CHAPTER 8

OVERALL FINDINGS

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Introduction

These are based on the examination of information presented to the Warden's Inquiry together with advice and comment received from Australian and Overseas consultants. These consultants included forensic scientists, forensic pathologists, mining engineers, scientists from a range of disciplines with experience in coal mine explosion research and explosives experts.

As to the Moura explosion it has been found that the collection of data from the area of the mine affected by the explosion was not adequate to re-construct the incident. The explosion occurred either in the goaf or immediately adjacent to it. The geometry of the affected area of the mine cannot be simulated to the extent necessary for an accurate finding to be obtained from experimentation with a physical or computer model.

Most of the experimentation and testing carried out in world-renowned explosion galleries are mostly confined to a single entry. The multiplicity of roadways and c/t's in the area of the mine affected by the explosion allowed for an explosion path of great complexity. The void created by the goaf added to the complexity. Further, it is not known how much of the caving of the goaf occurred prior to, during, and subsequent to, the explosion. The damage to ventilation stoppings created by a roof collapse in the goaf area cannot be determined and therefore it is not possible to estimate the damage by the explosion with any accuracy. not true

It is pertinent to quote here the work of Dr. F.V. Tideswell who carried out scientific investigation of a considerable number of coal mine explosions in his capacity as Senior Principal Scientific Officer of the Safety in Mines Research Establishment in Britain.

He stated in 1952 *"The tracing of the course of a mine explosion to its source and the determination of its nature are often surprisingly difficult. There are two complementary methods of approach. One, the intuitive approach, is based on experience and on knowledge of the pit and of the mining operations in progress; the other, the analytical approach, which it is the peculiar duty of the scientist to follow, is based on a dispassionate survey of all the evidence recoverable. Both approaches are needed and must be related."*

There is clearly a need to adopt the two approaches to explosion investigation and to combine the two results. Scale models should be constructed in order to carry out the explosion investigation. The benefit of having scale models such as that depicted in this report, has been considerable. It is suggested that such models should be provided for use in the Warden's Inquiry in addition to plans.

The aims and objectives of the Report are set out in section 1.1.3 and the findings resulting from an attempt to achieve them are set out below in the same sequence:

8.1 Forensic Pathology and Computer/Physical Modelling

Forensic Pathology

Well established techniques used in forensic pathology can identify the victims of a coal mine explosion. The time of death is more difficult to determine and relies on consequences of the explosion, such as damage to the power supply or telephone system. The manner of death is a matter of classification but the cause of death may be a combination of more than one factor.

Forensic examination can provide information on the magnitude, direction and duration of the force from the explosion pressure, as well as some idea of the temperature of the flame. When more than one pressure wave traverses the mine roadway the interpretation of the forensic examination is much more difficult.

Toxicology can assist in identifying the presence of CO and even CH_4 in the blood. Forensic examination can give information about the possibility of the victim surviving the explosion and whether or not a self-rescuer was used. Dust and soot in the airways can be examined to determine their source. Lung tissue can indicate the presence of pneumoconiosis which when related to dust exposure measurement can determine the effectiveness of dust control technologies.

Computer Modelling

The application of computer modelling to the analysis of coal mine explosions is still in its infancy. Even under controlled experimental conditions in explosion galleries there are considerable variations in flame velocity, dynamic pressure and static pressure with distance from the ignition point.

Although research is proceeding in overseas mining research centres with the development of computer models for coal mine explosions reliance is still placed on testing in explosion galleries.

The results from limited computer modelling of two roadway junctions of Moura No.4 Mine cannot be validated, at the present time, by experiments in an explosion gallery.

Physical Modelling

The physical model of the Moura No.4 Main Dips Workings, on a scale of 1:300, was of considerable benefit during this project. Part of the workings in the vicinity of 26 c/t was also modelled, on a scale of 1:50 and also of benefit to the project team and others who assisted.

However, in using a physical model for small scale explosion experiments there are scaling problems which cannot be overcome. The correct sequence of events concerning the fall in the goaf area is not known. Furthermore, it is difficult to reproduce the dynamic conditions which probably existed prior to the ignition.

(Golledge/Roberts)

As with computer modelling the results of any scale model testing would need to be validated in an explosion gallery. The potential exists for use of forensic science and modelling, the basis of this project. However, the hypotheses on which this project was based have not been sustained. The work carried out has not enabled a conclusion to be drawn on the Moura No.4 Mine explosion.

8.2 Identification of Evidence from Forensic Pathology (Moura)

Forensic pathology techniques were able to establish a number of important findings about the victims of the explosion.

An analysis of the photographs of the victims taken during the autopsies showed evidence on some bodies of exposure to flame and also some shredding of clothes due to the effects of the blast. No samples of clothes from the victims were taken for forensic analysis to obtain an estimate of exposure to flame, heat or blast. Deductions based on the presence of clothes shredding are therefore of uncertain value.

There was evidence in the mine of movement of an explosion blast wave in both directions along parts of No.3 Belt Road and other roads in Moura No.4 Mine.

8.3 Identification of Additional Characteristics of Blast (Moura)

A number of hypotheses has been considered in this report regarding the ignition source and the most probable direction of the blast. At the time of the inquiry a number of questions could not be answered due to the lack of evidence. The passage of nearly four years since the explosion at Moura No.4 Underground Mine has not provided any additional evidence.

Information collected during the investigation of the Moura explosion in 1986 and 1987 have been analysed differently from earlier reports submitted to the Warden's Inquiry. Hypotheses have been advanced suggesting that the source of ignition was other than the flame safety lamp. Such hypotheses rely on assumptions which cannot be proved or disproved and they fail to explain the behaviour and condition of the flame safety lamp gauzes involved in the Moura explosion.

Further research at SIMTARS has demonstrated that a properly assembled flame safety lamp, similar to the one used at Moura, is capable of acting as an ignition source for a methane or methane/coal dust explosion under mine ventilation conditions which could occur following a large goaf roof fall.

This project has not produced any evidence to challenge the Findings of the Mining Warden's Inquiry.

8.4 Structuring of Future Scientific Investigations

It is necessary to again refer to the above quotation from the work of Dr. Tideswell. The intuitive approach has to be combined with the analytical approach to obtain a proper result. The results of the two approaches has to be combined by the Chief Inspector of Coal Mines. The necessary scientific resources need to be made available to him. The basic work of examining and sampling the explosion area requires the services of engineers experienced in mining/electrical/mechanical engineering together with scientists with expertise in blast/flame/dust and air sampling and analysis/forensic science and pathology. In addition there will be a need for this work to be supported by suitable laboratory services. The whole of this investigative work should be co-ordinated by an experienced mining engineer who could be a Senior Inspector of Coal Mines, or other person trained for this work.

The results of the investigation with conclusions should be assembled in one official report for presentation by the Chief Inspector of Coal Mines to the Warden's Inquiry prescribed by the Queensland Coal Mining Act. The report and subsequent inquiry would then result in precise recommendations with regard to future mine operation and research, if necessary.

Whilst there is need for preparation for dealing with an event such as a mine explosion, it has to be realised that throughout the world the incidence of such disasters is continuing to reduce. Increased safety has undoubtedly contributed to this but we must realise that in some countries with the longest underground coal mining history there has been, and continues to be, a decline in coal production. Consequently experts in mine explosion investigation are becoming rare.

There is a need in Queensland to select and train staff in the area of coal mine explosion investigation who would in such an event be responsible for the meticulous investigation essential to establish a generally acceptable explanation of the cause and circumstances of the explosion.

8.5 Protection of Life in Underground Coal Mines

The matter which has priority is that of the ultimate prevention of coal mine explosions. This report deals at some length with the potential for disaster from impact of rock in a goaf. The only practical method of dealing with this potential ignition source is to render the goaf atmosphere inert. This is already under consideration for Queensland and has been practised for several years in coal mines overseas. Its application in Australia has been limited to date to dealing with an emergency.

The potential for explosions/fires from frictional ignition by machines requires attention particularly where there is a potential for contact with rock of high incendivity.

The work on this Project has required discussion regarding the value of stonedust in the arrest of a coal dust explosion. Research work in explosion galleries has shown that whilst stonedusting of roadways can be effective in arresting a coal dust explosion, the presence of methane combined with coal dust reduces that effectiveness. It is considered that the Main Dips Section roadways were adequately stonedusted to arrest a coal dust explosion. However, the presence of methane (possibly displaced by a goaf fall) allowed the explosion to extend along the roadways further than would have been the case without the presence of methane.

With regard to water and dust type barriers it is essential that all roadways have similar protection. However the elimination of explosion at source should have priority over this. To be specific with regard to dealing with the risk of fire/explosion from frictional ignition in the goaf it is worth repeating here an extract from the report on the Six Bells Colliery explosion (U.K. 1960) -

If a fall of stone of a not uncommon nature for a distance of six feet or so may be dangerous, the question immediately raised is the degree of risk involved in the routine collapse of roof in wastes. There is, however, no recorded experience of ignition of firedamp from this cause in longwall wastes in this country. This may well be because, for ignition to occur, there must be the remote coincidence of a number of conditions including the fall of a certain kind of rock, the right type and strength of impact and the presence at or about the point of impact of a firedamp-air mixture within a relatively narrow range.

Inertisation would prevent the remote coincidence in the goaf of conditions requisite to ignition/explosion. Ongoing research priorities are **goaf inertisation** and the **elimination of frictional ignition by machines.**

8.6 Liaison Between Government Departments

The Chief Inspector of Coal Mines should arrange close liaison with the Queensland Police Force so that there is a clear understanding of the role of both Departments in the event of an emergency. The same liaison is necessary between the office of the Chief Inspector of Coal Mines, SIMTARS and the Health Department. Personnel in those organisations together with the Coal Mines Inspectorate should be prepared for any future mine explosion investigation. The role of mining companies and union representatives is of course already defined in practice but these parties must be made aware of liaison established by the Chief Inspector of Coal Mines.

8.7 Facilities for Forensic Pathology

This report would not be complete without mention of the need for adequate facilities to enable the proper conduct of forensic pathology procedures in the regional centres of Queensland. For accident investigation such as that required for the Moura disaster there is a need for professional and ancillary staff to be made available at short notice at such regional centres. This would enable the maximum amount of information to be available for investigation of the cause of an incident.

The alternative is to provide suitable means for the transportation of bodies to Brisbane where the necessary facilities exist.

8.8 Summary

One of the features of the Warden's Inquiry Report which received a good deal of attention during this project was the source of ignition. It will be seen in this document that there is opinion to the effect that the flame safety lamp was not the ignition source. It has recently been demonstrated that a properly assembled flame safety lamp is capable of providing an ignition source for a methane/coal dust explosion under air velocity and methane concentrations which might occur following a goaf fall. In the absence of any experimental or other evidence of frictional ignition as a source it could still be argued that the flame safety lamp was the most probable source of the ignition at Moura.

The situation is that the use of a flame lamp is now prohibited in Queensland coal mines and its potential for causing ignition has been removed.

If the flame safety lamp were not the source of the ignition of the Moura No.4 Mine explosion, the heating of both gauzes to approximately 1000°C and the deposition of dust on the inner glass surface have to be accounted for by some other means. Testwork at SIMTARS and at Buxton to date has failed in every attempt to demonstrate such heating and deposition by any external source.

As to other sources of ignition it can be argued that there are many. The examinations at the Mine and in laboratories discount the entonox bottle, the mine rover and others with the exception of frictional impact by rock on rock or other material. Risk of ignition by rock impact can be dealt with by inertisation and means of achieving that are currently being considered.

Beyond that, no further research is recommended as a direct result of this project. That does not preclude work on other potential sources being considered for the future. That is being done by the SIMTARS Mines Safety Research Advisory Committee. It is stressed that it is well within the capacity of mine employees to maintain standards necessary to avoid ignition from items such as the entonox bottle, mine rover etc. which were considered as potential ignition sources at Moura. The underground coal mining industry is one of the most safety-conscious industries. No one works in an underground mine without concern for his own safety and that of others in the mine. There is in the industry a real commitment to avoid loss of life and injury.

It is a clear function of mine management to continuously audit safety procedures at underground coal mines. The accent should therefore be on prevention rather than how to deal with an emergency. Whilst the prime concern of management is the protection of life there is potential for serious economic loss including the closure of a mine and the sterilisation of huge reserves. The cost will vary in relation to the nature of the explosion and resultant damage. Since 1972 there have been five coal mine explosions in Australia. In all but one loss of life resulted. In two cases abandonment of the mine occurred as an immediate result of explosion.

The likely economic cost of an explosion in a new mine equipped with the technology currently available is likely to be in excess of $60 million where recovery is possible and mining operations resumed. Where a similar mine is abandoned the cost could exceed $250 million ignoring the possible loss of the remaining resource. Whilst such cost is not the prime concern it is in itself adequate reason for doing everything possible to prevent such an event.

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