CHAPTER 8
RECOMMENDATIONS

Introduction

The re-analysis of the investigation into the Moura explosion has been based on information that was available to the Inquiry and expert information from International and Australian experts who have been consulted by the team over the past 6 months.

The general response by forensic scientists, mining engineers, scientists working in the mining field, forensic pathologists and explosives experts is that the lack of detailed information gathering at the time of the incident and the failure to provide a systematically gathered data set does not allow a full reconstruction of the incident.

Computer simulation and scaled explosion modelling could provide further information.

The information that is available provides evidence for the need to hold a more general investigation. This investigation would allow the Departments of Resource Industries, Police and Emergency Services and Health to develop guidelines for the use of forensic science and systematic methods of analyses after an incident.

The investigative processes that occurred following the Moura explosion were contrary to forensic science procedures known elsewhere in the world.

The data gathering was organised by the Mines Inspectorate and did not include an independent scientific assessment of the incident. The mine was not sampled correctly for information about blast and heat and there was not a grid reference system to identify location. Patterns of blast and burning were not fully described in the mine, on equipment or on the victims.

Information from the forensic pathologist, the forensic odontologist, police, SIMTARS and Londonderry scientific establishments and the Mines Inspectorate was not brought together prior to the Inquiry.

The scientists at SIMTARS and Londonderry were not aware of what each group was doing. The Londonderry combustion scientist, Dr Green was allowed underground 30 days after the incident for 8 hours and the senior scientist at SIMTARS, Dr Golledge who was to contribute the major research effort on the flame safety lamp was not invited underground at all.

The evidence was displayed to the Inquiry Panel piecemeal and generally interpreted through cross examination. The Inspector of Mines who played a significant part in organising the emergency response at Moura provided most of the descriptive evidence to the Inquiry. An estimate of the total information to come before the Inquiry which could have been considered in the findings was possibly 10% of the real evidence from the incident.

This assessment is based on the fact that only a percentage of the information available was collected and of this percentage a small percentage was presented to the Court (with the guidance of the Chief Inspector of Mines). Of this amount, the areas subjected to cross examination by legal counsel narrowed the information further and determined the central focus of the Inquiry.

During the process of the Inquiry information was suddenly made available about the flame safety lamp being a proven ignition point. This information was presented without other scientific confirmation and the Inquiry Panel had in effect a "deus ex machina" presentation of the source of the ignition.

This sudden finding provided an identifiable mechanism for the Inquiry and with this evidence on its own there was little chance for any finding other than the one decided by the Panel.

The presentation of evidence in the preceding chapter has identified the negative indications relating to the flame safety lamp being within any area from which the explosion originated. There is a simple lack of agreement between the location of the flame safety lamp and data on the course of the explosion.

The use of a full scale forensic science approach to the problem at the time of the original investigation would have laid down procedures for:

- Presentation to the Inquiry of all factors identifying the flow of blast and flame i.e. the course of the explosion.

- From this analysis the identification of possible areas where the source of the ignition was likely.

- From this analysis of all likely sources in this area with a resultant finding on probabilities of certain items and/or events being the source of the ignition.

Within this analysis all negative factors are generally taken into account to discredit different possible explosion courses.

With the flame safety lamp finding, the work had focussed on proving that one item out of several possible sources of ignition could have caused an explosion and there was not work to disprove it. Any positive finding in this way does not give an Inquiry useful information on what has happened in a particular explosion but merely confirms that an item is an ignition source.

Similar work could be done on the Rover engine, the electrostatically charged trickle duster hoses, the cables to the miner and shuttle cars, frictional ignition of rock on rock, rock on steel, steel on steel, the lighting in the crib room and piezo-electric effects. With several months of experiment and use of resources any of the sources of ignition can be found to work.

The key work of the forensic scientists in a formally organised investigation is identifying the course of the explosion, proving what is not possible and then looking at what is possible.

The use of negative evidence was not a basic process presented to the Inquiry and there was no opportunity to assess the indicators that would have shown quite clearly that course of the explosion did not come from areas where the flame safety lamp was hypothesised to be.

The findings of the re-analysis of the Moura evidence include the following:

- There is evidence which rejects the hypothesis that the area where the flame safety lamp was, could be that area from which the explosion developed.

- The evidence of the course of the explosion shows that all the pressure and heat effects appear to have moved out from the northern area of the goaf.

- The possible sources of ignition in this area to be further explored are piezo-electric effects, electrostatic sources and the field of frictional ignition.

The quality of the information gathered after the Moura incident was influenced by:

Ignorance of forensic science procedures - this includes the contribution from forensic pathology on blast and heat effects on victims.

Absence of formal Guidelines for Investigation within the Mines Inspectorate.

Incapacity of SIMTARS to direct an independent scientific investigation separate to directions from the Mines Inspectorate and Mines Department.

Use of people who had a close association with the Mine to collect evidence rather than an independently guided collection of evidence.

The emotional response to the loss of miners underground influenced the haste in which information was gathered.

The pressure to return the mine to normal in association with the absence of Guidelines for Investigation allowed information to be lost permanently.

There are several urgent actions to be taken on the basis of this report despite the limitations of the evidence that is available.

Of foremost importance is the continuing safety of men underground.

There are a number of major recommendations which are based on the findings.

8.1 Protection of Life in Mines

Recommendation on Assumptions of Risk in Similar Mines

If there had been a full forensic science investigation of the Moura Explosion with the reconstruction of the incident using properly sampled and interpreted data the course of the explosion and later the probable ignition sources would have become known over a period of months.

In this time there would have been some concern for any mines with practices and structures similar to Moura No.4. A recommendation could have emerged at this time to audit mining procedures and emergency response procedures so that any possible risk was minimised.

The current situation is that all mines have been operating for four years and the general assumption has been that the withdrawal of the flame safety lamp has made all mines safe from an explosion similar to that of Moura No.4.

An argument that no incident has occurred in other Queensland mines in this time does not disprove there being a current risk. Any mine with similar conditions to that of Moura No.4 can carry the risk until the conditions occur in the right sequence to produce the explosion.

The level of risk will be unknown until further work is undertaken and in the meantime an assumption should be made that there is a risk in Queensland mines with similar conditions.

Safety Audits by Mine Managers

Although consideration of risk can only be hypothetical it is better to assume a worst possible case and minimise any potential risk through a safety audit undertaken by mine managers.

This audit should taken into account the problem that once there is the right condition for a gas ignition any of a number of sources may become responsible. Safety audits should apply to all risks in a mine and require an objective scientifically based technique.

Any safety audit should be assisted by Guidelines established through the Chief Inspector of Mines.

The aim of an audit is to identify whether the current procedures minimise risk through technical devices or methods of mining and whether these efforts are linked to effective emergency procedures.

Safety procedures for evacuation, rescue and management of major incidents should be reviewed by the Mine Manager until he is satisfied that men underground are being given the best possible protection.

Every effort should be made to involve miners, union delegates, union check inspectors and the mines inspectorate in all aspects of the assessment.

This recommendation is based on the fact that safety in mines is not solely the outcome of management decisions but an acceptance of joint responsibility by the workforce and management to reduce risks.

Effectiveness of Gas Inerting of the Goaf

Work is required to assess the practicability of inerting the goaf area. A technique for inerting the goaf is also potentially beneficial in preventing spontaneous combustion in the goaf area and any assessment should also consider this aspect.

The recommendation is made on the basis that a maximum effort should be directed at preventing the commencement of an explosion and thereby providing the best protection to miners at the coal face.

8.2 Explosion Prevention Through Method of Mining

It is interesting to examine the number of explosions and ignitions that occurred in the US during the period 1970 to 1978. In this context an 'ignition; is defined as the burning of methane or dust without causing a fatality or physical damage to the mine workings [ ].

Frictional sparking, caused by drum picks in contact with rocks accounted for 285 ignitions, welding for 24, electric arcing for 13 and other sources for 13.

During the period referred to above there were 56 explosions of which 32 were due to frictional sparking, as described above.

Thirty one of the frictional ignition explosions were associated with the presence of methane gas at the time of the ignition.

A reduction in the methane concentration at the pick/rock contact area will do much to minimise any ignitions from this cause. This could be achieved by improvements in face ventilation, methane drainage and introduction of equipment on longwall shearers and continuous miners to introduce air and water into the pick/rock contact area.

Re-Assessment of Stone Dust Effectiveness and Management Procedures

It is recommended that there be a reassessment of the role of stone dust in preventing the spread of an explosion - the Moura No.4 incident was not reduced by stone dust as shown by the pattern of blast damage.

Re-Assessment of the Effectiveness of Passive Water Barriers

Further simulation work is required on the Moura No.4 explosion to describe the functioning of this type of barrier. There has been considerable disquiet within SIMTARS following the scientific work undertaken by Dr Peter Golledge on the Moura No.4 explosion. This work should be further followed to develop barrier systems which work.

Further experimental work should lead to the provision of advice to the Chief Inspector of Mines on redrafting of legislation so that inappropriate requirements are not put upon industry.

Resources Provided to the Chief Inspector of Underground Coal Mines

The position of Chief Inspector of Coal Mines is central to the successful achievement of protecting life in Queensland underground coal mines.

It is recommended that the Mines Inspectorate to be given whatever training and expert assistance the Chief Inspector deems necessary to protect life in Queensland coal mines.

Involvement of the Queensland Mines Rescue in the Upgrading of Investigations of Underground Coal Mine Accidents

It is recommended that a Review of Mines Rescue Procedures be undertaken in association with any further scientific effort.

The Superintendent of Mines Rescue in Queensland should be provided with all relevant data and be asked to upgrade mines rescue procedures to assist with the introduction of forensic science techniques for investigation.

The observations and actions of trained Mines Rescue workers are critical to any subsequent investigation and to maintaining safety in the mines.

The Queensland Mines Rescue Service could assess:

(a) Whether there can be some form of photographic evidence recorded of the situation, prior to any form of movement of the deceased.

(b) That a more thorough recording of each body be carried out in colour negative/colour print material for the investigation team. Thought should be given to possible help that may arise from a set of x-rays showing the result of blast effect as recorded on the body, in various parts of the disaster area. This work to be done prior to any post mortem. It may well assist in showing a blast pattern. Photographic recording should be carried out at the earliest time after removal from the mine.

(c) Underground photography of the disaster area should be carried out to fully record the whole area, to show the relationship of: in roads, cut throughs, belt road etc. It is important that some one who knows the mine is with the photographer recording angles and areas taken, also taking note of any items recorded. It is equally important that this person notes on a plan of the mine where each shot was taken and the direction the camera was pointing. This would best be done by having one of the first set of prints available and a note of angle and photo reference number to be marked on master record plan. Copies of this plan and a typed sheet of photo content and reference number should provide each of the investigation team with a good record of the situation as found.

(d) The Mines Rescue Team could be provided with a recording system that would least hinder their main task in hand, that of rescue, would be a small 8mm video recording system fastened to the back pack of the Team leader with a fibre optic cable to a position near his cap lamp, sighting of the area being viewed could be marked on his visor. Greater assistance would be gained if the use of an image intensifier could be used.

Matters for Urgent Government Action

The findings of the re-investigation have arisen because of the lack of a full scientific investigation of the explosion at Moura No.4.

The immediate safety implications have been covered in the first section on recommendations.

The recommendations for Government action overlap the general safety recommendations but are directed at defining specific actions which should follow this report.

It is important that action be taken immediately so that there is not a subsequent situation in Queensland where there is an incomplete investigation into an incident.

It should be noted that the recommendations in this section will relate also to industrial accidents generally as the work on the Moura No.4 investigation has an application which is wider than the coal mining industry.

Further Inquiries or Task Force Investigations

It is recommended that the Queensland Government accept one of two options for further action.

- To establish a formal Inquiry into Procedures for the Scientific Investigation of Incidents in Underground Coal Mines; or

- To establish a Task Force which reports within a limited time frame of six months to the Government. This Task Force would be led either by the Department of Resource Industries or the Police and Emergency Services. The Task Force would draft guidelines for the Scientific Investigation of Accidents in Underground Coal Mines.

The re-investigation of Moura No.4 has shown that the Departments concerned need to rigorously assess procedures and co-ordinate with each other on agreed procedures for joint approaches to accidents.

In particular, the use of forensic science and the co-ordination of mining, scientific evidence and forensic pathology with safeguards against biasing results should be formally agreed.

Bias can enter into these investigations through the choice of internal personnel who protect a Department, or an Industry or of people with inadequate expertise who become expert witnesses in a Court of Law.

Specifically it is recommended that this action lead to the establishment of an investigative team constituted of the relevant disciplines, with personnel who have experience, to be expert witnesses, who are not associated with the mine or the incident, and including where relevant experts from outside Queensland or Australia.

It would be necessary to have all information eventually reported to a committee constituted by the Chief Inspector of Mines who is in charge of the overall investigation and who co-ordinates the final information that would be presented to a formal Inquiry.

The scientific investigation would be under direction of the Police and managed by forensic scientists. The independent investigation would use scientists from relevant fields, mining experts, company and union representatives, police, forensic pathologists and others to develop an independent and objective approach to the investigation of the incident when loss of life or risk to life has been involved.

Some of the police procedures that would be required in a disaster/accident response plan include the direction of the forensic science investigation team by a senior forensic scientist under the overall command of the Group Commander. The investigative team would include the Disaster victim Identification Group and other police force members who would collect evidence under strict controls. Photography would be used extensively at the scene and at the mortuary. Post mortems would ideally be conducted in Brisbane where resources are available for a full investigation. The chain of command would start at the Police Operations Centre using the Major Incident Room to monitor forward police activities. The Police Forward Command Post would be at the scene with trained police disaster response groups to carry out the forensic work. Specialised equipment, training and means of deployment would need to be included in the State level planning.

In parallel to the independent forensic investigation a Senior Inspector of Mines with a team would report to the Chief Inspector of Mines.

A caution is given in relation to the recommendation for a full Inquiry into Methods of Investigation of Incidents in Underground Coal Mines. This relates to the acceptance by the Government of a scientific approach to future investigations which would require the resourcing of the Departments of Resource Industries, Police and Emergency Services and Health immediately to develop the basis for such investigations. It would also require a significant input of resources following any incident to ensure and independent and competent investigation.

An example of the scale of this type of work is in a hotel bombing overseas which presented forensic scientists with several thousand rubbish bins of rubble for the reconstruction of the incident, took 18 months and required forensic scientists of no less than five years specialised forensic science training. The police effort directed work at the scene of the incident through making assessments and establishing a systematic collection of material from inside the hotel, the immediate outside, across a road and from a beach with every piece of material in these zones being collected.

In a similar piece of work following an aeroplane bombing, two countries worked together on the forensic science with every fragment being identified to show the cone like outward pressure effects of the device. An aeroplane hull was then set up with mannequins and a full scale reconstruction was carried out to ensure that the forensic science assessments of the course of the explosion and the source of the ignition had been correctly formed.

The commitment by the Queensland Departments to a scientific approach would include training of personnel, allocation of positions to carry the relevant responsibilities and monitoring of the quality of work being done. Because of the specialisation the monitoring could be more easily achieved with the assistance of a network of experts throughout Australia and in the United States, the United Kingdom, Germany and Poland.

The principle used in making this recommendation is that the death of a miner killed underground is as important as the loss of life from explosions on the surface.

Aircraft bombs and attacks on buildings have led to extensive scientific efforts to identify the cause and reconstruct the incident. it is just as important to understand what has happened in an explosion underground to find out how miners have died and to use this information to protect life in the future.

It is further recommended that if there remains significant doubt on the course of the explosion and the range of possible ignition sources following publication of this report there should be some partial re-opening of the Moura No.4 Inquiry to establish through more detailed forensic work and through cross examination of experts the facts of the situation.

This recommendation is made as an addendum to the above recommendations because it is realised that the limitations in data gathering and the lack of initial work limits a further Inquiry of this nature. However, if the risk to life is considered to be serious and if protective methods can only come in through a re-Inquiry then there is some justification.

Availability of this Report to the Industry and the Public

It is recommended that the Queensland Government make this Report available to the Industry and the public so that Industry can decide on its response to the relevant recommendations and the public can understand more fully the processes that happened in this incident and discuss the recommendations.

It is of particular importance that the relatives of people who died at Moura and all Moura miners have access to the information in the Report as it relates directly to people they know and provides some further explanation of why the incident happened.

Considerable distress was caused to relatives in some instances because of early reconstructions of the incident where scenarios involved certain victims and it is important that they understand that their close relatives were solely victims of the explosion and its aftermath and none of them in any way contributed to the incident.

It is also important that as part of this process members of the research team be available to the relatives and miners at Moura to discuss any parts of the report with them so that full attention is given to those people who have been closest to the incident.

Research into the Reconstruction of the Moura Incident

It is recommended that the current re-investigation into Moura No.4 explosion be continued so that the phases of modelling and reconstruction can further assist in protecting life from future incidents.

The current re-investigation requires the modelling of the critical factors to further determine the flow of blast and flame and the final evidence of a source of ignition emanating from a specific area.

This work includes continuing work by forensic scientists under direction of the Queensland Police Department.

This work is needed to develop the basis for the final work on the source of the ignition at Moura No.4. Modelling can be achieved through work by the two mining research establishments, SIMTARS and Londonderry. A combined program of scaled testing and computer simulation would allow for reconstruction of the explosion in Moura No.4.

The focus of the work would be on frictional ignition and possible electrostatic and piezo-electric effects. Because of the implications of this for safety in mines it would be necessary to commence the work as soon as possible with direct industry involvement.

The early involvement of Industry is essential in this type of research because the results must be practical and the expertise within the Industry will ensure that the research directions are comprehensively explored in relation to mining practices.

The work on Moura would require continuing financial support from the Queensland State Government and would be based on a decision by the Government to provide continuing support to the scientific investigation of the Moura No.4 explosion so that safeguards can be developed against future events. Funding would be required for the Departments of Resource Industry, Police and Health Departments.

The continuing work would also require the input of several Australian and international experts as recommended above.

Industry, Government and Unions can combine successfully to provide for this further work to be done. SIMTARS has already used the method of an expert Committee to assist in the research work and to ensure that the findings are immediately translated into industrial safety procedures.

In the original submission by SIMTARS to the Department of Resource Industries in August 1989, it was pointed out that the six month phase was to review the Moura evidence with the assistance of international experts and that this phase would most likely lead to a further phase of model testing.

Preliminary work with models has been done with the construction of scale models at SIMTARS for work on the forensic pathology and of a working model established through Londonderry with the assistance of the University of

Wollongong to test pressure flows, and some basic computer simulation to test some of the evidence.

Role of Industry in the Continuation of Safety Research

It is recommended that there be re-assessment of some of the technical methods of protecting life in mines and in particular the use of passive water barriers, triggered barriers, stone dust barriers and any other relevant device.

It is recommended that the Coal Mining industry provide continuing research resources for protection of life.

Testing of mine explosions is done in great detail elsewhere in the world with the large scale experimental mines in the United States, Germany and Poland. Australia has produced smaller scale experimental work including the work on the flame safety lamp at SIMTARS and the computer simulation work at Londonderry.

Some future research areas which are highlighted by the current study include:

1. Information on the course of the blast and heat in an underground coal mine explosion in a multi road system and the factors which increase the violence of this type of roadway system;

2. Information on the effects of blast and heat flows on humans, and common materials used underground using calibrated explosions and modelling techniques.

3. Information on the protection of life from blast and heat through goaf inertisation, stone dusting, passive water barriers, natural water barriers and methods of mining.

The specific research contribution is to provide further work on the use of technical systems such as triggered barriers, the scientific monitoring of stone dusting, and the incombustible content of the current operating mines to identify whether the particle size in stone dust is adequate to stop an explosion.

These approaches to further research can be made to Industry and an Industry determination can be made on whether to apportion grants to applied safety researches.

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Through the Manager the mine might need to arrange for special purchases of materials, gases (such as N_2) and other equipment not normally used.

The Inspectorate are legally responsible for carrying out any investigations, although in so doing they may and usually do request assistance from a range of scientific and technical services. Circumstances following an explosion lead to circumstances which do not occur in the normal operation of a mine. There are frequent discussions among representatives of Management, Inspectorate and the Union regarding proposed action during the time following an explosion when persons are required to wear self-contained breathing apparatus and before normal ventilation is resumed.

The Police under the Coroner's Act are granted custody of any deceased and strictly according to law the bodies cannot be moved until the police are satisfied. This creates a special problem following an explosion when toxic gases may still be present underground and the bodies cannot be examined by Police Officers who are not experienced miners trained in the use of self-contained breathing apparatus. It would appear that this problem cannot be resolved without some changes in legislation or in mines rescue practices.

Mining Unions protect the interests of their members and the union representatives need to be satisfied that proposed plans do not expose members to unnecessary risks.

Scientific Services include a broad range of disciplines including persons assisting in mapping of the area, collection of a range of samples, specialist examination of equipment, laboratory analyses, research and other technical investigations. It is important that sufficient samples are taken to afford statistical analysis of the results and that procedures are adequate to establish, to the satisfaction of any legal inquiry, ownership of the samples from the point of collection to analysis at the laboratory. Much of the scientific work would need to be carried out in laboratories accredited by NATA.

Overseas and other Expert Assistance may be needed to provide experience and knowledge not available in Australia or to provide expert confirmation of results already obtained. Explosions are relatively infrequent and there are few English speaking persons in the world with any depth of experience in the investigation of mines following explosions. Those that are around have had experience originally as assistants to older and more experienced persons.

8.3 Methodology of Investigation

8.3.1 Site Investigation

Following the restoration of ventilation and during this process if it is staged the Manager, Inspector and Unions would satisfy themselves that it is safe to allow members of the investigating team into the mine. Repairs would be carried out with minimum interference of parts of the mine affected by the explosion.

Surface

One task which should proceed as soon as possible is the interviewing of persons who could possibly assist in the investigations. It is important that such interviews be conducted quickly before a persons memory of the details is influenced by discussions with others.

A great deal of information is already available relating to the equipment used, ventilation records, gas analysis records, Record Book entries, incombustible dust analyses, equipment maintenance records. Information will also be available concerning the fan performance, water gauge readings and general body of mine air gas concentrations. Much of this and other relevant information can be collected while other work is proceeding in the underground.

Underground

It is essential that disturbance to the underground is minimised until all investigations have been completed. The first team underground after it has been declared safe should a mapping team charged with noting on proforma sheets (if possible) the position of all items of equipment. Temperature reference points can be established on the ribs of the roadway and all references made to such points which can later be picked up by a surveyor. The roadway between c/t's and c/t's themselves can be grided where necessary to pick up all the required detail. Photographs should also be taken to identify areas where a number of items have been moved by the force of the explosion and where a photograph is more appropriate than a sketch.

Once the mapping team has completed a section of the mine roadway between two c/t's or between two roadways, along the coal face or some other readily defined area, the sampling crew can move in. It may be necessary to take a large number of samples which should be placed in a metal container with a screwed top and clearly labelled both outside and inside. The metal container minimises any further degradation of particles in the samples during transportation from the mine to the laboratory. Proper dust sampling requires care and the use of standard techniques and procedures. Sampling of coke, soot and other flame indicators should be left to other experts who will be trying to determine the path and extent of the explosion.

Mines inspection staff will be carrying out investigation of machinery, conveyor systems, power cables, power boxes and looking for evidence of any object that may have been a possible ignition source. The presence of lightning at the time of the explosion would be checked and any evidence of contraband. Any evidence of spontaneous combustion would be checked and also that of frictional heating on any machine, conveyor roller or other item.

Some equipment may need to be opened underground, such as electrical switchgear and in some circumstances it may need to be sent to SIMTARS for further tests or referred by SIMTARS to another laboratory for metallurgical or other specialised examination or testing. appendixes 1 and 2 cover the procedure that could be adopted for such examinations.

8.3.2 Scientific Investigations

Experts experienced in investigating coal mine explosions would be asked to determine whether the explosion was one mainly of methane, or coal dust, or a combination of both. Evidence would be collected to establish the extent of both the blast and the flame, the former often extending far beyond the latter.

Evidence of Violence

An estimate of the violence of the explosion by damage to stoppings and overcasts caused by overpressure or the bending of fixed objects by dynamic pressure of the blast. Generally roof supports of wood or metal may be bent in the same general direction or moved in the same direction. However, if the explosion changes from a weak to a strong explosion it is possible to have a stronger blast running in the opposite direction to the flame.

Heavy objects can be moved by the forces generated during an explosion and because of their inertia they are not affected by subsequent movements of the air following the explosion unless such movements are unusually strong.

As a general guide evidence of movement is minimal near the ignition point of the explosion but this may not be true in the case of a strong explosion when a later blast wave may traverse the same area of the roadway. Movement damage is greatest in long roadways when pressure is released but there are complications when the roadway is intersected by c/t's at regular intervals. In development roadways damage is greatest outbye and small near the closed end but not as simple when the situation is a multi heading development with c/t's at regular intervals.

Evidence of Flame

The flame may pass over surfaces at very high speeds. With large objects there will be no observable changes to the surface. Scorching or burning, or both, occur to materials with a high surface area to weight ratio. This is evidence in pieces of paper, human air, fibrous particles of rope and fibres from plastic ropes. Some examination can be undertaken underground but will be taken to the laboratory for detailed microscopic and other examination.

Scorching is a good indication that the flame has passed along that area of the mine but the absence of scorching is not proof that the flame has not passed.

Loose scorched paper may indicate where the flame has passed since paper will tend to be pushed ahead of the flame initially and subsequently pushed backwards by expansion of the flame. Wood or paper may be charred due to exposure to an intense flame for a period of some seconds. More severe burning often occurs where the explosion was stopped at which place there could be a relatively long time of contact with the flame and a source of oxygen at the time of contraction of the hot gases inbye.

Fire

Fires may develop in such places and may be evident to the rescue team entering the mine or there may be areas of smouldering material, with the potential to become open fires when normal ventilation is restored.

Coking

Coke particles are formed when a flame passes through a dust cloud which is itself within the explosibility range or because the combination of coal dust and methane is explosive. The amount of coking varies with the type of coal, the dust concentration at the time of passage of the flame, the speed of the flame and its temperature. If the mine roadway is well stone dusted and the coal not of the coking type there may be little evidence of coking in the roadways.

Coked deposits may arise due to coking of dust in situ on the floor, ribs and roof of the mine roadway; dust may be disturbed by the force of the explosion, deposited at some other location and then coked; and dust may be coked as a dust cloud as described above. When the flame is steady or accelerating coked dust is moved backwards by the advancing flame and deposited on surfaces in the direction in which the flame has gone.

Explosion Dust

Explosion dust largely unaffected by the flame is raised ahead and behind the flame and settles out after the explosion has passed. This dust gives some measure of the composition of dust dispersed during the explosion. Samples taken within and well beyond the suspected limit of the explosion flame will show on microscopic examination where the dust has been coked or heated by the flame.

Evidence of Sooty Streamers

Sooty streamers are essentially composed of aggregates of fine unburnt dust particles that settle out under steamy hot conditions when the air is stagnant. They are not positive indicators of the passage of flame.

Incombustible Dust content

In a room and pillar or longwall mine it is probably desirable to sample road dust at intervals of 25m along the axis of all roadways and c/t's to allow a laboratory determination of the incombustible content of the dust. This sampling should take in the area thought to be affected by the explosion and beyond.

Wide differences may occur between the results of statutory samples and those taken after an explosion, of the incombustible content of the dust. Such difference may be due to the preferential raising of coal dust during an explosion as compared with stone dust.

No
Difference due to chemistry in the limestone

Loss of Volatiles from Dust

When a flame of sufficient temperature is in contact with a dust particle there will be some loss of the volatile content of the particle, depending on the temperature of the flame and the time of contact. The loss of volatile content may be up to about 10%.

When plotted on a plan of the mine roadways and c/t's the loss of volatiles can give some indication of the passage of flame and areas of high residence time due to roadway intersections and obstructions in the roadways.

Photography

As has already been stated photography is an essential component of the investigation process to record information which could not be described in words. During the scientific investigation, both at the mine and in the laboratory, it is essential that a complete photographic record be obtained to complement any report prepared.

Laboratory Analysis

Analysis of samples would be carried out at a number of laboratories since it is unlikely that any single laboratory would have all the necessary analytical equipment nor indeed the staff experienced in carrying out the analysis and assessing the results.

Equipment and Testing

Some equipment, if suspected of being faulty prior to the explosion, would need to be tested. In some cases this could be done at the surface of the mine concerned or it may be necessary to refer it to SIMTARS or another testing establishment.

For many items of equipment there are testing procedures laid down in Australian Standards which would be followed. In other cases there are no accepted Australian or International Standards when agreement would need to be reached between the inspectorate and the testing station regarding the procedures to be adopted for testing of the equipment.

The testing authority would certify as part of the test report that the equipment tested either complies with all or part of the relevant Australian Standards or the agreed testing procedures.

8.3.3 Input from Australian and Overseas Experts

It is unreasonable to expect that the government department would have within its own staff all the expertise necessary to investigate a relatively infrequent event such as a coal mine explosion.

Assistance would be sought from within Australia and overseas, depending on the circumstances.

It is desirable, if not essential, that for the underground mine investigations that any outside experts are familiar with mining conditions, preferably Australian mining conditions.

According to advice received from overseas explosion experts it is not always possible to establish the location of the ignition source nor indeed the sequence and route of the explosion. The complexity of the roadways and c/t's at Moura No. 4 Mine proved too difficult for overseas experts to attempt to answer the questions raised above. The design of longwall mines also incorporates many of the features of room and pillar operations and could well present difficulties during any analysis.

8.3.4 Report of Investigation - Input from All Parties

The Chief Inspector of Coal Mines should be in a position at the end of the investigation phase to assemble all the information gathered. It should then be possible to form some concussions as to the nature and cause or causes of the explosion.

Pathological evidence should be able to establish the time, manner and cause of death. Evidence should also be able to establish the presence of drugs in the victims, saturation of blood with CO and the possible presence of CH_4 prior to the explosion. It may also be possible to estimate the violence of the explosion in the area of the victims.

Other evidence would be able to establish the extent of flame, extent of the explosion and possibly the path of both.

It is not possible, in the present state of knowledge, to know with any certainty how explosions behave in a mine, where there are multiple roadway junctions. The necessary full-scale experiments have not been done.

Forensic reconstruction of the explosion may give some general indication of movement of bodies during the explosion process. The complex behaviour of mine explosions only allows generalisations to be made about body movement. In some cases the evidence may not be sufficiently strong to convince any official inquiry.

APPENDIX H

Photographs of Mine Damage with Description

No. 86 - 5641

This is a view of the mine rover located in No. 4 heading just inbye of No. 26 cut through (c/t). The camera is looking outbye.

Note:
1. The burnt fabric on the driver's seat.
2. The vehicle canopy is held by a roof bolt plate.
3. The bonnet has been removed by blast.

This evidence suggests that the vehicle was affected by flame travelling outbye from the goaf area. The evidence also suggests that the blast wave lifted the vehicle and at the same instant pushed it to the right of the photograph - in falling after the blast the canopy was caught by a roof bolt plate. It is suggested that the canopy supports were wrenched from the vehicle body (2.8 tonne vehicle) when the vehicle fell to the floor. It is of course quite possible that the damage to the canopy support was caused by the blast wave or a combination of blast and the fall of the vehicle.

During the investigation it was noted that the vehicle was parked and that there was no indication of the engine operating at the time of the explosion. The engine bonnet was blown outbye and it was noted from evidence that the engine bonnet was customarily left open (in a raised position) when the vehicle was parked.

No. 86 - 5783

This view is of the L.H. side of the mine rover with the camera looking inbye. The white arrow indicates where victim Friske was found. Evidence suggests that Friske was blown from the L.H. front passenger seat. The condition of the mesh on the L.H. side of the vehicle supports the belief that the R.H. canopy supports were wrenched when the vehicle fell.

No. 86 - 5724

A view of the fitter's bench of steel and considerable weight. It is not clear from mine plans - pre and post explosion - whether this bench was moved by blast. A comparison of the positions shown in the two plans suggest that it was moved by blast but it is not known how accurately the pre-explosion location is depicted.

The following observations are extracted from the report of an investigation by the Principal Mechanical Inspector of Coal Mines

"Considerable force was obviously applied in an outbye direction to deform the desk unit, but it is curious that some short lengths of hose suspended from the tubular "goalpost" (obvious in photograph) frame, approximately 1.0 metre away at the outbye end of the desk, remain hanging by string."

"Examination of the two crumpled and damaged lids from the desk of the fitters' bench and the hinge lugs of the desk indicate that both lids were apparently displaced in the inbye direction, despite the fact that the front lid was found over 300 metres outbye."

No. 86 - 5666

A view of remains of the belt conveyor in No. 3 road between No. 23 and 24 cut-throughs. The camera is looking inbye. The lighter coloured deposit is fly ash-this material was used post explosion to suppress a fire inbye of the camera position. It will be seen that the conveyor structure has been demolished and the upper strand of the belting removed by blast. The lower strand of belting remained in place.

No. 87 - 1138

The flame safety lamp considered by the Inquiry Panel to have caused the ignition. Note damage to hood and the coking of dust on the inside of the lamp glass.

No. 87 - 1145

Severe damage to the base of the lamp.

No. 86 - 5962

A view of the mine fan located on the surface. In the foreground are steel sheets damaged by the blast wave and replaced to restore the casing to operational standard.

The fan is located approximately 1.6 km from the location of the explosion. Three vertical panels on the outside of the curve were blown out. Each panel was retained in place by 18 bolts and measured approximately 12 feet high by 7 feet wide with a flange along each side. The bolts used for securing the panels damaged by the explosion, were thought to be ½" diameter.

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