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Troy A. Hayes, Ph.D., P.E. **Principal Engineer**

Professional Profile

Dr. Troy A. Hayes is a Principal Engineer in Exponent's Materials and Corrosion practice. He is currently the General Manager of Exponent Science and Technology Consulting (Hangzhou) Co. (Exponent China), which is a subsidiary of Exponent Inc. Dr. Hayes has extensive experience solving complex technical problems in a variety of industries including consumer products, medical devices, vehicles, industrial equipment, and technology product development. He conducts technology due diligence reviews of emerging technologies and intellectual property (IP) for investment firms, IP owners, and companies interested in purchasing IP or the associated products.

Dr. Hayes' consumer product work includes design reviews, targeted testing of new products before they are introduced into the marketplace, management of product and process changes during the course of production, use of risk methodologies, substantiation of product performance claims, failure analysis of field-returned products, consumer product recall-related investigations, and product liability. He often works with companies addressing the technical aspects of consumer product recalls.

He routinely performs failure analysis investigations on both commercial and industrial products, and addresses issues related to the mechanical behavior and degradation of materials including metal, polymer, and glass components. He has expertise in the areas of materials characterization, fatigue, fracture, and creep.

Dr. Hayes conducts engineering audits for processes such as battery cell manufacturing and battery pack assembly, consumer electronics assembly, printed circuit board assembly (PCBA), chemical etching, injection molding, and metal casting and forming. The focus of such audits is to improve the quality, reliability, and safety of the products and minimize reject rates through a detailed evaluation of the equipment, processes, and quality control in the factory.

Dr. Hayes works extensively on projects involving battery design, manufacturing, and failure analysis. In addition to performing root cause analyses of portable consumer products involving battery failures, he has conducted more than 30 on-site audits of battery manufacturers. He assists clients by conducting design reviews of batteries and battery packs to evaluate the potential for safety issues or field failures. Dr. Hayes also helps many clients evaluate and choose vendors that can produce batteries with the quality and safety that the client requires.

Dr. Hayes has performed accident reconstruction for automobile, tractor-trailer, heavy equipment, elevator, train, motorcycle, and bicycle accidents. He has performed numerous investigations of industrial accidents including evaluations of the proper use and effectiveness of personal protective equipment (PPE).

Before joining Exponent, Dr. Hayes served as a Senior Scientist with The Institute of Risk & Safety Analyses in Woodland Hills, California. He has successfully qualified and testified as an expert in trials, depositions, and arbitrations in California and Nevada.

Academic Credentials and Professional Honors

Ph.D., Materials Science and Engineering, University of California, San Diego, 2004
M.S., Materials Science and Engineering, Oregon State University, 1996
B.S., Mechanical Engineering, Oregon State University, 1995

Licenses and Certifications

Registered Professional Metallurgical Engineer, California, #MT1938
ISO 9001:2000 Lead Auditor

Languages

English, Chinese (Mandarin)

Publications

Hayes T, Mikolajczak C, Megerle M, Wu M, Gupta S, Halleck P. Use of CT scanning for defect detection in lithium-ion batteries. *Battery Power*, March/April 2011, V15-2:14–17.

Hayes TA, Mikolajczak C, Horn Q. Key manufacturing practices to achieve high quality cells. *Proceedings, 27th International Battery Seminar & Exhibit for Primary & Secondary Batteries, Small Fuel Cells, and Other Technologies*, Ft. Lauderdale, FL, March 15–18, 2010.

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Mikolajczak C, Harmon J, Hayes T, Megerle M, White K, Horn Q, Wu M. Li-ion battery cell failure analysis: The significance of surviving features on copper current collectors in cells that have experienced thermal runaway. *Proceedings, 25th International Battery Seminar & Exhibit*

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Mikolajczak CJ, Hayes TA, Megerle MV, Wu M. A scientific methodology for investigation of a lithium ion battery failure. IEEE Portable 2007 International Conference on Portable Information Devices, IEEE No. 1-4244-1039-8/07, Orlando, FL, March 2007.

Mergele MV, Hayes TA, Horn W. Methodologies of identifying root causes of failures in lithium ion battery packs. Proceedings, 24th International Battery Seminar & Exhibit for Primary & Secondary Batteries, Small Fuel Cells, and Other Technologies, Ft. Lauderdale, FL, March 19, 2007.

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Kassner ME, Hayes TA. Creep cavitation in metals. Int J Plasticity 2003; 19:1715–1748.

Barrabes S, Daraio C, Kassner ME, Hayes TA, Wang MZ. Dynamic restoration mechanisms and discontinuous dynamic recrystallization in α -Zirconium. pp. 825–839. In: Light Metals. Lewis T (ed), Canadian Inst. of Mining, Metallurgy and Petrol. Engineers, Montreal, 2002.

Hayes TA, Kassner ME, Rosen RS. Steady state creep of α -Zirconium at temperatures up to 850°C. Metall Mater Trans 2002; 33A:337–343.

Hayes TA, Rosen RS, Kassner ME, Vecchio KS. Analysis of dry storage temperature limits for zircaloy-clad spent nuclear fuel based on diffusion-controlled cavity growth. Proceedings, Scientific Basis for Nuclear Waste Management XXIII, Boston, MA, Materials Research Society, Vol. 608, pp. 23–28, 2000.

Kassner ME, Hayes TA. Subgrain strengthening revisited II. Proceedings, Deformation Processing and Properties of Structural Materials, Honorary Symposium for Professor Oleg D. Sherby (invited paper), TMS, Warrendale, PA, pp. 121–130, 2000.

Hayes TA, Rosen RS. Steady state creep of zirconium at high and intermediate temperatures. Proceedings, 8th Int'l Symposium on Plasticity and its Current Applications, Plastic and Viscoplastic Response of Materials and Metal Forming, Neat Press, 2000, pp. 342–344, Whistler, Canada, July 16–20, 1999.

Rosen RS, Hayes TA. Modeling creep rupture of zirconium alloys. Proceedings, 8th Int'l Symposium on Plasticity and its Current Applications, Plastic and Viscoplastic Response of Materials and Metal Forming, Neat Press, 2000, pp. 369–371, Whistler, Canada, July 16–20, 1999.

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Hayes TA, Kassner ME. Elastic constants, hardness and wear, intrinsic stress and thermal expansion coefficients in a-Si and Si:H. pp. 356–372. In: Properties of Amorphous Silicon and Its Alloys. T.M. Searle (ed), Inst. Electrical Engineers INSPE, Stoneridge, Herts, UK, 1998.

Hayes TA, Kassner ME, Rosen RS, Amick DA. Thermal stability of surface deformed zirconium. J Nuc Mater 1997; 246:60–69.

Hayes TA. Thermal stability of surface treated zirconium. Masters Thesis, Oregon State University, 137 pp, 1996.

Bergsm SC, Kassner ME, Li X, Delos-Reyes MA, Hayes TA. The optimized properties of the new aluminum alloy 6069. J Eng Mater Perf 1996; 5:111–116.

Book Chapters

Horn Q, Hayes T, Slee D, White K, Harmon J, Godithi R, Wu M, Megerle M, Singh S, Mikolajczak C. Methodologies for battery failure analysis. In: Handbook of Batteries, Fourth Edition. Thomas Reddy (ed), McGraw-Hill, October 2010.

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Selected Presentations

Hayes TA. Considerations when choosing batteries made in China. The 4th EV Li-Ion Battery Forum 2011, Shanghai, China, November 2011.

Hayes TA. Considerations when choosing batteries made in China. Lithium Asia 2011, Shanghai China, September 2011.

Hayes TA. Considerations when choosing batteries made in China. The 3rd EV Li-Ion Battery Forum 2011, Barcelona, Spain, April 2011.

Hayes TA. 1-day training course: Detecting failures and manufacturing defects in Li-ion batteries. The 3rd EV Li-Ion Battery Forum 2011, Barcelona, Spain, April 2011.

Hayes TA. 2-day training course: Manufacturing, testing and recycling safe EV Li-Ion batteries. The 2nd EV Li-Ion Battery Forum 2010, Beijing China, August 2010.

Hayes TA. Analyzing electronic product battery failures. GlobalSpec Webinar on Electronic Product Design, June 2010.

Hayes TA, Mikolajczak C, Horn Q. Key Manufacturing Practices to Achieve High Quality Cells, 27th International Battery Seminar & Exhibit, Ft. Lauderdale, FL, March 16, 2010.

Hayes TA. Identifying a non-safe Li-ion battery in the production cycle to avoid safety recalls and maintaining your brand's trust. EV Li-ion Forum 2009, Shanghai China, September 2–3, 2009.

Hayes TA. 1-day workshop: Design and manufacturing of safe lithium ion batteries for EVs. The EV Li-Ion Battery Forum 2009, Shanghai China, September 2009.

Hayes TA, Mikolajczak CJ, Megerle MV, Wu M, Gupta S, Halleck P. Use of CT scanning for defect detection in lithium ion batteries. The 7th China International Battery Power Supply System of Advanced Technology and Market Seminar, Shanghai China, July 2009 (in Mandarin Chinese).

Hayes TA, Mikolajczak CJ, Megerle MV, Wu M, Gupta S, Halleck P. Use of CT scanning for defect detection in lithium ion batteries. 26th International Battery Seminar & Exhibit, Ft. Lauderdale, FL, March 16, 2009.

Megerle MV, Hayes TA, Horn W. Methodologies of identifying root causes of failures in lithium ion battery packs. 24th International Battery Seminar & Exhibit, Ft. Lauderdale, FL, March 19, 2007.

Hayes TA, Du Y. A scientific methodology for investigation of a lithium ion product failure. 4th International Battery Exhibition, Shanghai, China, November 9, 2005.

Hayes TA. Creep of zirconium and zirconium alloys. Creep Deformation and Fracture, Design, and Life Extension, Materials Science & Technology (MS&T'05), Pittsburgh, PA, September 25–28, 2005 (Invited Talk).

Hayes TA. Creep fracture of zirconium alloys. Creep Deformation and Fracture, Design, and Life Extension, Materials Science & Technology (MS&T'05), Pittsburgh, PA, September 25–28, 2005 (Invited Talk).

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Hayes TA. Modeling creep rupture of Zirconium alloys. Plastic and Viscoelastic Response of Materials and Metal Forming, Whistler, Canada, July 16–20, 1999.

Prior Experience

Senior Scientist, Institute of Risk & Safety Analyses, 2001–2005

Professional Affiliations

- Materials Research Society
- The Minerals, Metals and Materials Society
- ASM International