



Exponent[®]
Engineering & Scientific Consulting

Steve Murray, Ph.D., P.E.

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Professional Profile

Dr. Murray's areas of expertise include failure analysis of electrical and mechanical systems, metallurgy, and the mechanical and electrical properties of materials. Technically, Dr. Murray specializes in the areas of electronics, magnetism, and magnetic materials. From his more than twenty-year's experience in product safety and quality, Dr. Murray also advises companies on their product integrity organizations and other aspects of their business.

Dr. Murray provides data science, electrical and materials consulting services to a variety of industries. Engineering systems investigated include appliances, computers and consumer electronics, medical electronics, and large electrical generators and motors. These investigations have involved risk assessment, understanding of complex electrical and electronic systems, fracture and fractography, environmental effects, electrical and magnetic modeling, and materials defects. Dr. Murray has also conducted multiple investigations related to potential product recalls and applies statistical methods to reach solutions for difficult failure problems in large populations of products.

Dr. Murray held an appointment as a Consulting Assistant Professor in the School of Engineering at Stanford University where he taught the course *Techniques of Failure Analysis* from 2006-2015.

Academic Credentials & Professional Honors

Ph.D., Electronic Materials, Massachusetts Institute of Technology (MIT), 2000

B.S., Materials Science and Mineral Engineering, University of California, Berkeley, 1996

ASM Undergraduate Award, 1996

Drake Scholar, University of California at Berkeley, 1992 - 1996

Chancellor's Scholar, University of California at Berkeley, 1992 - 1996

Academic Appointments

Consulting Assistant Professor Stanford University, Department of Aeronautics and Astronautics, appointed yearly from January to June, 2006-2015

Prior Experience

Senior Engineer, Mide Technology Corporation, 2000 - 2001

Student Researcher, LORD Corporation, 1998

Student Researcher, Lawrence Berkeley National Laboratory, 1994 - 1996

Professional Affiliations

American Society of Mechanical Engineers

American Society for Metals

Institute of Electrical and Electronics Engineers

Board Member, Berkeley Engineering Fund (2007-2009)

Member of the Advisory Board for the Department of Materials Science and Engineering at the University of California at Berkeley (2015-)

Publications

Nguyen, N, "Prep Your Tech for Power Outages and Other Emergencies," Wall Street Journal, September 2020.

Donahoe D, Zha K, Murray SJ, Ray R. Accelerated life testing. In: Encyclopedia of Quantitative Risk Assessment. Everitt B and Melnick E (eds), Wiley, in press.

Edmonds J, Daneshpooy A, Murray SJ, Sire R. Turbogenerator stator core study. Proceedings, IEEE Symposium for Electrical Machines, Power Electronics & Drives, Cracow, Poland, in press.

Murray SJ, Ray R, Grossman H. Using Weibull analysis for cases with an unknown susceptible population. Proceedings, IMECE2007, Seattle, WA, 2007.

Kemal A, Mattison D, Murray SJ, Loose M. Degradation and ignition of polyvinyl chloride wire insulation. Proceeding, Fire and Materials, San Francisco, CA, 2007.

Ray RM, Grossman H, Murray SJ, Lange R. Evaluation of passenger vehicle crashworthiness using field performance data. Proceedings, IMECE2006, Chicago, IL, 2006.

Murray SJ, Loud J, Caligiuri RD. Failure modes in Calrod-type heaters used in home appliances. Proceedings, International Appliance Technology Conference, Chicago, IL, 2006.

Loud J, Murray SJ, Ray RM, Iyer M, Jackson O. Shock injury risk assessment of portable and handheld appliances and use environments. Proceedings, International Appliance Technology Conference, Chicago, IL, 2006.

James BA, Wood L, Murray SJ, Eiselstein LE, Foulds JR. Compressive damage-induced cracking in nitinol. Proceedings, International Conference on Shape Memory and Superelastic Technologies, 2004.

Murray SJ. Ferromagnetic shape memory alloys, principals and applications. Proceedings, International Conference on Shape Memory and Superelastic Technologies, 2004.

Murray SJ, Edmonds J, Foulds JR, Sire RA, Chi W-M. Modeling fault propagation in an electric generator stator core. Proceedings, 8th EPRI Steam Turbine-Generator Workshop and Vendor Exposition, 2003.

James BA, Murray SJ, Saint S. Fracture characterization in nickel titanium alloys. Proceedings, International Conference on Shape Memory and Superelastic Technologies, pp. 321-330, 2003.

Murray SJ, Marioni M, Tello PG, Allen SM, O'Handley RC. Giant magnetic-field-induced strain in Ni-Mn-Ga crystals: Experimental results and modeling. *Magnet Magnetic Mat* 2001; 226-230:945-947.

Murray SJ, O'Handley RC, Allen SM. Model for discontinuous actuation of ferromagnetic shape memory alloy under stress. *Appl Phys* 2001; 89(2):1295-1301, January 15.

Murray SJ, Marioni M, Allen SM, O'Handley RC, Lograsso TA. 6% magnetic-field-induced strain by twin-boundary motion in ferromagnetic Ni-Mn-Ga. *Appl Phys Lett* 2000; 77:886-888.

Murray SJ, Marioni M, Kulka AM, Robinson J, O'Handley RC, Allen SM. Large, field-induced strain in single crystal NiMnGa ferromagnetic shape memory alloys. *Appl Phys* 2000; 87:5744.

Hayashi R, Murray SJ, O'Handley RC, Allen SM. Magnetic and mechanical properties of Fe-Ni-Co-Ti magnetic shape memory alloy. *Sensor Actuator A*, 2000; 81:219-223.

Murray SJ. Magneto-mechanical properties and applications of Ni-Mn-Ga ferromagnetic shape memory alloy. Doctoral Dissertation, Massachusetts Institute of Technology, 2000.

Murray SJ, O'Handley RC, Allen SM. Modeling and experiments for deformation under load in Ni-Mn-Ga ferromagnetic shape memory alloy. *Proceedings, MRS*, Vol. 604, pp. 279-284, 2000.

Murray SJ, O'Handley RC, Marioni M, Nembach H, Allen SM. Phenomenology of giant magnetic-field induced strain in ferromagnetic shape memory materials. *Appl Phys* 2000; 87:4712.

Murray SJ, Hayashi R, Marioni M, Allen SM, O'Handley RC. Magnetic and mechanical properties of FeNiCoTi and NiMnGa magnetic shape memory alloys. *SPIE Smart Materials Technologies* 1999; 3675.

Murray SJ, Marioni M, Huang JK, O'Handley RC, Allen SM. Field-induced strain under load in Ni-Mn-Ga magnetic shape memory materials," *Appl Phys* 1998; 83:7297.

Published Report

Murray SJ, Foulds JR, Spisak A. Generator core overheating risk assessment, J.T. Deely core investigation. Electric Power Research Institute, TR-1008738, Palo Alto, CA, September 2003.

Presentations

Murray SJ, Enabling Digital Transformation A Cross-Industry Perspective, DIA 2022 Chicago, IL

Murray SJ, What is a Tolerable Risk? DIA Pharmacovigilance and Risk Management Strategies Conference, January 2020.

Murray SJ. Design for reliability and safety with thermal limit devices. IEEE Product Safety Engineering Society Conference, Longmont, CO, October 2007.

Murray SJ. Failure analysis in materials science. University of California at Berkeley, Department of Materials Science and Mineral Engineering, October 2007.

Murray SJ. Careers in engineering research and failure analysis. Milpitas High School, March 2007.

Murray SJ. Accelerated stress testing for home appliances. IEEE ASTR Conference, San Francisco, CA,

October 2006.

Murray SJ. Consumer product failure investigations. International Bar Association Conference, Chicago, IL, 2006.

Murray SJ. Product defect investigations. Farella, Braun + Martel, LLP, San Francisco, CA, March 2005.

Murray SJ. Ferromagnetic shape memory alloys, principals and applications. Shape Memory and Superelastic Technologies Conference, Baden-Baden, Germany, October 2004.

Murray SJ. Failure investigations and quality processes in engineering. NASA Ames, Mountain View, CA, December 2003.

Murray SJ. Engineering in litigation: how engineering knowledge and experience becomes evidence in the courtroom. ASM/NACE Joint Meeting, Oakland, CA, November 2003.

Murray SJ. Product defect investigations. Claims Conference of Northern California, Sacramento, CA, September 2003.

Murray SJ. Fracture characterization in superelastic nitinol. Lawrence Berkeley National Laboratory, Berkeley, CA, April 2003.

Murray SJ. Magneto-mechanical performance and mechanical properties of Ni-Mn-Ga ferromagnetic shape memory alloys. SPIE Conference on Smart Materials and Structures in Newport Beach, CA, March 2000.

Murray SJ. Magnetic shape memory. Invited seminar for the Materials Processing Center at MIT's Materials Unlimited Seminar Series, Boston, MA, May 1999.

Murray SJ. Magnetic and mechanical properties of FeNiCoTi and NiMnGa magnetic shape memory alloys. SPIE Conference on Smart Materials and Structures in Newport Beach, CA, March 1999.

Murray SJ. Modeling and experiments for deformation under load in Ni-Mn-Ga ferromagnetic shape memory alloy. Fall Meeting of the Materials Research Society, Boston, MA, November 1999.

Murray SJ. Large field induced strain in single crystalline Ni-Mn-Ga ferromagnetic shape memory alloy. Magnetics and Magnetic Materials Conference, San Jose, CA, December 1999.

Murray SJ. Magnetic shape memory alloy. Presentations on continuing research given to the Board of Directors of Lord Corporation on three occasions, January 1998, July 1998, and January 1999.

Murray SJ. Magnetic and mechanical properties of Fe-Ni-Co-Ti shape memory alloy. 2nd European Magnetic Sensors and Actuators Conference, Sheffield, England, July 1998.

Murray SJ. The shape memory effect. Midé Technology Corporation, Cambridge, MA, October 1997.

Selected Technical Reports

Murray SJ. Report on Thermonorte STG failure in Porto Velho, Brazil. Exponent Failure Analysis Associates, Inc., January 2005.

Murray SJ. Investigation of El Dorado fan blade fracture. Exponent Failure Analysis Associates, Inc., September 2004.

Murray SJ, Foulds JR. Examination and aging study of Deely generator laminations. Exponent Failure Analysis Associates, Inc., February 2003.

Murray SJ, Hopkins S, Duffner D. Supplemental report on applied materials Centura [shipment] damage. Exponent Failure Analysis Associates, Inc., December.

Murray SJ, Hopkins S, Duffner D. Analysis of [shipment] damage to an applied materials Centura tool. Exponent Failure Analysis Associates, Inc., November.

Murray SJ. Investigation of corrosion failure of Cal-Prop copper laterals. Exponent Failure Analysis Associates, Inc., May 2002.

Murray SJ. Investigation of heat exchangers 100 and 301 at Merck's Flint River Plant. Exponent Failure Analysis Associates, Inc., March 2002.

Murray SJ. Investigation of the Collapse of the Derrick Barge Lili Bisso. Exponent Failure Analysis Associates, Inc., November 2001 (with R.D. Caligiuri).

Murray SJ, James B. Metallurgical investigation of Equilon Tracy kickoff valve failure. Exponent Failure Analysis Associates, Inc., July 2001.

Murray SJ, James B. Evaluation of pitting and cracking in Sonoma Cutrer hot water storage tank. Exponent Failure Analysis Associates, Inc., July 2001.

Project Experience

General Failure Analysis

Copper Lateral Failure - Investigated corrosion and construction of copper laterals that led to multiple underground failures at a home development in Northern California. Evaluated and modeled the progression of pitting corrosion, as well as the effect of geometric anomalies in the pipes themselves.

Solar Panel Failure Analysis – Investigated the failure mode of a large population of solar panels and modeled the possible progression of electrical failures of the panels over time. Also investigated panel delamination failures, and electrical failures in the panels.

Copper Wire Arcing - Assessed evidence related to melted copper wiring to understand if it could be concluded that a branch circuit was energized at the time when a fire attacked the area. This exam involved electron and optical microscopy to characterize the damage.

Heart Monitor Investigation - Investigated a heart monitor and catheter used during surgery. This involved extensive software and hardware review. Modeling and recreating the monitor software to understand its role and possible connector errors it could have during an incident.

Inverter Failure Analysis – inspected and understood component failures and overheating in micro-inverters and large-scale inverters for solar power applications.

Drag Magnet Assessment – Performed modeling and testing of drag magnets used to scour horse paddocks for nails after an equine injury. Efforts included understanding the relationship between the speed at which the grounds were dragged and the effectiveness the magnets had at picking up nails.

Post Stress Tendon Analysis – Examined a failed post stress tendon from a commercial building. The issues in the failure involved corrosion protection, fractography, and the construction history at the site.

Humidifier Injury Investigation - Investigated an injury due to hot water burn allegedly from a humidifier. Was asked to opine on the feasibility of alternate designs for the electrical cord, and how they might have

affected the incident.

Evaluating and testing of security magnetometers at airports in relation to a major terrorist attack. Theoretical and practical testing of magnetometers to understand their technical performance limits, and compared those limits to how they were actually used at the time of the incident.

Consumer Products and Electronics

Oil Filled Heater Fire Investigation – Investigated what role an oil filled heater may have played, if any, in a fire inside a mobile home. Evidence examination included cal-rod heaters, electrical cords, and multiple control switches and electronics.

Evaluated solid state switches used in refrigeration in relation to their failure and potential safety effects. This investigation involved complex electrical re-creation of arcing events, chemical degradation testing, reliability modeling and understanding of oxide growth phenomena in aluminum and nickel.

Investigated safety incidents related to cal-rod heater failures in dishwashers after service. These heaters involved positive temperature coefficient heating wires that reduced power at high temperature. The investigation included thermal modeling, chemical interaction modeling, and understanding of corrosion mechanisms in high-temperature alloys.

Investigation of a dishwasher involved in a home fire to understand its contribution, if any, to the incident. The investigation involved inspection of evidence for signs of arc damage or other damage that may have led to ignition.

Engineering investigation of a wildfire and how the role of an overheated power line connector may have played. This investigation involved arc damage assessments, recreation of the event timeline and electrical parameters, and physical inspection of incident evidence. Construction codes for power lines were also evaluated.

Engineering evaluation of coffee makers with regard to multiple modes of failure that caused a higher-than-normal rate of field return for quality and safety issues. This highly-complex coffee maker involved heaters, electronics, wireless communication, food handling, and thermal controls. Incident and exemplar information was examined, along with field return records, to develop a comprehensive understanding of failure modes and why they may be occurring.

Leading investigation of thousands of failed displays for various electronics such as computers, phones, watches and tablets. These investigations determine the origin of the fracture, stress at fracture and any contributing factors. Electron microscopy, chemical analysis, and focused-ion-beam sectioning are routinely used in these investigations.

Wildfires

Investigation of electric power lines at two separate sites involved in a major wildfire. This involved both copper and aluminum high-voltage transmission lines. The evaluation focused on arc-damage to the lines, mapping such damage, and thermos-mechanical modeling to understand the proficiency of any arc debris to ignite materials on the ground.

Investigation of a downed power line, and the role it played, if any, in a wildfire in the same location. This investigation involved evaluation of construction standards and codes for distribution lines and wind dampers, as well as an investigation of the site.

Investigation of an electric utility pole and equipment with regard to a wildfire in the surrounding area. The investigation focused on the role that pole-top equipment may have played in the initial ignition of the fire. Evaluations included arc-damage assessments, optical and electron microscopy of fractures, and

mechanical evaluation of pole-top equipment.