust in the main working area to support the explosion. Mr Brady's evidence stated that the standard of stone dusting at Moura No. 4 mine exceeded the statutory requirements. It is probably that this high level of stone dusting combined with the presence of a water barrier on the belt road and a swilley filled with water in other roadways prevented the explosion propagating outbye 22 Cut Through. It is likely that the arrest of the explosion at this point saved the lives of Mr Bayles and Mr Foden who were at the boot end of Dip 1 belt at the time and conceivably could have saved the lives of the other men who were working underground.

Records of the UNOR tube bundle continuous monitoring system showed that ventilation in the Main Dips Section was diluting methane emissions to a level of approximately 0.3% in the panel return prior to the fall. However, it is inevitable that higher percentages of methane would be present in the goaf with some diffusion to join the main ventilation flow. Some of this methane would be expelled from the goaf as a result of the goaf fall.

The possibility of a sudden release of gas from the upper strata was discounted by Mr Poppitt and considered unlikely by Dr Hargreaves. Mr Poppitt bases his conslusions on a series of gamma ray logs taken from boreholes which were drilled to the goaf area as part of the recovery operation.

Evidence suggests that the conditions prevailing in the section and in the goaf prior to the fall were not unusual. The quantity of methane necessary to be mixed with air and coal dust to provide the fuel for the explosion was relatively small. Officials at all mines should be aware of the potential for similar circumstances arising during the extraction phase.

3. SOURCES OF IGNITION:

(A) **Discountered sources of ignition**

The Inquiry was provided with detailed investigation of a range of possible sources of ignition. Of these a number were discounted:—

Fire or Spontaneous Combustion

The only evidence of fire after the incident was in 24 Cut Through between 2 and 3 Headings and this clearly occurred as a result of the explosion. Any heating in this area prior to the incident would have been readily detected in the panel and also by Mr Bayles and Mr Foden who inspected the belt road a short time before. Carbon monoxdide levels recorded by the continuous monitoring unit in the Main Dips Section return airway were extremely low prior to the explosion and preclude any possibility of a heating having occurred in the goaf.

Electrical Apparatus and Cables

An exhaustive examination carried out under the supervision of Electrical Inspector McMaster revealed no evidence of faulty apparatus. There were a number of damaged cables but these showed no signs of electrical arcing and it can be concluded that the damage to them took place as a result of the explosion itself.

Electro-Static Discharge

Mr Hislop of SIMTARS carried out a series of investigations to determine the anti-static nature of hoses and brattice sheets. He determined that the bull hoses used for compressed air reticulation in the face area were not anti-static and were capable of a build up of potential which, if discharged, could provide a spark which might ignite gas. However, these hoses were not in use at the time of the explosion.

Mechanical Equipment

An exhaustive investigation supervised by Mechanical Inspector Hepburn showed no evidence of any mechanical faults likely to produce undue heating. This investigation included the conveyor system which was inspected shortly before the explosion.

The Aluminium Entonox Cylinder

During the investigation the theory was propounded that the damaged aluminium Entonox cylinder found in the vicinity of 26 Cut Through 4 Heading may have been responsible for initiating the explosion. It was speculated that as the cylinder was being carried to the site of the accident involving Mr Hull it may have been accidentally struck against a solid object thereby breaking off the valve and causing the cylinder to rocket. It then may have struck rusty steel and produced the incendive spark which ignited the gas and coal dust in the atmosphere.

Mr Hepburn and Mr Thomas each carried out an investigaion on the damage to the cylinder and produced evidence which indicates that this scenario was highly unlikely.

Contraband

The search of the underground area carried out after the incident failed to locate any item of contraband which was likely to contribute to the explosion.

In respect of the six possible sources referred to above namely Fire or Spontaneous Combution, Electrical Apparatus and Cables, Electro-Static Discharge, Mechanical Equipment, The Aluminium Entonox Cylinder and Contraband, the members of the Inquiry after considering all the evidence have come to the view that these can be discounted as the source of ignition.

(B) **Other ignition sources**

Two other ignition sources are considered possible. These are frictional ignition and the flame safety lamp carried by Deputy Keyworth.

(a) **Frictional Ignition**

The possibility of fricitonal ignition was considered in three separate contexts:—

(I) the possibility of the cutter picks of the continuous miner striking the sandstone roof and causing ignition in the working place;

(ii) the possibility of sandstone falling in the goaf and striking steel such as a roof bolt or W strap; and

(iii) the possibility of friction between adjacent blocks of sandstone during a roof fall.

Extensive research carried out overseas has indicated that certain sandstones are capable of creating incendive sparks when impacted upon steel objects or rotating cutter picks.

The orderly withdrawal of the equipment from the working area suggests that the impact of rotating picks of the continuous miner is a highly unlikely source of ignition. The evidence of tests undertaken by Mr Poppitt reinforces the view that sandstone striking steel is also highly unlikely as the source of ignition.

This leaves the possibility of frictional ignition between blocks of sandstone. The National Coal Board have issued a standard classifying the incendivity of rocks within the United Kingdom according tho their quartz content. It was stated by Dr Roberts that they measure the quartz content by the point counting protorlogical method. By this standard Moura sandstone could not be considered as incendive.

However, both Mr Poppitt and Dr Roberts were able to ignite methane in the laboratory by creating friction between a grinding wheel made of Moura sandstone and similar piece of sandstone pressed against the wheel.

Further assessment of quartz content was then undertaken using the x-ray diffraction method by which the finer grains of quartz contained with other similar fine grained minerals can be measured. Although witnesses seem to agree that the point counting petrological method should be more appropriate in assessing the incendivity of the rock, it is apparent that the significance of total quartz content should be further assessed by research so that a more appropriate standard can be established to cover the Permian strata of the Queensland coal fields.

Mr Poppitt and Dr Roberts were able to ignite gas in their grind wheel experiments. Mr Poppitt estimated that the rock had almost reached its melting point before ignition was achieved. He expressed the view that the likelihood of such temperatures being reproduced as a result of friction between rocks during a roof fall is remote.

The members of the Inquiry are of the view that frictional ignition from sandstone on sandstone of the type found at Moura is highly unlikely to have been the source of ignition.

(b) **The Flame Safety Lamp**

The second possible source to be considered is the flame safety lamp carried by Deputy Keyworth.

This lamp was found close to the body of Keyworth and an initial inspection at the disaster site showed it to be full of fine dust. The lamp and its contents were sent to the Safety in Mines Testing and Research Station at Redbank where it was subjected to intensive examination and testing under the direction of Dr Golledge. The examination and tests revealed:—

(i) that except for minor superficial damage, the lamp was correctly assembled and in good order;
(ii) both inner and outer gauzes of the lamp had been subjected to temperatures of about 900 deg.C;
(iii) that the internal surface of the lamp glass was evenly coated with fine coal dust particles which were fused to the glass;

(iv) that the outer surfaces of the bonnet and the glass were evenly coated with dust particles. In this resepct the experiments showed that this effect and the fusing of coal dust on the glass could only be reproduced by an explosion source close to the lamp itself;
(v) that by igniting an atmosphere of coal dust and methane within an identical lamp and maintaining the same explosive atmosphere, ignitions continued to develop inside the lamp after the wick was extinquished;
(vi) that the ignition temperature necessary to ignite an atmosphere of methane and coal dust was significantly lower than that for methane alone, and that such lower temperatures were easily attained in the outer gauze of a flame safety lamp.

The testing and experimental programme under the direction of Dr Golledge has established that it is possible for an explosive mixture of coal dust and methane to be ignited by the heat generated in the gauze of a flame safety lamp. He has also established that the temperature necessary for such ignitions can exist following repeated internal explosions when the fuel is a mixture of fine coal dust and methane.

At the time Dr Golledge presented his evidence to the Inquiry he reported he had been unable to ignite explosive atmospheres outside the outer gauze. This may have been associated with the inability to maintain the necessary explosive mixture around the lamp throughout the experiment and this indicates the need for further immediate research. Dr Golledge has now reported that during his continuing research and experiments he was able to ignite an explosive mixture outside the outer gauze. Dr Golledge's further report is annexed as Appendix "H".

These matters, plus the fact that metallurgical examinations of the gauzes in Deputy Keyworth's flame safety lamp confirmed that temperatures of about 900 deg. C. had been generated, indicate that the flame safety lamp could have been the source of ignition.

Considering all the evidence and the expert opinions presented, the members of the Inquiry have formed the view that the most likley source of ignition was the flame safety lamp.

SEQUENCE OF EVENTS

The members of the Inquiry believe that the most likely sequence of events in the Main Dips Section of Moura No. 4 Mine on 16th July 1986 was:—

At approximately 11 a.m. the deputy and crew observed increased evidence of roof movement in the goaf as they were extracting the fender inbye of 27 Cut Through and between 2 and 3 Headings. They judged that a fall was imminent and proceeded to withdraw the continuous miner and other equipment to a safe position in 3 Heading outbye of 27 Cut Through.

When the withdrawal was almost complete, and only the continuous miner cable remained in an exposed position, Mr Hull, a Cadet Manager, was struck by the outbye end of shuttle car No. 31 as it was being moved in an outbye direction. The chassis of the car pinned him beneath it but the wheels stopped short of running him over. He was injured but not killed by the accident.

Other members of the crew went to his assistance including the deputy, Mr Keyworth who carried his flame safety lamp on his belt.

At this time, approximately 11 a.m. the expected roof fall took place in the goaf, inbye of 26 Cut Through and between 1A and 2 Headings.

The wind blast from the fall blew a mixture of methane, air and coal dust from the goaf and inbye working area outbye to 26 Cut Through and perhaps beyond. It also destroyed the brattice ventilation stoppings, thereby short circuiting the normal ventilation so that it was able to pass directly along 26 Cut Through and into the return.

An explosive atmosphere containing methane and coal dust developed around the men and in particular the deputy's flame safety lamp. The flame ignited this atmosphere within the lamp, and the resultant internal explosion extinguished the flame but heated the inner gauze to a temperature that caused it to continue to ignite the methane/coal dust mixture. After some seconds the outer gauze was heated sufficiently to cause it to propagate the ignition to the explosive atmosphere outside the lamp.

The explosion propagated both inbye and outbye and probably reached its greatest source of fuel in the goaf area.

Pressure waves and heat caused entensive damage in all areas inbye of 22 Cut Through.

The explosion was quenched by the presence of a water barrier on the conveyor roadway and substatial quantities of water in swilleys in other headings.

All twelve men in the Section at the time would have died almost instantly.

OTHER MATTERS

During the Inquiry many matters other than those directly associated with the explosion were raised which require some comment as they are matters applicable to underground coal mining throughout the State and are relevant to attaining high safety standards.

These matters referred to are:—

(a) The training of initial entrants to the coal mining industry and the regular retraining of existing coal miners. The retraining of management, the inspectors of coal mines and the mines rescue brigade superintendents in all matters associated with explosions in coal mines and other disastrous incidents.

(b) The establishment of comprehensive emergency procedures throughout the State to deal with disas ter emergencies. The provision of gas analysis equipment at strategic locations throughout the coal fields and the training of appropriate personnel in its use.

(c) The need to establish a more autonomous Testing and Research Station at Redbank.

(d) The need to undertake an immediate investigation into the application of inertisation in the control of mine fires and spontaneous heating in underground coal mines.

(e) The need for total control of the use of aluminium alloys in underground coal mines.

(f) The need for the use of environmental monitoring in underground coal mines, and the immediate need for existing installations to be fitted with a power source which is independent of the normal mine supply.

(g) The need for stricter control of the pillar extraction operation.

(a) Training and Retraining

Evidence taken during the hearing and comments made by some witnesses highlighted the fact that the formal statutory training requirements in the Queensland Coal Mining Industry were inadequate and that the training and supervision of new entrants into the industry are below a satisfactory level. It is also apparent that the retraining of existing underground miners is not satisfactory bearing in mind the rapid changes in technology which are taking place in the industry at the present time.

A review of underground training and retraining schemes appears essential. The membors of the Inquiry believe that any formal training programme which is developed should be approved by the Chief Inspector of Coal Mines. The Inquiry was given details of the method of work employed at the mine and the events immediately before and after the explosion took place. Members of the Inquiry are aware of the extreme circumstances which existed at the mine immediately after the incident and the understandable desire on the part of the other employees to render assistance to the miners trapped in the mine.

Nevertheless serious concern must be expressed that those responsible failed for some time to consider alternative causes for the disaster other than a wind blast from the goaf area of the Main Dips Section of the No. 4 Underground Mine. Further serious concern relates to the instructions given to and action taken by the first two rescue teams who, although equipped with self-contained breathing apparatus, took no steps to use that equipment nor to determine the nature of the obviously hostile atmosphere which they were entering.

Indeed the evidence shows that the first rescue team failed to take any gas monitoring equipment with them and in fact were transported by a miner who was not equipped with or trained in the use of self-contained breathing apparatus.

(b) Emergency Procedures

During the hearing the members of the Inquiry formed the view that basic procedures should exist throughout the Queensland underground coal mining industry to cover disaster emergencies.

Evidence indicated that the first qualitative analysis of mine air was not available for some 11 hours after the detection of the incident, and that no emergency procedure existed which would automatically alert and call up experts and equipment.

At Moura this delay did not contribute to events after the explosion but it is obvious that a complete understanding of qualitative and quantitative ventilation conditions is essential if correct decisions are to be made following incidents of this nature. The need for such a service has been demonstrated as has the need for mine managers to have expert advice and access to all services. The development of more detailed disaster procedures is essential.

(c) Testing and Research Station—Redbank

Considerable evidence was also taken which related to the Safety in Mines Testing and Research Station at Redbank. Members of the Inquiry were aware that the Station was being newly equipped when the disaster occurred and they considered that the staff operated effectively under difficult circumstances.

It is desirable that this Station enjoy a considerable level of autonomy within the organisation of the Mines Department. It is accepted that budgetry and management control makes complete autonomy impossible. The members of the Inquiry consider it is necessary for the head of this establishment to be responsible to a senior member of the Mines Department who does not have delegated authority or responsibility for the inspectorial aspects of the Department.

By developing such a line management arrangement it may be possible to eliminate any conflict of interest which could exist and may permit the organisation to service the many needs of the coal mining industry in a manner seen to be objective.

(d) Inertisation

Inspector Brady's report and oral evidence given to the Inquiry dealt with the work of inertisation of the goaf and the immedaiate face area with nitrogen vapour. Notwithstanding problems related to the availability of nitorgen, equipment, necessary expertise and technical problems associated with the preparation of drill holes, the use of nitrogen achieved some degree of success in lowering the oxygen to safer limits.

The use of such a method of inertisation has been successful overseas as well as in Australia and obviously warrants more attention as a potential method of dealing with open fires, post explosion conditions and spontaneous heating particularly where access by surface bore holes is possible.

(e) Aluminium Alloys

Considerable evidence and technical opinion was given on the possible involvement of the aluminium alloy Entonox cylinder which was in the Main Dips Section. It was demonstrated that this equipment played no active part in this disaster but the members of the Inquiry are concerned that such equipment existed underground at the time of the incident notwithstanting the widespread understanding of the dangers associated with aluminium alloys in underground coal mines.

(f) Monitoring Equipment

The Moura No. 4 Mine used remote monitoring equipment and records showed that it worked effectively up to the time of the explosion. It did however cease functioning when the main electricity supply was isolated to the mine following damage to the mine ventilation fan. It is desirable that the power supply to such equipment should be independent of the normal supply service. The continued use of this equipment even though some of the tube installation suffered damage could have provided invaluable information concerning the conditions at the time of and immediately after the explosion. The pre explosion information quickly established the absence of a spontaneous combustion development before the explosion and it has demonstrated the need for such equipment to be put into general use in the Queensland coalfields.

(g) Pillar Extraction

Initial evidence presented to the Inquiry established the pre-explosion conditions and the development of the Main Dips Section up to the time of the incident. The pillar extraction system was varied on three occasions and it was clear that non-adherence to pillar extraction plans caused concern to the Inspectorate, the Union Inspectors and members of the Mine management. Indeed the variation and non-compliance would have aggravated roof control within the area. The management had proper consultation with all parties before changes occurred and the proper notification was given to the Mines Department. It is noted that no formal acknowledgement or approval is required following such notification and in the light of experience a requirement for such acknowledgement and approval would seem appropriate.

RECOMMENDATIONS

1. FLAME SAFETY LAMPS

(a) It is recommended that research be continued at the Safety in Mines Testing and Research Station at Redbank to establish the ignition hazards associated with approved flame safety lamps in explosive mixtures of methane and coal dust. It is also suggested that such research should be undertaken in an environment similar to those which may be experienced in underground coal mines.

(b) It is further recommended that legislation should be amended to prohibit the use of flame safety lamps in underground coal mines in Queensland and that the wording of the interim recommendation of the Inquiry be revised to ensure that:—

(i) exemption by Mines Department to allow use of the flame safety lamp be for a finite period and only the Chief Inspector be empowered to exempt—in writing.
(ii) all statutory underground officials be required to carry instruments for detection of methane and oxygen deficiency.

2. RESEARCH—FRICTIONAL IGNITION

It is recommended that the necessary funds be sought to enable continued research and experimentation into the phenomenon of frictional ignition. The purpose of the research should be to ultimately establish a standard whereby all strata rocks found in Queensland coalfields can be classified according to their degree of incendivity.

3. RESEARCH—IGNITION BY OTHER UNDERGROUND APPARATUS

It is further recommended that research be undertaken into the effect of the apparent lower temperature of ignition of concentrations of methane gas and coal dust on the safety of other apparatus in use underground.

4. TRAINING

It is recommended that a committee be established comprising representatives from the Mines Department, Queensland Coal Association, and Unions to establish minimum requirements for training in the Coal Industry of Queensland.

It is strongly recommended that a formal training programme, approved by the Chief Inspector of Coal Mines, be required at every mine. The content of the training programme should be determined by the specific circumstances of each particular mine, but all approved programmes should include:—

(i) an initial induction period of adequate duration for all new employees;
(ii) a period of ongoing training and tuition with regular retraining;
(iii) an oral examination by an approved official before an employee is classified as experienced.

It is further recommended that a retraining programme in all aspects of explosions in underground coal mines be undertaken as a matter of urgency. This retraining programme should be directed to mine management, the Coal Mines Inspectorate and Mines Rescue Brigade Superintendents.

5. EMERGENCY PROCEDURES.

It is recommended that the manager of a mine be required to prepare detailed emergency procedures which would apply in the event of the following events occurring at his mine:—

(i) explosion;
(ii) open fire;
(iii) self heating—spontaneous combustion;
(iv) inundations.

These procedures should be drawn up after due consultation with the Mines Department Inspector, the District Union Inspector and the Mines Rescue Brigade Superintendent.

They should include detailed instructions concerning identification of the occurrence, evacuation of employees, notification of officials and statutory requirements, duty sheets for persons assigned specific tasks, and lines of delegation in the case of absence of statutory officials. They should also include involvement of outside services such as police, State Emergency Services, and hosptials, and rapid transportation of persons and equipment, medical officers and specialist assistance.

An emergency control centre should be established at the mine together with a control team under the control of the mine manager. Members of the team should include the Mines Department Inspector, the Union Inspector and the Mines Rescue Brigade Superintendent. The manager would be empowered to co-opt additional persons to that team appropriate to the circumstances of a particular occurrence. Copies of the emergency procedures should be issued to every official at the mine and should made readily available to all other employees on request.

It is further recommended that an up to date list of experts in the various aspects of mine safety and emergency procedures be compiled and maintained by the Mines Department.

6. GAS ANALYSIS EQUIPMENT

It is recommended that each mines rescue station in Queensland be equipped with sufficient gas analysis and other equipment to enable it to accurately and expeditiously determine the explosibility of a mine air sample. It is considered that the current arrangement of maintaining a chromatograph in Rockhampton is less than adequate due to the time required for its transport to a mine site in case of an emergency.

Various opinions were expressed at the Inquiry as to the availability of a suitable alternative to the chromatograph for the determination of hydrogen content. The research station at Redbank should be assigned to urgently determine if such an instrument is available. If it is, it should be acquired for each of the Mines Rescue Stations.

If it is not readily available then a chromatograph with support equipment should be purchased for each Mines Rescue Station in Central and Northern Queensland. It is recognised that the research station at Redbank is in close enough proximity to serve the needs of the West Moreton field.

Differing opinions were expressed at the Inquiry as to the ability required to maintain and operate a chromatograph. The members of the Inquiry believe that the availability of this or equivalent gas analysis equipment at the Rescue Stations is essential. The District Rescue Management Committees should be given the responsibility to ensure that adequately trained personnel are available and deployed to ensure the readiness and accuracy of the equipment in an emergency.

7. AN AUTONOMOUS SAFETY IN MINES TESTING AND RESEARCH STATION AT REDBANK IN QUEENSLAND

It is recommended that arrangements be made to increase the level of autonomy in this organisation.

It is suggested that this can be achieved by making the head of the Station answerable to the Minister for Mines and Energy or to his Director-General.

It is further suggested that an advisory committee be set up under the chairmanship of an independent person and that representation on the committee should include nominees from:—

The Department of Mines
The Queensland Coal Association
The Queensland Chamber of Mines
The Queensland Mining Unions
The Queensland Tertiary Institutions
The Safety in Mines Testing and Research Station

The role of such an advisory committee would include advice to the Minister for Mines and Energy on:—

Priorities for research
Budget estimates
Fee Policy
Staffing levels

8. INERTISATION

It is recommended that the Chief Inspector of Coal Mines appoint a committee to investigate all aspects of the control of mine fires, post-explosion conditions and heatings by inertisation.

9. ALUMINIUM ALLOYS

It is noted that the use of aluminium alloys is generally prohibited in underground coal mines in Queensland by Rule 29.1 of the General Rules for Underground Coal Mines and that any exemption to such prohibition is the subject of investigation and approval by the Chief Inspector of Coal Mines. It is recommended that this rule be rigorously enforced.

10. CONTINUOUS MONITORING

It is recommended that an approved continuous monitoring system, capable of automatically determining the composition of the mine atmosphere at pre-determined points in the airway system be required at all underground coal mines in Queensland.

Features of this system should include as a minimum standard:—

(i) the ability to accurately determine the concentration of methane and carbon monoxide and to rec ord the results at the surface;
(ii) monitoring points in all return airways where methane content has exceeded 0.5%

(iii) monitoring points in return airways from waste or goaf areas where spontaneous combustion my develop;
(iv) monitoring points on main conveyor roadways which are not frequently travelled by men;
(v) a continuous recording system at the surface which provides an historical record of gas levels at each monitoring point;
(vi) an auxiliary power supply which enables continuity of operation in the event of a power interruption;
(vii) the positioning of monitoring points should be determined by the Manager approved by the In spector and recorded in a book kept for the prupose. No person should be permitted to move the position of a monitoring point except with the permission of the Manager.

11. PILLAR EXTRACTION

It is recommended that existing legislation be amended to require that second working (pillar extraction) of a seam be permitted only on the written authority of the Mines Department Inspector.

In seeking such authority the Manager should apply in writing, setting out the method and sequence of extraction to be used illustrating these with a detailed mine plan of the area to be extracted.

In granting such an authority the Inspector should do so subject to a set of special conditions. These special conditions should include;—

(i) a requirement that no departure from the approved method and sequence of extraction be under taken unless only of a minor nature and then only with the specific approval of the Mine Manager.

(ii) a requirement that the plan be displayed on notice boards at the surface of the mine and in the working section.

(iii) in the case of a partial extraction method adequate control to ensure that remnant pillars are not extracted beyond their final design dimensions. To this end the practice of “punching” pillars is undesirable as it is a system in which the required control is unlikely to be achieved.

12. MONITORING OF OVERSEAS DEVELOPMENTS

It is recommended that a group comprising representatives from both Government and Industry be formed to monitor safety developments overseas and to deliver its findings to the Queensland Coal Industry on a continuing basis.

J. Maitland
H. Jones
K. Ross
B.A. Kathage

I agree with the above findings and concur with the recommendations.

K.P. Lynn
WARDEN

Dated at ROCKHAMPTON this 12th day of JUNE 1987.

APPENDIX "A"

List of Victims

Name	Age	Marital Status	Previous Address	Cause of Death
Kevin Ronald Keyworth	53 years	Married	5 Farmer Street, Moura	Head injuries
Raymond Charles Holton	37 years	Married	17 Rogers Street, Moura	Asphyxia
Peter Vincent Waning	35 years	Married	16 Minoque Street, Moura	Asphyxia
Brandt Afton Fechner	18 years	Single	24 King Street, Moura	Head injuries
Robert Turner	41 years	Married	8 Nobbs Street, Moura	Head injuries
Scott Kenneth McPherson	22 years	Married	16 Becker Street, Moura	Head injuries
Paul Allan Sainsbury	23 years	Married	12 Wenck Street, Moura	Asphyxia
Lee Anthony McCulloch	23 years	Single	88 Nobbs Street, Moura	Asphyxia
Ernest Kevin Sleep	57 years	Married	36 Nobbs Street, Moura	Incineration
Paul Douglas Laing	28 years	Married	6 Minoque Street Moura	Asphyxia
Carl Steivon Friske	25 years	Married	29 King Street, Moura	Asphyxia
Steven Craig Hull	19 years	Single	T.D.M. Barracks, Moura	Asphyxia

APPENDIX "B"

List of Witnesses Examined

Number	Name	Occupation
1.	BRADY, John	Mines Inspector
2.	EDWARDS, Glen Barry	Surveyor
3.	MORRIS, Det.Senr.Sgt. Kenneth Cambadge	Police Officer
4.	BLACK, Sgt. Dennis John	Police Officer
5.	FOWLER, Donald	Manager
6.	CAFFERY, Michael	Engineer
7.	MASON, George Arthur	Under Manager
8.	BLYTON, John William Thomas	Deputy
9.	DULLAHIDE, John Robert	Driver
9A.	BLYTON, John Willam Thomas—Recalled	Deputy
10.	CADDELL, Michael Robert	Deputy
11.	STRONG, Edward Clarence	Deputy
12.	ZIEBELL, George Ronald	Miner(15years experience)
13.	GREAVES, William Octavorius Butler	Electrician
14.	ATTO, Donald	Lamp Room Attendant
15.	FODEN, Warren Michael	Miner(1 year experience)
16.	BAYLES, Clarence Charles	Miner(7½ years experience)
17.	HENDERSON, Alexander John	Fire Safety Officer
18.	GUEST, Kenneth Neil	Deputy
19.	REED, Phillip John	Manager
20.	GLAZEBROOK, Christopher John	Open-Cut Examiner
21.	ALLISON, William Mead	District Union Inspector
22.	CUMNER, Leonard Frederick	Deputy Operations Manager
23.	ANSFORD, Anthony Joseph	Specialist Pathologist
24.	McMASTER, Allan Edgar	Electrical Inspector of Coal Mines
24A.	ANSFORD, Anthony Joseph—recalled and interposed	Specialist Pathologist
24B.	McMASTER, Allan Edgar—continued	Electrical Inspector of Coal Mines
25.	HEPBURN, Allan Morten	Principal Mechanical Inspector of Coal Mines
26.	THOMAS, Roger Henry Maitland	Technologist
26A.	BRADY, John Patrick—recalled	Mines Inspector
27.	JOYCE, Dr Alwyn Stanley—interposed	Principal, Geochempet Services
27A	BRADY, John Patrick—continued	Mines Inspector
28.	GOLLEDGE, Dr Peter—interposed	Chief Engineer, Research and Technical Services Branch, Safety in Mines, Testing and Research Station, Redbank
28A.	BRADY, John Patrick—continued	Mines Inspector
29.	HISLOP, Thomas Graham	Senior Inspector, Electrical Testing, Safety in Mines, Testing and Research Station, Redbank
30.	POPPITT, Ian Lindsay	Underground Geologist
31.	GREEN, Peter Michael	Geologist, Geological Survey of Queensland
32.	BELL, Stewart Lynn	Senior Chemist, Safety in Mines, Testing and Research Station, Redbank
32A.	GOLLEDGE, Dr Peter—recalled	Chief Engineer, Research and Technical Services Branch, Safety in Mines, Testing and Research Station, Redbank
32B.	BELL, Stewart Lynn—recalled	Senior Chemist, Safety in Mines, Testing and Research Station, Redbank
32C.	BRADY, John Patrick—recalled	Mines Inspector

APPENDIX "B" (Cont'd)

Number	Name	Occupation
33.	HARGRAVES, Dr Allan James	Mining Engineering Consultant
34.	GREEN, Dr Anthony Roland	Senior Projects Officer (combustion) Londonderry Occupational Safety Cente, New South Wales
35.	FORRESTER, Dr Ralph William	Senior Engineer, Cylinder Technology for Commonwealth Industrial Gases
35A.	HEPBURN, Allan Morten—recalled	Principal Mechanical Inspector of Coal Mines
36.	HARDIE, Grahame Eric	Chief Inspector of Coal Mines
36A.	HARDIE, Grahame Eric—recalled	Chief Inspector of Coal Mines

APPENDIX "C"

List of Exhibits

No. of dered Exhibit	Nature of Exhibit	Ten- by
1.	Statement—John Patrick Brady	Brady
2.	Part 1—Investigation prepared by Brady (Bound) (97 pages)	Brady
	Part 2—Appendix 36 (Inspections of Mechanical Apparatus prepared by Hepburn)	Brady
	Part 3—Appendix 22 (Photocopies Gas Level Readings)	Brady
	Part 4—Appendix 25—(Photographs)	Brady
	Part 5—Appendix 23—(Photocopies of Statements and Interview Records)	Brady
	Part 6—Appendices 1 to 40 (except 22, 23, 25 and 36)	Brady
3.	Statutory Reports/Mine Record Book/Daily Reports/Mine Monitory System	Brady
	Part 1—Appendix 3—June Ventilation Survey	Brady
	Part 2—Appendix 4—Original Acirl Sample Results	Brady
	Part 3—Appendix 5—Notice Intention to partially extract 29-5-86	Brady
	Part 4—Appendix 7—Notification Proposed Changes to extraction 24-6-86	Brady
	Part 5—Appendix 10—Caffery Plan	Brady
	Part 6—Appendix 22—Original Sample Results	Brady
	Part 7—Appendix 23—Original Statements	Brady
	Part 8—Appendix 24—Mine Monitor Record Book	Brady
	Part 9—Appendix 24—Original Statutory Reports Deputies Conveyor Inspections and Daily Gas	Brady
	Part 10—Appendix 24—Tests Diesel Vehicles Mine Record Book	Brady
	Part 11—Appendix 24—Electrical Statutory and Shift Reports	Brady
4.	Part 1—Belt Conveyor Report Book	Brady
	Part 2—Main Dip Report Book	Brady
	Part 3—`A' Panel Report Book	Brady
	Part 4—Main North Return From Surface Report Book	Brady
	Part 5—4 South Report Book	Brady
	Part 6—3 South Report Book	Brady
	Part 7—Electrical—Daily Shift Report Commenced 10-4-86	Brady
	Part 8—Electrical—Daily Shift Report Commenced 23-6-86	Brady
	Part 9—Weekly Check—Mine Rover 9	Brady
	Part 10—Mechanical Shift Reports	Brady
5.	Schematic Plan	Edwards
6.	Running Sheet (Police)	Morris
7.	Enlarged Section Appendix 26 to Brady's Report	Fowler

EXHIBITS 1 TO 7 TENDERED ON 9-2-87

8.	Hand Plan—(No. 4 U/G Main Dips—25-1-84 to 20-12-85)	Fowler
9.	Hand Plan—(No. 4 U/G Main Dips—20-12-85 to 17-2-86)	Fowler
10.	Hand Plan—(No. 4 U/G Main Dips—17-2-86 to 26-2-86)	Fowler
11.	Hand Plan—(No. 4 U/G Main Dips—26-2-86 to 21-3-86)	Fowler
12.	Hand Plan—(No. 4 U/G Main Dips—21-3-86 to 9-4-86)	Fowler
13.	Hand Plan—(No. 4 U/G Main Dips—9-4-86 to 26-5-86)	Fowler
14.	Hand Plan—(No. 4 U/G Main Dips—26-5-86 to 28-6-86)	Fowler
15.	Hand Plan—(No. 4 U/G Main Dips—28-6-86 to 16-7-86)	Fowler
16.	Schematic Plan to Scale—Roadways 2, 3 and 4	Fowler
17.	Schedule—(Typed Extracts from 3 sets of Books—Stone Dusting)	Fowler
18	Schedule—Stone Dust Sample Results	Fowler

EXHIBITS 8 TO 18 TENDERED ON 10-2-87

19.	Photocopy hand written notes summary of reports written by Caffery plus Plan	Caffery
20.	Work Experience Schedule of Men on Duty U/G on 16-7-86	Mason

EXHIBITS 19 AND 20 TENDERED ON 11-2-87

APPENDIX "C" (Cont'd)

No. of dered Exhibit	Nature of Exhibit	Ten- by
21	Note book containing Hand-Written notes by Reed (3 pages by Caffery at end) and typed copy of those notes	Reed
22.(a)	Statement—Events on 17-7-86 by Glazebrook	Glazebrook
22.(b)	Statement—Events on 23-7-86 by Glazebrook	Glazebrook
23.	Statement—By Witness plus Plan	Allison
	EXHIBITS 21 TO 23 TENDERED ON 13-2-87	
24.	T.D.M. U/G Induction and Training Plan	Cumner
25.	Schedule of Questions (22 pages) U/G Mining—Staff use on Induction and Training Programme	Cumner
26.	Post-Mortem Reports on 12 deceased	Ansford
27	Letter dated 5-2-87—Spectra Lighting P/L *re* Manufacturers Standards	McMaster
	EXHIBITS 24 TO 27 TENDERED ON 16-2-87	
28.	Videotape `Entonox' cylinder examination	Hepburn
29	Curriculum Vitae witness Thomas	Thomas
	EXHIBITS 28 AND 29 TENDERED ON 17-2-87	
30.	Telex—Roberts to Hardie *re* Frictional Ignition Moura Rock Samples	Brady
	EXHIBIT 30 TENDERED ON 18-2-87	
31.	Model Report on Rock Fall by CSIRO	Brady
32.	Curriculum Vitae witness Golledge	Golledge
33.	Report of Investigations of Flame Safety Lamp	Golledge
	EXHIBITS 31 TO 33 TENDERED ON 19-2-87	
34.	Curriculum Vitae witness Hislop	Hislop
35.	Report Freeman/Letter Hislop—Static Electricity Accumulations on Brattice U/G Coal Mines	Hislop
36.	3 dimensional Plans: `C' seam roof; `A' seam floor; `B' seam floor and Main Dips Profile; `C' seam roof biro insert line of workings/supplyroad/Taj Mahal; Paper Model Fracture Pattern	Poppitt
37	Contour Plans (3)	Poppitt
38.	Videotape (unmarked) First Experiment Sandstone/Sandstone	Poppitt
39.	Videotape (marked) Mining Pick/Sandstone	Poppitt
40.	Mining Pick and 2 Sandstone wheels	Poppitt
41.	Sandstone Sample No. 4 Mine	Poppitt
	EXHIBITS 34 TO 41 TENDERED ON 20-1-87	
42.	Gamma Logs Recovery Holes No.6 and 12, 22-12-86; 10-1-87 and 11-2-87 Ignition	Poppitt
43.	3 Reports from T.D.M. Part I—Frictional Ignition/Incendivity 22-12-86 Part II—Frictional Ignition/Incendivity 14-1-87 Part III—Frictional Ignition of Methane 11-2-87	Poppitt
44.	Part 1—1975 Paper by Powell and Billinge The Frictional Ignition Hazard associated Colliery Rocks	Poppitt
	Part 2—Frictional Ignition of Gas during a Roof Fall—Report by Nagy and Kawenski	Poppitt
	Part 3—Report of Explosion at Six Bells Colliery, Monmouthshire (1961)	Poppitt
45.	Curriculum Vitae witness Green	Green
46.	Part 1 Petrological Report Part 2 Supplementary Data	Green

Green

APPENDIX "C" (Cont'd)

No. of dered Exhibit	Nature of Exhibit	Ten- by
47.	Curriculum Vitae witness Bell	Bell
48.	Part 1—Laboratory Investigation Report	Bell
	Part 2—Colour Coded Chart (Optical Microscope Observation String, Rope and Other Items)	Bell
	Part 3—Colour Coded Chart (Rib Dust Analysis by Electron Microscope)	Bell
	Part 4—Photocopies Photos. Series: 86L-1 to 86L-356	Bell
49.	Miners Safety Lamp	Golledge

EXHIBITS 42 TO 49 PLUS BIRO INSERT/PAPER MODEL PART OF EXHIBIT 36 TENDERED ON 24-2-87

50.	Handwritten Timetable/Running Sheet	Golledge
51	Container—2 pieces tissue paper used in Tests	Golledge
52	Gauze Samples subjected to different Temperatures	Golledge
53.	Videotape—Explosion Experiments	Golledge
54.	Timetable/Running Sheet—Experiments	Golledge
55.	Memo to Chief Inspector of Coal Mines from Golledge dated 20-1-87	Golledge
56.	Faxed Report 24-2-87 from Southern Mines Rescue Station	Bell
57.	Curriculum Vitae witness Hargraves	Hargraves

EXHIBITS 50 TO 57 TENDERED ON 25-2-87

58.	Curriculum Vitae witness Green	Green
59.	S.M.R.E. Research Report No. 223	Green
60.	Plan—Modified Version of Ex. 7. (by Green) National Coal Board Instructions Leaflet Ref: P.I./1984/4	Green
61.	Ignition Risk Quartz and Pyrites	Green
62.	Curriculum Vitae witness Forrester	Forrester
63.	Statement by Dr Forrester	Forrester
64.	Empty Cylinder with Valve In Situ	Forrester
65.	Valve	Forrester

EXHIBITS 58 TO 65 TENDERED ON 26-2-87

APPENDIX "G"

Interim Recommendation

1.(a) The Chief Inspector of Coal Mines take all necessary steps to ensure the immediate revocation of Rule 5.5 of the Special Rules for coal mines made pursuant to the Coal Mining Act.

1.(b) That the Chief Inspector advise that pending the revocation of Rule 5.5 no prosecution be commenced for any breach of that Rule arising out of the failure to use a flame safety lamp.

2. That the use of flame safety lamps be prohibited in the following circumstances—

2.1 At any mine where adequate alternative means are on hand to ensure that the use of the flame lamp can be safely replaced.

2.2 At all mines in areas where large falls of roof are likely to produce clouds of coal dust and/or methane. This should include all pillar extraction areas and all long wall panels.

3. That where flame safety lamps are to be used in areas other than those specified above, it can only be done with the specific approval of the Inspectorate of the Mines Department.

APPENDIX "H"

Further Report of Dr Golledge

DEPARTMENT OF MINES
SAFETY IN MINES
TESTING AND RESEARCH STATION

2 Smith Street,
Redbank, Qld 4301

Mr K. Lynn, S.M.,
Mining Warden,
Rockhampton Magistrates Court,
Rockhampton

Dear Mr Lynn,

Re: **Investigation of Flame Safety Lamp**

During the inquiry into the explosion at Moura No. 4 Mine I reported to the inquiry that investigations into the behaviour of a flame safety lamp, similar to the one recovered from the mine, had been carried out at the Testing and Research Station. It had not been possible in the laboratory to ignite an atmosphere external to the lamp from the operation of the lamp.

Since the inquiry, modifications have been made to the test apparatus and on Monday, 18th May, 1987 a successful ignition of an explosive atmosphere external to the lamp was achieved. This was done without the bonnet, the lamp having been mounted in the vertical position in the explosion chamber of the test apparatus. The lamp was operated with a low flame in a methane/coal dust atmosphere which was slowly increasing in methane concentration and with an air velocity of 2.5 m/s. There was no attempt to inject coal dust into the chamber but some dust was raised into suspension by action of the airstream on the dust deposit on the floor of the chamber and in the flexible duct from previous tests.

In previous investigations, with a closed loop test, it was observed that the oxygen concentration decreased with time due to combustion in the lamp. In the successful test the level of oxygen in the chamber was adjusted to compensate for the decrease observed in previous tests.

The internal and external gauzes were heated by combustion of the methane and coal dust to a cherry red colour and the outer gauze eventually reached a temperature sufficient to ignite the explosive atmosphere surrounding the lamp. The external explosion started as a methane explosion which raised dust into the air from the floor of the explosion chamber and propagated through the apparatus as a coal dust explosion. Explosion vents in the explosion chamber allowed the pressure generated by the explosion to be released with only minor damage to the flexible duct. The test was recorded on video film.

Further investigations will follow which will involve instrumenting the apparatus to obtain on-line measurements of critical parameters. The lamp will be tested over a range of conditions to determine the operating conditions within which the lamp could operate in an unsafe manner.

(P. GOLLEDGE)
Chief Engineer
Testing and Research Station,
Redbank

21st May, 1987.