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Mining Equipment Reliability, Maintainability, and Safety

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This book is affectionately dedicated to my dear friend Dr. S.N. Rayapati for his stimulating conversations, support, and friendship over the years.

Preface

The history of mining may be traced back to the ancient Egyptians, who operated malachite mines. Today a large number of people are employed in the mining industry throughout the world. For example, in the USA alone around 675,000 people work in the natural resources and mining sector. Today, the mining industry uses various types of complex and sophisticated equipment whose reliability, maintainability, and safety have become an important issue.

Although over the years a large number of journal and conference proceedings articles on mining equipment reliability, maintainability, and safety have appeared, to the best of author's knowledge, there is no book that covers all three of these topics within its framework. This causes a great deal of difficulty for information seekers on the subjects because they must consult many different and diverse sources.

Thus, the main objective of this book is to combine all three of these topics into a single volume, to eliminate the need to consult many different and diverse sources in obtaining desired information. The sources of most of the material presented are given in the reference section at the end of each chapter. This will be useful to readers if they desire to delve deeper into a particular area. The book contains a chapter on mathematical concepts and another chapter on introductory material on reliability, maintainability, and safety considered essential to understand contents of subsequent chapters.

The topics covered in the volume are treated in such a manner that the reader will require no previous knowledge to understand the contents. At appropriate places, the book contains examples along with their solutions, and at the end of each chapter there are numerous problems to test reader comprehension.

An extensive list of references on mining equipment reliability, maintainability, and safety is provided at the end of the book to give readers a view of developments in the area over the years.

The book is composed of 11 chapters. Chapter 1 presents the need for improving mining equipment reliability, maintainability, and safety; mining-equipment-related facts and figures, important terms and definitions, and useful information on mining equipment reliability, maintainability, and safety classified under six distinct categories. Chapter 2 is devoted to mathematical concepts considered useful for per-

forming mining equipment reliability, maintainability, and safety analysis. It covers topics such as Boolean algebra laws, probability properties, useful mathematical definitions, and probability distributions.

Chapter 3 presents various introductory aspects of reliability, maintainability, and safety including reliability networks, commonly used methods in reliability analysis, maintainability functions, maintainability analysis tools, safety analysis methods, and safety indexes. Chapter 4 is devoted to mining equipment reliability and covers topics such as reasons for improving mining equipment reliability, open-pit system reliability analysis, programmable electronic mining system failures, fault tree analysis of shovel machine, and dump-truck tire reliability and factors affecting their reliability. Various aspects of human factors and error in mining are covered in Chap. 5. Some of the topics covered in the chapter are the need for human-factor application in mining, human sensory capacities, human-factor formulas, useful general human-factor guidelines for application in mining equipment design, classifications and causes of human errors leading to fatal accidents in mines, typical mining equipment maintenance errors, useful design improvements to reduce mining equipment maintenance errors, and human error analysis methods for application in the area of mining.

Chapters 6 and 7 are devoted to mining equipment maintainability and mining equipment reliability and maintainability testing, respectively. Chapter 6 covers topics such as reliability test classifications, success testing, accelerated testing, confidence interval estimates for mining equipment mean time between failures, test methods to obtain maintainability-related test data for mining equipment, test methods for demonstrating diverse maintainability parameters, and useful guidelines for avoiding pitfalls in maintainability testing of mining equipment. Some of the topics covered in Chap. 7 are the meanings of the mining equipment maintainability and design-induced maintainability problems of mining equipment, advantages of the improved mining equipment maintainability design, mining equipment maintainability design characteristics, maintainability measures for mining equipment, and common maintainability design errors and useful maintainability design guideline for mining equipment.

Chapter 8 presents various important aspects of mining equipment maintenance including maintenance-related facts and figures, factors contributing to equipment maintenance cost in mines, maintenance of explosion-protected switchgear in mines, useful maintenance measures for mines, and mathematical models for performing mining equipment maintenance. Various important aspects of mining equipment costing are covered in Chap. 9. Some of the topics covered include reasons for mining equipment costing, methods for making mining equipment investment decisions, cost estimation models for mining equipment, life cycle costing concept, and life cycle cost estimation models for mining equipment.

Chapter 10 is devoted to the introductory aspects of mining equipment safety and covers topics such as facts and figures, quarry accidents, causes of mining equipment accidents and major sources of mining equipment fires, methods for performing mining equipment safety analysis, human-factor-related tips for safer mining equipment, strategies to reduce mining equipment fires and injuries, and general ar-

reas for safety improvements in mines. Finally, Chap. 11 presents various important aspects of programmable electronic mining system safety including programmable-electronic-related mishaps, methods for performing hazard and risk analysis of programmable electronic mining systems, lessons learned in addressing the safety of programmable electronic mining systems, and sources for obtaining programmable electronic mining system safety-related information.

This book will be useful to many individuals including engineering professionals working in the mining industry, mining administrators, mining engineering undergraduate and graduate students, mining engineering researchers and instructors, reliability, maintainability, maintenance, human factors, and safety professionals, and design engineers and associated professionals concerned with mining equipment.

The author is deeply indebted to many colleagues and students for their interest throughout this project. The invisible contributions of my children, Jasmine and Mark, are also appreciated. Last but not least, I thank my other half, friend, and wife, Rosy, for typing various portions of the book and other related materials, and for her timely help in proofreading and tolerance.

Ottawa, Ontario

B.S. Dhillon

Contents

1	Introduction	1
1.1	Need for Improving Mining Equipment Reliability, Maintainability, and Safety	1
1.2	Mining-equipment-related Facts and Figures	1
1.3	Terms and Definitions	2
1.4	Useful Information on Mining Equipment Reliability, Maintainability, and Safety	4
1.4.1	Journals and Magazines	4
1.4.2	Conference Proceedings	5
1.4.3	Books	5
1.4.4	Organizations	6
1.4.5	Standards	6
1.4.6	Data Information Sources	7
1.5	Problems	7
	References	8
2	Introductory Mathematical Concepts for Mining Equipment Reliability, Maintainability, and Safety Analysis	11
2.1	Introduction	11
2.2	Range, Arithmetic Mean, Mean Deviation, and Standard Deviation .	11
2.2.1	Range	12
2.2.2	Arithmetic Mean	12
2.2.3	Mean Deviation	13
2.2.4	Standard Deviation	14
2.3	Boolean Algebra Laws and Probability Definition and Properties ...	14
2.4	Useful Mathematical Definitions	17
2.4.1	Cumulative Distribution Function	17
2.4.2	Probability Density Function	17
2.4.3	Reliability Function	18
2.4.4	Expected Value	18
2.4.5	Variance	18

- 2.4.6 Laplace Transform 19
- 2.4.7 Laplace Transform: Final Value Theorem 19
- 2.5 Probability Distributions 20
 - 2.5.1 Binomial Distribution 20
 - 2.5.2 Exponential Distribution 20
 - 2.5.3 Rayleigh Distribution 21
 - 2.5.4 Weibull Distribution 21
 - 2.5.5 Normal Distribution 22
 - 2.5.6 Lognormal Distribution 22
- 2.6 Solving Differential Equations Using Laplace Transforms 23
- 2.7 Problems 24
- References 25

- 3 Introduction to Reliability, Maintainability, and Safety 27**
 - 3.1 Introduction 27
 - 3.2 Need for Reliability and Bathtub Hazard Rate Curve 28
 - 3.3 General Reliability, Hazard Rate, and Mean Time to Failure Functions 29
 - 3.3.1 General Reliability Function 29
 - 3.3.2 Hazard Rate Function 30
 - 3.3.3 Mean Time to Failure 30
 - 3.4 Reliability Networks 31
 - 3.4.1 Series Configuration 31
 - 3.4.2 Parallel Configuration 33
 - 3.4.3 *k*-out-of-*m* Configuration 35
 - 3.4.4 Standby System 36
 - 3.4.5 Bridge Configuration 37
 - 3.5 Commonly Used Methods in Reliability Analysis 39
 - 3.5.1 Failure Modes and Effect Analysis (FMEA) 39
 - 3.5.2 Markov Method 39
 - 3.5.3 Fault Tree Analysis 42
 - 3.6 Need for Maintainability and Maintainability Versus Reliability 47
 - 3.7 Maintainability Functions 47
 - 3.7.1 Maintainability Function I: Exponential Distribution 48
 - 3.7.2 Maintainability Function II: Weibull Distribution 48
 - 3.8 Maintainability Design Factors and Maintainability Analysis Tools 49
 - 3.8.1 Total Quality Management 49
 - 3.8.2 Cause and Effect Diagram 50
 - 3.9 Maintainability-Management-Related Tasks During the Equipment Life Cycle 51
 - 3.10 Need for Safety and Safety-Related Facts and Figures 51
 - 3.11 Equipment Hazard Classifications and Common Mechanical Injuries 52
 - 3.12 Safety Analysis Methods 52
 - 3.12.1 Hazard and Operability Analysis (HAZOP) 52

3.12.2	Job Safety Analysis	53
3.12.3	Technic of Operations Review (TOR)	53
3.13	Safety Indexes	54
3.13.1	Index I: Disabling Injury Frequency Rate	54
3.13.2	Index II: Disabling Injury Severity Rate	54
3.14	Problems	55
	References	55
4	Mining Equipment Reliability	57
4.1	Introduction	57
4.2	Reasons for Improving Mining Equipment Reliability, Factors Impacting Mining System Reliability, and Useful Mining-Equipment-Reliability-Related Measures	57
4.2.1	Useful Mining-Equipment-Reliability-Related Measures ...	59
4.3	Open-Pit-System Reliability Analysis	60
4.3.1	Open-Pit Series System	61
4.3.2	Open-Pit Parallel System	62
4.4	Programmable Electronic Mining System Failures	64
4.4.1	Random Hardware Failures	64
4.4.2	Systematic Failures	65
4.5	Designing Reliable Conveyor Belt Systems and Methods of Measuring Winder Rope Degradation	65
4.5.1	Visual Inspection Method	66
4.5.2	Nondestructive Testing Method	67
4.6	Fault Tree Analysis of Shovel Machine	67
4.7	Dump-truck Tire Reliability and the Factors Affecting Their Life ..	69
4.8	Problems	69
	References	70
5	Human Factors and Error in Mining	71
5.1	Introduction	71
5.2	The Need to Apply Human Factors in Mining and Common Roadblocks to the Introduction of Human Factors in an Organization	72
5.3	Human Sensory Capacities and Human-Factor Considerations in Equipment Design	73
5.3.1	Human-Factor Considerations in Equipment Design	74
5.4	Human-Factor Formulas	76
5.4.1	Formula I	76
5.4.2	Formula II	77
5.4.3	Formula III	77
5.4.4	Formula IV	77
5.5	Useful General Human Factors Guidelines for Application in Mining Equipment Design	78

- 5.6 Classifications and Causes of Human Errors Leading to Fatal Accidents in Mines 78
- 5.7 Typical Mining Equipment Maintenance Errors, Factors Contributing to Maintenance Error, and Useful Engineering Design Improvements to Reduce Mining Equipment Maintenance Errors 79
- 5.8 Types of Chemicals Released in Human-Error-Related Events in the Mining and Manufacturing Industries and Factors Responsible for Failing to Reduce the Occurrence of Human Error in Mines 80
- 5.9 Human-Error-Analysis Methods for Application in the Area of Mining 81
 - 5.9.1 Probability Tree Method 81
 - 5.9.2 Throughput Ratio Method 83
 - 5.9.3 Fault Tree Analysis 84
- 5.10 Problems 87
- References 87

- 6 Mining Equipment Maintainability 89**
 - 6.1 Introduction 89
 - 6.2 The Meanings of Mining Equipment Maintainability and Design-induced Maintainability Problems of Mining Equipment ... 89
 - 6.3 Advantages of Improved Mining Equipment Maintainability Design 91
 - 6.4 Mining Equipment Maintainability Design Characteristics 92
 - 6.4.1 Standardization 92
 - 6.4.2 Interchangeability 92
 - 6.4.3 Accessibility 93
 - 6.4.4 Safety 93
 - 6.5 Maintainability Measures for Mining Equipment 93
 - 6.5.1 Mean Time to Repair 94
 - 6.5.2 Mean Preventive Maintenance Time 95
 - 6.5.3 Maintainability Function 95
 - 6.6 Common Maintainability Design Errors and Useful Maintainability Design Guidelines for Mining Equipment 97
 - 6.7 Conclusions: State of Maintainability in the Underground Mining Industry 98
 - 6.8 Problems 98
 - References 99

- 7 Mining Equipment Reliability and Maintainability Testing 101**
 - 7.1 Introduction 101
 - 7.2 Reliability Test Classifications 101
 - 7.3 Success Testing 102
 - 7.4 Accelerated Testing 104

- 7.5 Confidence Interval Estimates for Mining Equipment Mean Time Between Failures 105
- 7.6 Documents on Reliability Testing 108
- 7.7 Planning and Control Requirements for Mining Equipment Maintainability Testing and Demonstration 109
- 7.8 Test Methods to Obtain Maintainability-related Test Data for Mining Equipment 110
- 7.9 Test Methods for Demonstrating Diverse Maintainability Parameters 110
- 7.10 Useful Guidelines for Avoiding Pitfalls in Maintainability Testing of Mining Equipment 112
- 7.11 Problems 112
- References 113

- 8 Mining Equipment Maintenance 115**
 - 8.1 Introduction 115
 - 8.2 Maintenance-related Facts and Figures 115
 - 8.3 Maintenance Engineering Objectives, Total Productive Maintenance, and Reasons for Its Performance 116
 - 8.4 Factors Contributing to Equipment Maintenance Cost in Mines 118
 - 8.5 Maintenance of Explosion-protected Switchgear in Mines 119
 - 8.6 Useful Maintenance Measures for Mines 120
 - 8.7 Mathematical Models for Performing Mining Equipment Maintenance 123
 - 8.8 Problems 132
 - References 132

- 9 Mining Equipment Costing 135**
 - 9.1 Introduction 135
 - 9.2 Reasons for Mining Equipment Costing and Methods for Making Mining Equipment Investment Decisions 135
 - 9.2.1 Benefit/Cost Analysis Method 136
 - 9.2.2 Return on Investment Method 137
 - 9.2.3 Payback Period Method 138
 - 9.3 Cost Estimation Models for Mining Equipment 140
 - 9.3.1 Cost-capacity Model 140
 - 9.3.2 Corrective Maintenance Labor Cost Estimation Model 141
 - 9.3.3 Total Maintenance Labor Cost Estimation Model 141
 - 9.3.4 Production Facility Downtime Cost Estimation Model 142
 - 9.3.5 Motor Operation Cost Estimation Model 142
 - 9.3.6 Failure Mode and Effect Analysis Cost Estimation Model 143
 - 9.3.7 Reliability Testing Cost Estimation Model 144
 - 9.4 Life Cycle Costing Concept 144
 - 9.5 Life Cycle Costing Steps 145

- 9.6 Life Cycle Cost Estimation Models for Mining Equipment 146
 - 9.6.1 Model I 146
 - 9.6.2 Model II 147
- 9.7 Problems 149
- References 150
- 10 Introduction to Mining Equipment Safety 153**
 - 10.1 Introduction 153
 - 10.2 Facts and Figures 154
 - 10.3 Quarry Accidents and Electrical-, Equipment Fire-,
and Maintenance-related Mining Accidents 154
 - 10.4 Causes of Mining Equipment Accidents and Major Ignition
Sources for Mining Equipment Fires 155
 - 10.5 Methods for Performing Mining Equipment Safety Analysis 157
 - 10.5.1 Preliminary Hazards Analysis 157
 - 10.5.2 Failure Modes and Effect Analysis (FMEA) 157
 - 10.5.3 Management Oversight and Risk Tree (MORT) Analysis . . . 160
 - 10.5.4 Consequence Analysis 160
 - 10.5.5 Binary Matrices 161
 - 10.5.6 Human Reliability Analysis 162
 - 10.6 Hazardous Area Signaling and Ranging Device (HASARD)
Proximity Warning System 162
 - 10.7 Human-Factor-related Tips for Safer Mining Equipment,
Guidelines to Improve Electrical Safety in the Mining Industry,
and Strategies to Reduce Mining Equipment Fires and Injuries 163
 - 10.8 General Areas for Safety Improvements in Mines 165
 - 10.9 Problems 166
 - References 166
- 11 Programmable Electronic Mining System Safety 169**
 - 11.1 Introduction 169
 - 11.2 Programmable Electronics Usage Trends in Mining 169
 - 11.3 Programmable-electronic-related Mishaps 170
 - 11.4 Methods for Performing Hazard and Risk Analysis
of Programmable Electronic Mining Systems 172
 - 11.4.1 Hazard and Operability Studies (HAZOP) 172
 - 11.4.2 Event Tree Analysis 173
 - 11.4.3 Interface Analysis 174
 - 11.4.4 Action Error Analysis (AEA) 175
 - 11.4.5 Operating and Support Analysis (OASA) 175
 - 11.4.6 Sequentially Timed Events Plot (STEP)
Investigation System 176
 - 11.4.7 Potential or Predictive Human Error Analysis 176
 - 11.5 Lessons Learned in Addressing the Safety of Programmable
Electronic Mining Systems 177

- 11.6 Obtaining Programmable Electronic Mining System
 - Safety-Related Information 177
 - 11.6.1 Organizations and Systems 177
 - 11.6.2 Books and Standards 178
 - 11.6.3 Commercial Sources for Obtaining Standards 179
- 11.7 Problems 179
- References 179

- Bibliography: Literature on Mining Equipment Reliability,
Maintainability, and Safety** 181

- Author Biography** 197

- Index** 199