

C O N T E N T S

	<u>Page</u>
FOREWORD	7
EXECUTIVE SUMMARY	8
RECOMMENDATIONS	11
REVIEW OF THE COAL MINE EXPLOSION RESEARCH PROJECT REPORT By Professor D. Rowlands	13

CHAPTER 1

BACKGROUND TO PROJECT.	1. 1
1.1 Introduction	1. 1
1.1.1 Overview of the Moura No.4 Underground Coal Mine Explosion	1. 1
1.1.2 Background to New Research	1. 2
1.1.3 Aims and Objectives	1. 5
1.2 Research Program	1. 6
1.2.1 Structure of Project Team and Review Committee	1. 6
1.2.2 Timetable and Progress of Research Project	1. 7
1.3 Project Structure	1. 9
1.3.1 Methods for Study	1. 9
1.3.2 Visit to US Bureau of Mines	1.10
1.3.3 Visit to Research and Laboratory Services Division, Buxton, United Kingdom	1.12
1.3.4 Visit to Experimental Mine Tremonia, Federal Republic of Germany	1.13

CHAPTER 2

EVIDENCE PRESENTED TO THE MINING WARDEN'S INQUIRY 1987 . .	2. 1
2.1 Summary of Report and Processes Leading to	2. 1
2.1.1 Description of Mine and Events Preceding the Explosion	2. 1
2.1.2 The Situation in the Main Dips Section Immediately Prior to the Explosion	2. 3
2.1.3 Initial Examination of Workings	2. 4
2.1.4 Dust Sampling	2. 7
2.1.5 Extent of the Flame	2. 8
2.1.6 Arrest of the Explosion	2. 9
2.1.7 Blast Waves	2. 9
2.1.8 Type and Source of Fuel	2.11
2.1.9 On-Site and Laboratory Investigations	2.11
2.2 Summary of Witnesses Examined and Evidence Given	2.27

CHAPTER 3

FUEL SOURCES FOR THE MOURA EXPLOSION.	3. 1
3.1 Sources of Methane	3. 1
3.1.1 General Body Concentration	3. 1
3.1.2 Methane Layer in Goaf	3. 1

3.1.3	Gas Outburst in Mine	3. 2
3.2	Sources of Coal Dust	3. 3
3.3	Methane/Coal Dust	3. 4
3.4	Gases from Mine Fires or Spontaneous Combustion	3. 4
3.5	Other Fuel Sources	3. 5

CHAPTER 4

	IGNITION SOURCE FOR THE MOURA EXPLOSION	4. 1
4.1	Fire or Spontaneous Combustion	4. 1
4.1.1	Roadways and Cut Throughs	4. 1
4.1.2	Goaf Area	4. 1
4.2	Electrical Apparatus and Cables	4. 1
4.2.1	Apparatus	4. 1
4.2.2	Other Electrical Equipment	4. 1
4.3	Electro-Static Discharge	4. 2
4.3.1	Hoses	4. 2
4.3.2	Brattice	4. 3
4.3.3	Piezzo Electric Sparking	4. 3
4.3.4	Other Equipment as Electro Static Discharge Sources	4. 3
4.4	Mechanical Equipment	4. 3
4.4.1	Joy Continuous Miner (JCM-12CM3-BVW)	4. 3
4.4.2	Joy Shuttle Cars (15SC/48/MCHPVW, Nos.31 and 30)	4. 3
4.4.3	Main Dips Belt Conveyor	4. 4
4.4.4	No.9 Mine Rover	4. 4
4.4.5	Miscellaneous Mechanical Equipment	4. 4
4.5	Aluminium Entonox Cylinder	4. 4
4.6	Frictional Ignition	4. 5
4.7	Flame Safety Lamp from Moura No.4 Mine	4.19

CHAPTER 5

	THE INVESTIGATION OF A COAL MINE EXPLOSION	5. 1
	FORENSIC SCIENCE EXAMINATION OF RECORDS AT MOURA NO.4 MINE EXPLOSION, 1986	5. 1
5.1	Investigation of a Coal Mine Explosion	5. 1
5.2	Methods of Examination at the Mine	5. 1
5.3	Use of Forensic Pathology in Coal Mine Explosion Investigation	5. 2
5.4	Forensic Science Examination of Records at Moura No.4 Mine Explosion 1986	5. 4
5.4.1	Forensic Science	5. 4
5.4.2	Forensic Pathology	5. 5
5.4.3	Recovery of the Victims at Moura	5. 6
5.4.4	Post Mortem Reports	5. 7
5.5	Examination of Records	5. 8
5.5.1	Classification of the Incident	5. 8
5.5.2	Approach to the Scene: Immediate Actions	5. 9
5.5.3	General Characteristics of the Explosion	5.10
5.5.4	Observed Personnel Effects	5.11
5.5.5	Condition of Deceased Miners after Explosion	5.14
5.5.6	Observed Material Effects	5.14
5.6	Discussion	5.16
5.7	Summary	5.16

CHAPTER 6

MINE EXPLOSION ANALYSIS.		6. 1
6.1	Investigation Techniques	6. 1
6.2	Australian and Overseas Forensic Research	6. 2
6.2.1	Estimating Overpressures from Damage to Structures	6. 3
6.2.2	Displacement of Objects	6. 3
6.2.3	Heat Damage	6. 4
6.3	Modelling of Explosions	6. 5
6.3.1	Physical Models	6. 5
6.3.2	Mathematical Models	6. 6
6.4	Reanalysis of the Moura No.4 Mine Explosion	6. 8
6.4.1	Brick Stoppings	6. 8
6.4.2	Movement of the Shuttle Cars	6.10
6.4.3	Movement of the Bodies	6.11
6.4.4	Discussion	6.12
6.5	Modelling Studies	6.13
6.5.1	1:54 Scale Model Experiments	6.13
6.6	Computer Simulation Experiments	6.16
6.7	Discussion	6.19

CHAPTER 7

SOME FINDINGS ON RE-ANALYSIS OF MOURA EXPLOSION.		7. 1
7.1	The Critical Data Set	7. 1
7.2	The Flame Safety Lamp	7. 2
7.3	The Course of the Explosion	7. 5
7.3.1	The area in 24 c/t and from the direction of the Boot End	7. 6
7.3.2	The Crib Room and Surrounding Area	7. 7
7.3.3	The Area Around the Continuous Miner	7. 8
7.3.4	The Northern Section of the Goaf	7. 9
7.3.5	The Southern Section of the Goaf	7.11
7.4	Discussion	7.12
7.5	Conclusion	7.14

CHAPTER 8

OVERALL FINDINGS.		8. 1
8.1	Forensic Pathology and Computer/Physical Modelling	8. 2
8.2	Identification of Evidence from Forensic Pathology (Moura)	8. 3
8.3	Identification of Additional Characteristics of Blast (Moura)	8. 3
8.4	Structuring of Future Scientific Investigations	8. 3
8.5	Protection of Life in Underground Coal Mines	8. 4
8.6	Liaison Between Government Departments	8. 5
8.7	Facilities for Forensic Pathology	8. 5
8.8	Summary	8. 5

LIST OF TABLES

6.1	Pressure Damage from Chemical and Nuclear Explosion	6.21
6.2	Maximum and Minimum Movement of Brick Debris	6.22
6.3	Damage Sustained to Brick Stoppings	6.23
6.4	Air Velocities and Impulse Based on Maximum and Minimum Brick Displacements	6.24
6.5	Movement of Shuttle Car No.31	6.25
6.6	Body Displacement	6.26
7.1	Critical Factors for Scenario of Ignition	7.16

LIST OF FIGURES

6.1	Plot of the Position of the Dummy During Translation as Viewed at the Side of the Vertical Plane in Which It Moved	6.27
6.2	10m Ignition Tube - Experimental Pressures	6.28
6.3	10m Ignition Tube - Calculated Pressures	6.28
6.4	Movement of Mine Stopping Debris	6.29
6.5	End Displacement of Shuttle Car No.31	6.29
6.6	Body Displacement	6.30
6.7	Schematic of the 1:54 Scale Model.	6.30
6.8	Ignition : South Goaf	6.31
6.8	Continued	6.32
6.9	Ignition : 27 c/t and No.4 Supply Road	6.33
6.10	Ignition : 26 c/t and No.3 Belt Road	6.34
6.10	Continued	6.35
6.11	Grid Used for Mathematical Simulations : Resolution 0.5m	6.36
6.12	Pressure : Ignition at 27 c/t and No.4 Supply Road	6.37
6.13	U Velocity : Ignition 27 c/t and No.4 Supply Road.	6.38
6.14	V Velocity : Ignition 27 c/t and No.4 Supply Road.	6.39
6.15	Pressure from Scale Model Experiments : Ignition at 27 c/t and No.4 Supply Road.	6.40
6.16	Pressure : Ignition at 26 c/t and No.3 Belt Road	6.41
6.17	U Velocity : Ignition at 26 c/t and No.3 Belt Road	6.42
6.18	V Velocity : Ignition at 26 c/t and No.3 Belt Road	6.43
7.1	Ignition Sources : Probability for Various Locations	7.18

LIST OF APPENDICES

APPENDIX A	Plan of Moura No.4 Mine (1:2500).
APPENDIX B	No.4 Underground Mines Rescue Plan. Main Dips Section (Pre-Disaster) (1:250).
APPENDIX C	Part of the Mine Disaster Plan (1:250).
APPENDIX D	Part of the Mine Disaster Plan showing approximate caving (1:250).
APPENDIX E	% DAFV post explosion and damage to stoppings (1:1250).
APPENDIX F	The extent of flame in the Main Dips Section.
APPENDIX G	The direction of major explosion airflows.
APPENDIX H	Photographs of damage caused by explosion.
APPENDIX J	Photograph of scale model of the Main Dips workings.
APPENDIX K	Experts who gave assistance to the project.
APPENDIX L	References.
APPENDIX M	CV of Authors of various Chapters.
APPENDIX N	CV of Independent Reviewer.
APPENDIX O	Listing of Review Committee Members.
APPENDIX P	Distribution of Report.