

# Bibliography: Literature on Mining Equipment Reliability, Maintainability, and Safety

## Introduction

Over the years, a large number of publications relating to mining equipment reliability, maintainability, and safety have appeared in the form of journal articles, conference proceedings articles, technical reports, etc. This appendix presents an extensive list of such publications.

The period covered by the listing is 1965–2007. The main objective of this listing is to provide readers with sources for obtaining additional information on mining equipment reliability, maintainability, and safety.

## Publications

1. Akashev, Z.T., Atagulov, B.E.: Organizational indexes of quality of repair of quarry locomotives, *Tyazheloe Mashinostroenie* 3, 25–27 (2005)
2. Aldinger, J.A., Keran, C.M.: A review of accidents during surface mine mobile equipment operations. In: *Proc. of the 25th Annual Institute on Mining Health, Safety, and Research*, pp. 99–108 (1994)
3. Altshuler, V.M.: A method of constructing a mathematical model to study the reliability of mine transportation systems. *Sov. Min. Sci.* 5, 72–76 (1969)
4. Ambs, J.L., Setren, R. S.: Safety evaluation of disposable diesel exhaust filters for permissible mining equipment. In: *Proceedings of the 7th US Mine Ventilation Symposium*, pp. 105–110 (1995)
5. Anderson, W.D., Silbert, M.N., Lloyd, J.R.: Reliability procedure for fixed offshore platforms. *J. Struct. Div. Am. Soc. Civil Eng.* 108, ST11, 2517–2538 (1982)
6. Angelides, D.C., Vereziano, D., Sunder, S.S.: Random sea and reliability of offshore foundations. *J. Eng. Mechan. Div. Am. Soc. Civil Eng.* 107, EMI, 131–148 (1981)

7. Anon.: Environmental safety underground. *Colliery Guardian* 235, 5, 170–172 (1987)
8. Anon.: High altitude reliability for heavy mining vehicles. *Austral. Min.* 85, 4, 20–22 (1993)
9. Anon.: Recent mine safety R&D projects of the U.S. Bureau of Mines. *Eng. Min. J.* 196, 11, 26–28 (1995)
10. Anon.: U.S. enacts new mine safety policies. *Coal Age* 111, 6, 24–27 (2006)
11. Anon.: Conveying safety, *Min. Mag.* 193, 4, 24–26 (2005)
12. Anon.: Crane Hire Group helps LIFT mine maintenance rates. *Austral. Min.* 98, 4, 38 (2006)
13. Anon.: Emerson's machinery health technologies enable UK coal to avoid equipment failures. *Coal Int.* 254, 3, 42–43 (2006)
14. Anon.: Improvements to cat machine safety. *Min. Mag.* January, 45 (2006)
15. Anon.: Management in action-new versus used equipment: know your supplier. *Min. Mag.* 194, 3, 28–29 (2006)
16. Anon.: Management in action-safety: still unacceptable. *Min. Mag.* 194, 4, 22–26 (2006)
17. Anon.: Minimizing maintenance with oil condition monitoring. *Coal Age*, 110, 9, 36–37 (2005)
18. Anon.: Monitoring mining equipment. *Eng. Australia* 77, 4, 59–60 (2005)
19. Anon.: New products aim at cutting equipment maintenance costs. *Eng. Min. J.* 207, 3, 60–63 (2006)
20. Anon.: Stop bolting hazards in their tracks. *Austral. Min.* 98, 6, 34 (2006)
21. Anon.: The color of safety. *Eng. Min. J.* 207, 5, 46–49 (2006)
22. Astafyev, Y.: Simulation ore reserves control model based on reliability characteristics of open-pit equipment. In: *Proc. of the Symposium on Applications of Computer Methods in the Mining Industry*, pp. 10–14 (1976)
23. Bakewell, D.: The reliability problem. *Min. Technol.* 64, 736, 50–53 (1982)
24. Barabady, J.: Reliability and maintainability analysis of crushing plants in Jajarm bauxite mine of Iran. In: *Proc. of the Annual Reliability and Maintainability Symposium*, pp. 109–115 (2005)
25. Barczak, T., Gearhart, D.: Performance and safety considerations of hydraulic support systems. In: *Proc. of the 17th Int. Conf. on Ground Control in Mining*, pp. 176–186 (1998)
26. Barkand, T.D.: Emergency braking systems for mine elevators. In: *Proc. of the Conf. on New Technology in Mine Health and Safety*, pp. 325–336 (1992)
27. Barlow, P.: The economics, reliability and versatility of high-angle conveyors. *Quarry Manage.* 21, 4, 17–23 (1994)
28. Barton, J.L., Murray, R.A.: Application of conveyor belt monitoring technology to conveyor belt reliability. *CIM Bull.* 85, 959, 37–44 (1992)
29. Bates J.J.: The technical performance and reliability of powered support installations. *Min. Technol.* 59, 679, 168–175 (1977)
30. Bates, J.J.: Technical commissioning of coal face equipment. *Min. Technol.* 55, 628, 52–62 (1973)

31. Bates, J.J.: The key technical factors of machine performance and reliability – No. 1. *Min. Technol.* 63, 725, 31–33 (1981)
32. Bates, J.J.: The key technical factors of machine performance and reliability – No. 2. *Min. Technol.* 63, 724, 31–33 (1981)
33. Bates, J.J.: The key technical factors of machine performance and reliability – No. 3. *Min. Technol.* 63, 725, 105–107 (1981)
34. Bates, J.J.: The key technical factors of machine performance and reliability – No. 4. *Min. Technol.* 63, 726, 159–160 (1981)
35. Bates, J.J.: The key technical factors of machine performance and reliability – No. 5. *Min. Technol.* 64, 742, 383–385 (1982)
36. Bates, J.J.: The key technical factors of machine performance and reliability (second series: Part I). *Min. Technol.* 66, 759, 23–25 (1984)
37. Bates, J.J.: The key technical factors of machine performance and reliability (second series: Part II). *Min. Technol.* 66, 760, 67–60 (1984)
38. Bates, J.J.: The key technical factors of machine performance and reliability (second series: Part III). *Min. Technol.* 66, 761, 99–104 (1984)
39. Bates, J.J.: The key technical factors of machine performance and reliability (second series: Part IV). *Min. Technol.* 66, 762, 147–152 (1984)
40. Bates, J.J.: The key technical factors of machine performance and reliability (second series: Part V). *Min. Technol.* 66, 766, 277–281 (1984)
41. Bea, R.G.: Reliability considerations in offshore platform criteria. *J. Struct. Div. Am. Soc. Civil Eng.* 106, ST9, 1835–1853 (1980)
42. Bea, R.G.: Selection of environmental criteria for offshore platform design. *J. Petroleum Technol.* 1206–1214 (1974)
43. Bello, G.C., Avogadsi S.: Offshore pipeline system – how to decide the optimal redundancies using reliability engineering. *Reliabil. Eng.* 3, 89–99 (1982)
44. Benger, H.: Mine ventilation system with automatically exchangeable active parts. *Brown Boveri Rev.* 73, 4, 204–210 (1986)
45. Beus, M.J., Iverson, S.: Safer mine hoisting with conveyance position and load monitoring. *Am. J. Ind. Med.* 36, 119–121 (1999)
46. Bickel, K.L.: Five Automatic Fire Protection Systems for Mobile Mining Equipment: Their Design and in Mine Reliability Testing, US Bureau of Mines, Washington, DC, pp. 14–17 (1977)
47. Bleazard, D., Hepler, D., Dearman, L.: Equipment reliability improved at Barrick goldstrike. *Min. Eng.* 50, 1, 45–49 (1998)
48. Bobick, T.G.: Increasing safety in underground coal mining through improved materials-handling systems. In: *Proc. of the SME Annual Meeting*, pp. 1–9 (1988)
49. Bondar, S.A., Meruov, V.V.: Operational reliability of conveyer lines with intermediate storage capacity. *Sov. Min. Sci.* 15, 3, 268–270 (1979)
50. Bozorgebrahimi, A., Hall, R.A., Morin, M.A.: Equipment size effects on open pit mining performance. *Int. J. Surface Min. Reclamat. Environ.* 19, 1, 41–56 (2005)

51. Brahma, K.C., Pal, B.K., Das, C.: A study on application of markovian decision process in drilling and blasting operation of opencast mines. *J. Mines Metals Fuels* 55, 1–2, 24–29 (2007)
52. Brodzinski, S.: Reliability of hydraulic disc brakes in winders. *Colliery Guardian* February, 67–69 (1984)
53. Burgess, T., Shimbel, L.: What is the prognosis maintenance program? *Eng. Min. J.* 196, 5, 32–35 (1995)
54. Butani, S.J.: Hazard analysis of mining equipment by mine type and geographical region. In: *Proc. of the Symp. on Engineering Health and Safety*, pp. 158–173 (1986)
55. Butosin, Yu.M., Gavrilenko, V.A.: Some aspects of the reliability of drilling equipment. *Sov. Min. Sci.* 12, 62–65 (1976)
56. Castanier, B., Rausand, M.: Maintenance optimization for subsea oil pipelines. *Int. J. Pressure Vessels Pip.* 83, 236–243 (2006)
57. Cawley, J.C.: Electrical accidents in the mining industry, 1990–1999. In: *Proceedings of the 36th IAS Annual Meeting*, 2, 1361–1368 (2001)
58. Cawley, J. C.: Probability of Spark Ignition in Intrinsically Safe Circuits, Report No. 9183, *Report of Investigations*, US Bureau of Mines, Washington DC, pp. 1–15 (1988)
59. Clark, D.: Tribology – its application to equipment reliability and maintainability design in the underground coal mining industry. In: *Proc. of the Int. Tribology Conference*, pp. 38–44 (1990)
60. Clark, R., Dawkins, G., Kennedy, R., Grainger, A., Lysaght, A.: Maintenance performance improvement – a structured approach. In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 89–94 (1991)
61. Collins, J., Singhal, R.K., Fytas, K.: Mine maintenance analysis through Markov chain schemes. *Int. J. Surface Min. Reclam.* 6, 1, 47–56 (1992)
62. Committee on Reliability of Offshore Structures, Application of Reliability Methods in Design and Analysis of Offshore Platforms, *J. Struct. Eng.* 109, 10, 2265–2291 (1983)
63. Conway, E.J., Unger, R.L.: Maintainability design of mobile underground mining equipment. In: *Proc. of the Bureau of Mines Technology Transfer Seminar*, pp. 61–65 (1987)
64. Conyngham, M.G.: Role of quality assurance in manufacturing of mining equipment. In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 95–103 (1991)
65. Cooper, B.: Maintenance strategy procedures development and implementation. *Min. Technol.* 78, 893, 3–6 (1996)
66. Cox, D.: The maintenance and repair of explosion-protected equipment in coal mines. *Vector (Electr. Eng.)* October, 19–22 (1998)
67. Cutts, A.: Improving the reliability of machines and systems used in the production processes, automation and control technologies. In: *Proc. of the International Conference on Reliability, Production, and Control in Coal Mines*, pp. 18–24 (1991)

68. Czaplicki, J.M., Brodzinski, S.: Reliability Testing of Polish Winders. *Colliery Guard. Coal Int.* January, 38–39 (1980)
69. Daniel, J.H.: Diesels – Backbone of a changing mining industry. In: *Proc. of the 4rth US Mine Ventilation Symposium*, pp. 561–568 (1989)
70. Daniel, J.H.: Reducing mine accidents by design. In: *Proc. of the SME Annual Meeting*, pp. 1–11 (1991)
71. Dasgupta, K., Chattapadhyay, A., Mondal, S.K.: Selection of fire resistant hydraulic fluids through system modeling and simulation. *Simulat. Modell. Pract. Theory* 13, 1, 1–20 (2005)
72. Davies, R.K.L.: Monitoring hoist safety equipment. *Coal Age* 21, 1, 66–68 (1986)
73. Dawson, V.E., Heistad, R.: Performance and field testing of the service brakes of mining trucks in B.C. *Trans. Can. Inst. Min. Metallurgy* LXXX, 129–136 (1977)
74. De La Mare, R.F.: Failure characteristics of mechanical equipment which receives comprehensive maintenance overhaul. *Qual. Reliabil. Eng. Int.* 5, 3, 189–202 (1989)
75. De Rosa, M.I.: Equipment fires cause injuries. *Coal Age* 109, 10, 28–31 (2004)
76. DeGaspari, J.: Armchair mining. *Mech. Eng.* 125, 5, 42 (2003)
77. Dey, A., Bhattacharya, J., Banerjee, S.: Prediction of field reliability for dumper tyres. *Int. J. Surface Min. Reclamat.* 8, 1, 23–25 (1994)
78. Dhillon, B.S.: Bibliography of literature on mining equipment reliability. *Microelectron. Reliabil.* 26, 6, 1131–1138 (1986)
79. Dittrich, W., Dralle, H.: Inspection of opencast mine equipment. *World Min.-Surface Underground* 59, 1, 22–26 (2007)
80. Dkilog, K.N.: Reliability of the technology of extracting seams with complex geology. *Sov. Min. Sci.* 16, 3, 242–247 (1980)
81. Dotson, J.C.: Reliability engineering and its application in mining. *Min. Congr. J.* 52, 8, 68–76 (1966)
82. Dreyer, E.: Cost-effective prevention of equipment failure in the mining industry. *Int. J. Pressure Vessels Pip.* 61, 2–3, 329–347 (1995)
83. Dunn, S.: Optimizing production scheduling for maximum plant utilization and minimum downtime, the reliability revolution. In: *Proc. of the Dollar Driven Mining Conference*, Perth, Western Australia, pp. 8–12 (July 1997)
84. Dunzgun, H.S.B., Einstein, H.H.: Assessment and management of roof fall risks in underground coal mines. *Safety Sci.* 42, 1, 23–41 (2004)
85. Dvornikov, L.T., Turov, V.A.: Composition and structure of reliability properties. *Sov. Min. Sci.* 24, 5, 448–451 (1989)
86. Dvornikov, L.T., Gudimov, N.I., Turov, V., Davydov, A.P.: Reliability analysis of BGA rotary – percussive units for drilling boreholes in rock. *Sov. Min. Sci.* 15, 4, 365–370 (1979)
87. Earthrowl, B.: Design for reduced maintenance costs – the application of split roller bearings in mining equipment. *Min. Technol.* 76, 876, 168–170 (1994)

88. Ercelebi, S.G., Yegulalp, T.M.: Reliability and availability analysis of mining systems. *Trans. Inst. Min. Metallurgy* 102, 51–58 (1993)
89. Erskine, W.W.: Qualities necessary for engineering management. *Min. Technol.* September, 392–395 (1982)
90. Esterhuizen, S.G., Gurtunca, R.G.: Coal mine safety achievements in the USA and the contribution of NIOSH research. *J. South African Inst. Min. Metallurgy* 106, 12, 813–820 (2006)
91. Feder, D.K.: Preventive maintenance of open-cut continuous mining equipment. *Weld. World* 32, 1, 267–276 (1993)
92. Feltes, M.J.: Mechanical belt fasteners increase conveyor availability. *Min. Eng.* 45, 3, 273–274 (1993)
93. Forsman, B., Kumar, U.: Surface mining equipment and maintenance trends in the Scandinavian countries. *J. Mines Metals Fuels* 40, (8–9), 266–269 (1992)
94. Freeman, S.: Remote blasting lifts safety and output. *Austral. Min.* 97, 7, 38–39 (2005)
95. Freidina, E.V., Kovalenko, A.S., Rudenko, O.A.: Effect of mine-transport-equipment reliability on the productivity of a quarry system. *Sov. Min. Sci.* 10, 50–54 (1975)
96. Gel'Fand, F.M., Bur'ka, V.F., Shul'gin, E.I.: Probabilistic method of finding burst hazard factor or index and its limiting values for safe and hazardous seams. *Sov. Min. Sci.* 15, 3, 275–278 (1979)
97. Gibiec, M.: Prediction of machine health with application of an intelligent approach: a mining machinery case study. *Key Eng. Mater.* 293/294, 661–668 (2005)
98. Gimel'shein, L.Y., Nikeshin, B.S.: Quantitative reliability criteria for electromechanical systems in mines. *Sov. Min. Sci.* 3, 199–202 (1967)
99. Girard, J., McHugh, E.: Detecting Problems with Mine Slope Stability. In: *Proc. of the 32nd Annual Institute on Mining Health, Safety, and Research*, pp. 1–8 (2000)
100. Glavin, J.: Health and safety in Australia's mines. *Mater. World*, 14, 4, 22–23 (2006)
101. Goldheck, L.: Stored energy in conveyor belts: managing the risk. *Eng. Min. J.* 207, 10, 56–59 (2006)
102. Gordon, R.P.E., Flin, R.H., Mearns, K., Fleming, M.T.: Assessing the Human Factors causes of accidents in the offshore oil industry. In: *Proc. of the Int. Conf. on Health, Safety, and Environment in Oil Gas Exploration and Production*, pp. 635–644 (1996)
103. Gorzalczynski, S.: Limitations of safety arrest mechanisms for mine shaft conveyances. *CIM Bull.* 95, 1065, 67–71 (2002)
104. Gupta, S., Ramkrishna, N., Battacharya, J.: Replacement and maintenance analysis of longwall shearer using fault tree technique. *Trans. Inst. Min. Metallurgy Sect. A Min. Technol.* 115, 2, 49–58 (2006)
105. Gwinnett, T.: Underground breakdown. *Colliery Guard.* July, 265–266 (1981)

106. Hall, L.: System design and equipment reliability for Wide Web Working at Hem Heath Colliery, *Min. Technol.* 64, 736, 54–57 (1982)
107. Hall, R.A., Daneshmend, L.K.: Reliability and maintainability models for mobile underground haulage equipment. *CIM Bull.* 96, 1072, 159–165 (2003)
108. Hall, R.A., Daneshmend, L.K.: Reliability modelling of surface mining equipment: data gathering and analysis methodologies. *Int. J. Surf. Min. Reclamat. Environ.* 17, 3, 139–155 (2003)
109. Hall, R.A., Daneshmend, L.K., Lipsett, M.G., Wong, J.: Reliability analysis as a tool for surface mining equipment evaluation and selection. *CIM Bull.* 93, 1044, 78–82 (2000)
110. Hartley, D., Jarvis, E.E.: Time or condition-based maintenance. *Min. Eng.* 146, 305, 506–508 (1987)
111. Hartman, H.L., Novak, T., Gregg, A.J.: Health hazards of diesel and electric vehicles in an underground coal mine. *Min. Sci. Technol.* 5, 2, 131–151 (1987)
112. Haskayne, J.D., Farmer, S.D.: The reliability problem – powered supports. *Min. Technol.* 64, 736, 84–87 (1982)
113. Heyns, F., Van Der Westhuizen, J.: A mining case study: the safe maintenance of underground railway track. *Civil Eng.* 14, 5, 8–10 (2006)
114. Heyns, F.J.: Construction and maintenance of underground railway tracks to safety standard of SANS: 0339. *J. So. Afr. Inst. Min. Metallurgy* 106, 12, 793–798 (2006)
115. Hosseini, M.: Reliability revolution. *Can. Min. J.* 120, 2, 33–35 (1999)
116. Howey, R.A., Gaarder, O.H.: Application of reliability engineering to offshore production equipment. *J. Petroleum Technol.* April, 339–346 (1977)
117. Iannacchione, A.T., et al.: Controlling roof beam failures from high horizontal stresses in underground stone mines. In: *Proc. of the 17th Int. Conf. on Ground Control in Mining*, pp. 102–112 (1998)
118. Iannacchione, A.T., et al.: Safer mine layouts for underground stone mines subjected to excessive levels of horizontal stress. *Min. Eng.* 55, April, 25–31 (2003)
119. Iannacchione, A.T., Prosser, L.J., Esterhuizen, G., Bajpayee, T.S.: Technique to Assess Hazards in Underground Stone Mines: The Roof-Fall-Risk Index (RFRI), *Min. Eng.* 59, 1, 49–57 (2007)
120. Iannacchione, A.T., Marshall, T.E., Prosser, L.J.: Failure characteristic of roof falls at an underground stone mine in southwestern Pennsylvania. In: *Proc. of the 20th Int. Conf. on Ground Control in Mining*, pp. 119–125 (2001)
121. Iverson, S., Kerkering, J.C., Coleman, P.: Using fault tree analysis to focus mine safety research. In: *Proc. of the 108th Annual Meeting of the Society for Mining, Metallurgy, and Exploration*, pp. 1–10 (2001)
122. Iyko, V.I., Ovchinnikova, L.K., Plontnikova, V.I.: A method of estimating the operational reliability of kinematic mechanized support systems. *Sov. Min. Sci.* 9, 333–335 (1974)

123. Jaeger, F.T.: Wear – is your maintenance dollar going? In: *Proceedings of the 4th Canadian Institute of Mining Mechanical/Electrical Plant Engineering and Maintenance Conference*, pp. 38–44 (1984)
124. Jain, V.K.: Developments in surface mining technology-planning, equipment maintenance and environmental management. *J. Mines Metals Fuels* 52, 11, 293–294 (2006)
125. Jardine, A.K.S., Banjevic, D., Wiseman, M., Buck, S., Joseph, T.: Optimising a mine haul truck wheel motors' condition monitoring program: use of proportional hazards modelling. *J. Qual. Mainten. Eng.* 7, 4, 286–301 (2001)
126. Jolly, S.M., Deakin, M.P.: Predictive maintenance, a practical approach. *Min. Technol.* 75, 864, 99–104 (1993)
127. Joy, J.: Use of qualitative and quantitative risk analysis techniques to control safety and other losses in underground coal mining. In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 333–335 (1991)
128. Kamenskii, M.K., Nikitina, M.A., Muratov, A.S.: Investigation of the operational reliability of grade EVT-1140V mining cables. *Sov. Electr. Eng.* 51, 12, 113–117 (1980)
129. Keran, C.M., Hendricks, P.A.: Automation and safety of mobile mining equipment. *Eng. Min. J.* 196, 2, 30–33 (1995)
130. Kielblock, A.J.: Ergonomics: A Nice-to-Have for the South African Mining Industry or Potential Time-Bomb? *J. Mine Ventilat.* 52, 3, 116–121 (1999)
131. Kincaid, R.L.: Modern mine maintenance: toolbox, blackbox, or tribo-technology? *Int. J. Surf. Min. Reclamat. Environ.* 10, 2, 47–54 (1996)
132. Kohler, J.L., Sottile, J., Trutt, F.C.: Condition-based maintenance of electrical machines. In: *Proc. of the IAS Annual Meeting*, 1, 205–211 (1999)
133. Koketayev, A.I.: Problems of safety when catastrophic failure arises at mines. In: *Proc. of the 12th Int. Symp. on Mine Planning and Equipment Selection*, p. 505 (2003)
134. Kolomiitsov, M.D., Gabov, V.V.: Dependence of the operational reliability of a cutter-loader on the magnitude and character of the load. *Sov. Min. Sci.* 13, 2, 164–167 (1977)
135. Kuklin, L.G., Boyarskikh, G.A., Semakina, T.P.: Assessing the Technological reliability of drilling equipment. *Min. J.* 5, 70–72 (1983)
136. Kulakov, V.N., Frolov, B.A.: Improving the reliability of engineering systems by introducing an effective reserve. *Sov. Min. Sci.* 11, 6, 763–766 (1975)
137. Kumar, N., Paul, B.: Planning of risk assessment and safety management in indian surface mines. *J. Mines Metals Fuels* 52, 11, 314–316 (2006)
138. Kumar, U., Granholm, S.: Some simple graphical methods for reliability analysis in mines. In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 36–41 (1991)
139. Kumar, U., Klefsjoe, B.: Reliability analysis of hydraulic systems of LHD machines using the power law process model. *Reliabil. Eng. Syst. Safety* 35, 3, 217–224 (1992)



140. Kumar, U.: Maintenance management for modern mining equipment. *J. Mines Metals Fuels* 44, 1, 25–29 (1996)
141. Kuruppu, M.: Methods and reliability of measuring winder rope degradation. In: *Proc. of the 12th Int. Symp. on Mine Planning and Equipment Selection*, 1, 261–266 (2003)
142. Kuznetsov, A.P.: Attaining statistical reliability in models of random properties of a continuous medium. *Sov. Min. Sci.* 9, 5, 573–575 (1973)
143. Kwitowski, A.J., Brautigam, A.L., Monaghan, W.D.: Teleoperated continuous mining machine for improved safety. *Min. Eng.* 47, 8, 753–759 (1995)
144. Kyriazi, N., Kovac, J., Duerr, W., Shubilla, J.: Laboratory Testing of Compressed – Oxygen Self – Rescuers for Ruggedness and Reliability, US Bureau of Mines, Report of Investigation 8839, Washington, DC (1983)
145. Lauterback, T.: Management in action: safety. *Min. Mag.* 194, 4, 28–29 (2006)
146. Lawrence, A.C.: Human error as a cause of accidents in gold mining. *J. Safety Res.* 6, 2, 78–88 (1974)
147. Leakovich, P.E., Chalenko, N.E.: Use of reliability theory to calculate the required number of reserve longwall faces. *Sov. Min. Sci.* 5, 2, 160–164 (1969)
148. Leugner, T.: Developing a total productive maintenance (TPM) programme. *Quarry Manage.* 23, 8, 21–25 (1996)
149. Lewis, M.W., Steinberg, L.: Maintenance of mobile mine equipment in the information age. *J. Qual. Mainten. Eng.* 7, 4, 264–274 (2001)
150. Liang, X.: Application of casualty diagram in fault analysis of machine equipment in coal mines. *Jisuanji Gongcheng/Comput. Eng.*, 31, 5, 204–209 (2005)
151. Lipowczan, A.: Increasing the reliability and safety of mining machines by application of the vibration diagnostic (experiences and results). In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 155–163 (1991)
152. Litton, C.D.: Improving fire detection in underground coal mines. In: *Proc. of the SME Annual Meeting*, pp. 216–226 (1986)
153. Lloyd, M.R.: Engineering testing, assessment and research for equipment safety in New South Wales coal mines. *Min. Technol.* 68, 792, 307–308 (1986)
154. Louit, D.M., Knights, P.F.: Simulation of initiatives to improve mine maintenance. *Trans. Inst. Min. Metallurgy* 110, 47–58 (2001)
155. Lysenko, V.N., Pavlovskaya, S.A.: A method for estimating the reliability of burst-prevention measures. *Sov. Min. Sci.* 14, 3, 319–320 (1978)
156. Ma, Y., Song, H., Sun, B.: Research on the reliability of mining production systems and optimal maintenance policy. In: *Proc. of the 3rd Int. Symp. on Mine Planning and Equipment Selection*, pp. 451–454 (1994)
157. Majumdar, S.K.: Study on reliability modelling of a hydraulic excavator system. *Qual. Reliabil. Eng. Int.* 11, 1, 49–63 (1995)
158. Makhinin, A.I.: The reliability and service life of the MS-50m centrifugal pit pump, *Sov. Min. Sci.* 5, 6, 719–722 (1969)

159. Marquez, A.C.: Modeling critical failures maintenance: a case study for mining. *J. Qual. Mainten. Eng.* 11, 4, 301–317 (2005)
160. Marshall, P.W.: Risk evaluation for offshore structures. *J. Struct. Div. Am. Soc. Civil Eng.* 95, ST12, 2907–2929 (1969)
161. Mason, N.S.: Monitoring the reliability of coalface equipment. *Min. Eng.* 143, 264, 105–112 (1983)
162. May, J.P., Aldinger, J.A.: Overview of bureau research directed towards surface powered haulage safety. In: *Proc. of the 26th Annual Institute on Mining Health, Safety, and Research*, pp. 121–131 (1995)
163. McIvor, R.A.: Mine shaft conveyance safety mechanism – free-fall testing. *CIM Bull.* 89, 1004, 47–50 (1996)
164. Miller, R.E., Lowe, N.T., Thompson, R.: A GPS based system for minimizing jolts to heavy equipment operators. In: *Proc. of the Society of Automotive Engineer (SAE) Commercial Vehicle Engineering Congress and Exhibition*, pp. 1–4 (2004)
165. Miller, S.M., *et al.*: Computer modelling of catch benches to mitigate rock-fall hazards in open pit mines. In: *Proc. of the 4th North American Rock Mechanics Symposium*, pp. 539–545 (2000)
166. Mohan, S., Duarte, D.: Cognitive modelling of underground miners response to accidents. In: *Proc. of the Annual Reliability and Maintainability Symposium*, pp. 51–56 (2006)
167. Moody, C.: Reliable conveyor belt design. In: *Proc. of the American Mining Congress Coal Convention*, 579–582 (1991)
168. Moore, K.: Testing and reliability. *Min. Eng.* 142, 257, 457–462 (1983)
169. Morrell, H.W.: European standards – mining machinery safety. *Min. Technol.* 74, 851, 13–14 (1992)
170. Moses, F., Stahl, B.: Reliability analysis format for offshore structures. *J. Petroleum Technol.* March, 347–354 (1979)
171. Mosinets, V.N.: Assessment of new mining technologies using the theory of reliability. *Sov. Min. Sci.* 1, 4, 335–342 (1965)
172. Mrig, G.C.: Reliability of machines and systems used in production process in mines – a case study of South Eastern Coalfields Limited, India. In: *Proc. of the Int. Conf. on Reliability, Production, and Control in Coal Mines*, pp. 104–110 (1991)
173. Mukherjee, P.S.: Analysis of lubricant use in mining equipment – a tool for maintenance management. *Ind. Lubricat. Tribol.* 53, 6, 256–260 (2001)
174. Mukhopadhyay, A.K.: Open pit system reliability. *J. Mines Metals Fuels* 36, 8, 389–392 (1988)
175. Muller, C., Scharmach, M., Gaal, M., Guelle, A., Lewis, D., Sieber, A.: Performance demonstration for humanitarian demining Q – test and evaluation of mine searching equipment in detecting mines. *Mater. Test.* 45, 11, 504–512 (2003)
176. Muller, D., Uhelmann, S.: Open-cast mine optimization: maintenance. *World Min. Surf. Underground* 59, 2, 106–109 (2007)

177. Nollet, G., Prince, D.: Rotating equipment reliability for surface operation. Part II: Oil analysis in a mine. *CIM Bull.* 96, 1067, 82–86 (2003)
178. Nollet, G., Prince, D.: Rotating equipment reliability for surface operation. Part I: Vibration analysis for rotating equipment. *CIM Bull.* 95, 1065, 72–77 (2002)
179. Nussey, C.: The use of systematic reliability assessment techniques for the evaluation and design of mining electronic systems. *J. Occupat. Accidents* 7, 1–16 (April 1985)
180. Pal, B.K., Maiti, J.: Lean maintenance – concept, procedure, and usefulness. *J. Mines Metals Fuels* 52, 11, 318–321 (2006)
181. Paraszczak, J.: Failure and downtime reporting – a key to improve mine equipment performance. *CIM Bull.* 93, 1044, 73–77 (2000)
182. Paraszczak, J., Kallio, P., Honkanen, J.: Setting reliability standards for underground mining equipment. *CIM Bull.* 91, 1024, 74–79 (1998)
183. Passlow, G.: Vibration: more than a pain in backside: *Austral. Min.* 97, 10, 30 (2005)
184. Patton, P.W., Stewart, B.M., Clark, C.C.: Reducing materials handling injuries in underground mines. In: *Proc. of the 32nd Institute on Mining Health, Safety, and Research*, Salt Lake City, UT, 5–7 Aug., 1–14 (2001)
185. Petrov, N.N., Ponomarev, P.T.: Reliability of the main fan units in automatically controlled pit ventilation systems. *Sov. Min. Sci.* 6, 2, 175–179 (1970)
186. Pontt, J., *et al.*: Resonance mitigation and dynamical behavior of systems with harmonic filters for improving reliability in mining plants. In: *Proc. of the 41st IEEE Industry Applications Conference*, pp. 5–10 (2006)
187. Pontt, J., Rodriguez, J., Dixon, J.: Safety, reliability, and economics in mining systems. In: *Proc. of the 41st IEEE Industry Applications Conf.*, 1–5 (2006)
188. Prasad, P.V.N., Rao, K.R.M.: Reliability models of repairable systems considering the effect of operating conditions. In: *Proc. of the Annual Reliability and Maintainability Symposium*, pp. 503–510 (2002)
189. Rahaman, M.T., Banerjee, G., Singh, V.K., Dey, N.C.: Risk assessment and prediction of roof fall of indian coal mines using seismic monitoring systems. *Indian Min. Eng. J.* April, 23–27 (2004)
190. Raju, P.G.: Longwall mining experiences at GDK No.11A mine – planned equipment salvage with particular reference to roof and side fall accidents. *J. Mines Metals Fuels* 46, 2, 92–100 (1998)
191. Ramani, R.V., Bhattacharjee, A., Pawlikowski, R.J.: Reliability, maintainability and availability analysis of longwall mining systems. In: *Proc. of the SME Annual Meeting*, pp. 1–12 (1988)
192. Randolph, R.F., Boldt, C.M.K.: Safety analysis of surface haulage accidents. In: *Proc. of the 27th Annual Institute on Mining Health, Safety, and Research*, 29–38 (1996)
193. Rugbinshtein, B.S.: Some aspects of the reliability of mining equipment. *Sov. Min. Sci.* 11, 4, 349–352 (1975)

194. Ruiz, S.E.: Reliability index for offshore pipes subjected to bending. *Struct. Safety* 2, 83–90 (1984)
195. Rushworth, A.M.: Reducing accident potential by improving the ergonomics and safety of locomotive and FSV driver cabs by retrofit. *Min. Technol.* 78, 898, 153–159 (1996)
196. Sacks, H.K., Cawley, J.C., Homce, G.T., Yenchek, M.R.: Feasibility study to reduce injuries and fatalities caused by contact of cranes, drill rigs, and haul trucks with high-tension lines. *IEEE Trans. Ind. Appl.* 37, 3, 914–919 (2001)
197. Samanta, B.M.S.K.: Reliability centred maintenance (RCM) for heavy earth-moving machinery in an open cast coal mine. *CIM Bull.* 94, 1056, 104–108 (2001)
198. Sammarco, J.J.: Addressing the safety of programmable electronic mining systems: lessons learned. In: *Proc. of the IEEE 37th Industry Applications Society Annual Meeting*, 692–698 (2003)
199. Schoolderman, A.J.: Detection performance assessment of hand-held mine detection systems in a procurement process: test set-up for MDs and MD/GPRs. In: *Proc. of the SPIE Conf. on Detection and Remediation Technologies for Mines and Minelike Targets X*, pp. 912–918 (2005)
200. Schoolderman, A.J., Roosenboom, J.H.J.: Detection performance assessment of hand-held mine detection systems in a procurement process: test set-up for MDs and MD/GPRs. *Proc. SPIE* 5794, 912–918 (2005)
201. Schroeder, C.: Reliability of main fans in coal mines. *Glueckauf Translat.* 122, 20, 367–370 (1986)
202. Scott, A.: Killing off errors. *Mine Quarry* 24, 9, 14–18 (1995)
203. Seal, A.B., Bise, C.J.: Case study using task-based, noise-exposure assessment methods to evaluate miner noise hazard. *Min. Eng.* 54, 11, 44–48 (2002)
204. Shpiganovich, A.N., Maslovskaya, T.N.: Effect of the reliability of electrical equipment on the parameters of sectional bulk transport and the performance of mining machinery. *Sov. Min. Sci.* 21, 6, 503–506 (1982)
205. Simpson, G.C.: Promoting Safety Improvements via Potential Human Error Audits, *Min. Eng.* 154, 395, 38–42 (1994)
206. Singh, B.P., Tiwari, S.K.: Application of reliability and availability to underground mine transport. *Indian J. Mines Metals Fuels* Jan–Feb., 23–30 (1984)
207. Smith, A.: Exploding the myth of condition monitoring and preventative maintenance. *Min. Technol.* 75, 864, 105–111 (1993)
208. Soldatov, A.N.: Reliability of blasting equipment. *Sov. Min. Sci.* 5, 5, 518–523 (1969)
209. Sottile, J.J., Holloway, L.E.: Overview of fault monitoring and diagnosis in mining equipment. *IEEE Trans. Ind. Appl.* 30, 5, 1326–1332 (1994)
210. Sottile, J.J., Kohler, J.L.: On-line method to detect incipient failure of turn insulation in random-wound motors. *IEEE Trans. Energy Convers.* 8, 4, 762–768 (1993)
211. Spanton, H.M., Belloch, J.D.: Reliability of machines and machine systems. *Colliery Guard. Annu. Rev.* August, 495–503 (1977)

212. Steele, J.P.H., Archuleta, M., Brown, G.D., Drouillard, T., Schlieff, D., Seifert, T.D.: Intelligent on-line monitoring of machine health for robots in critical environments. In: *Proc. of the 2nd Speciality Conference on Robotics for Challenging Environments*, pp. 262–275 (1996)
213. Stewart, B., Iverson, S., Beus, M.: Safety considerations for transport of ore and waste in underground ore passes. *Min. Eng.* 51, 3, 53–60 (1999)
214. Tait, R.B., Emsile, C.: The use of fracture mechanics in failure analysis in the offshore diamond mining industry. *Eng. Failure Anal.* 12, 6, 893–905 (2005)
215. Tan, Z., Cai, M., Yue, Z., Tham, L.G., Lee, C.F.: Application and reliability analysis of DPM system in site investigation of HK weathered granite. *J. Univers. Sci. Technol. Beijing Mineral Metallurgy Mater.* 12, 6, 481–488 (2005)
216. Thompson, R.J., Visser, A.T.: Mine haul road maintenance management systems. *J. So. Afr. Inst. Min. Metallurgy* June, 303–312 (2003)
217. Tien, J.C.: Health and safety challenges for China’s mining industry. *Min. Eng.* 57, 4, 15–23 (2005)
218. Tomlinsong, P.D.: Conducting mobile equipment maintenance. *Coal* 99, 11, 40–42 (1994)
219. Tomlinsong, P.D.: Achieving world class maintenance status. *Min. Eng.* 58, 11, 30–33 (2006)
220. Tregelles, P.G., Worthington, B.: Reliability assessment as an aid to the development of mining equipment. *Min. Eng.* 142, 251, 95–102 (1982)
221. Turcic, P.M.: Health and safety implications of the use of diesel-powered equipment in underground coal mines. In: *Proc. of the 3rd Mine Ventilation Symposium*, p. 390 (1987)
222. Ursenbach, A., Wang, Q., Rao, M., Coward, J., Lamb, D.K.: Intelligent maintenance support system for mining truck conditioning monitoring and troubleshooting. *Int. J. Surf. Min. Reclamat. Environ.* 8, 2, 73–81 (1994)
223. Vagenas, N., Kazakidis, V., Scoble, M., Espley, S.: Applying a maintenance methodology for excavation reliability. *Int. J. Surf. Min. Reclamat. Environ.* 17, 1, 4–19 (2003)
224. Vagenas, N., Nuziale, T.: Genetic algorithms for reliability assessment of mining equipment. *J. Qual. Mainten. Eng.* 7, 4, 302–311 (2001)
225. Vagenas, N., Runciman, N., Clement, S.R.: Methodology for maintenance analysis of mining equipment. *Int. J. Surf. Min. Reclamat. Environ.* 11, 1, 33–40 (1997)
226. Van Wijk, J., Latilla, J., Wevell, E., Neal, D.: Development of a risk rating system for use in underground coal mining. In: *Proc. of the 21st Int. Conf. on Ground Control in Mining*, pp. 310–313 (2002)
227. Vanmarcke, E.H., Angelides, D.: Risk assessment for offshore structures: a review. *J. Struct. Eng.* 109, 2, 555–571 (1983)
228. Vayenas, N., Yuriy, G.: GenRel – a computer model for prediction of mining equipment failures based on genetic algorithms (GAs). *Int. J. Surf. Min. Reclamat. Environ.* 19, 1, 3–11 (2005)

229. Vayenas, N., Yuriy, G.: Using GenRel for reliability assessment of mining equipment. *J. Qual. Mainten. Eng.* 13, 1, 67–74 (2007)
230. Veskov, M.I.: Estimating the reliability of new methods of coal cutting. *Sov. Min. Sci.* 3, May–June, 196–199 (1965)
231. Vinnem, J.E.: Quantitative risk analysis in the design of offshore installations. *Reliabil. Eng.* 6, 1–12 (1983)
232. Walker, A.J.: Engineering reliability into AFCS. *Min. Technol.* 64, 736, 88–91 (1982)
233. Wang, Y., Lu, G.: Analysis and definition of devices' availability and operation ratio in coal-mining systems. In: *Proc. of the Mining Science and Safety Technology Conference*, pp. 83–89 (2002)
234. Wei, F., ZhangLi, B., Yu, G.: ON microcomputer monitoring system for examining reliability of fully mechanised mining equipment. In: *Proc. of the 19th Int. Symp. on Application of Computers and Operation Research in Minerals*, pp. 848–854 (1986)
235. Whyatt, J., Miller, S., Dwyer, J.G.: NIOSH computer programs for bench crest failure analysis in fractured rock. In: *Proc. of the 32nd Int. Conf. on the Application of Computers and Operations Research in the Mineral Industry*, pp. 439–446 (2005)
236. Wilkie, J.F.: Care and reliability of rotating mining equipment. *Min. Technol.* 56, 639, 18–19, 22–23 (1974)
237. Wilson, E.B.: Reliability engineering and replacement theory – aids to maintenance decisions. *Can. Inst. Min. Bull.* 463–471 (1970)
238. Winkelmann, C.A., Craig, A., Kissel, A.M., Nutter, R.S.: Microprocessor self-testing for mine monitor systems. *IEEE Trans. Ind. Appl.* 1A–21, 1, 158–161 (1985)
239. Wirsching, P.H.: Fatigue reliability for offshore structures. *J. Struct. Eng.* 110, 10, 2340–2356 (1984)
240. Wirsching, P.H., Stahl, B., Nolte, K.G.: Probabilistic fatigue design for ocean structures. *J. Struct. Div. Am. Soc. Civil Eng.* 103, ST10, 2049–2062 (1977)
241. Wood, J.: Explosive equipment. *Electr. World* July, 22–23 (2001)
242. Worthington, B.: Reliability assessment of mining electronic systems. *Min. Eng.* 144, 277, 233–236 (1984)
243. Yamshchikov, V.S., Blok, A.V.: Information parameters and estimates of the reliability of geomonitoring of the state of the rocks. *Sov. Min. Sci.* 12, 1, 114–117 (1976)
244. Zel'vyanskii, A. Sh., Kaufman, L.L., Miroshnikov, S.I.: A method of sequential optimization of the distribution of reliability indices among the components of the transport network of a mine. *Sov. Min. Sci.* 5, 532–536 (1976)
245. Zeng, W.: Exploration for human factors in the design of coal-mine safety and rescue devices. In: *Proc. of the 7th Int. Conf. on Computer-Aided Industrial Design and Conceptual Design*, pp. 3–4 (2006)
246. Zhang, L., Luo, S., Chen, W.: The reliability analysis of the NONEL Detonating system in open-pit. In: *Proc. of the 3rd Int. Symp. on Mine Planning*, pp. 727–733 (1994)

247. Zhang, R.X., *et al.*: Surface mine system simulation and safety risk management. *J. China Univ. Min. Technol.* 16, 4, 413–415 (2006)
248. Zhitkov, E.F.: Use of the theory of random functions to assess the reliability of roof control by smooth caving onto yielding chain pillars. *Sov. Min. Sci.* 8, 1, 63–65 (1972)

# Author Biography

Dr. B.S. Dhillon is a professor of engineering management in the Department of Mechanical Engineering at the University of Ottawa. He has served as chairman/director of the Mechanical Engineering Department/Engineering Management Program for over 10 years at the same institution. He has published over 335 (i.e., 195 journal + 140 conference proceedings) articles on reliability, maintainability, safety, engineering management, etc. He is or has been on the editorial boards of nine international scientific journals. In addition, Dr. Dhillon has written 33 books on various aspects of reliability, maintainability, design, safety, quality, and engineering management published by Wiley (1981), Van Nostrand (1982), Butterworth (1983), Marcel Dekker (1984), Pergamon (1986), etc. His books are being used in over 75 countries, and many have been translated into languages such as German, Russian, and Chinese. In 1987, he served as general chairman of two international conferences on reliability and quality control held in Los Angeles and Paris.

Professor Dhillon has served as a consultant to various organizations and bodies and has many years of experience in the industrial sector. At the University of Ottawa, he has been teaching reliability, quality, engineering management, design, and related areas for over 28 years and has also lectured in over 50 countries, including keynote addresses at various international scientific conferences held in North America, Europe, Asia, and Africa. In March 2004, Dr. Dhillon was a distinguished speaker at the Conference/Workshop on Surgical Errors (sponsored by the White House Health and Safety Committee and the Pentagon) held on Capitol Hill (One Constitution Avenue, Washington, D.C.).

Professor Dhillon attended the University of Wales, where he received a B.S. in electrical and electronic engineering and an M.S. in mechanical engineering. He received a Ph.D. in industrial engineering from the University of Windsor.



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