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## **Troy A. Hayes, Ph.D., P.E.** **Senior Managing Engineer**

### **Professional Profile**

Dr. Troy A. Hayes is a Senior Managing Engineer in Exponent's Mechanical Engineering and Materials/Metallurgy 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 (PCB) manufacturing and processing, 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**

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 for Primary & Secondary Batteries, Small Fuel Cells, and Other Technologies, Fort Lauderdale, FL, March 17–20, 2008.

Mikolajczak CJ, Hayes TA, Megerle MV, Wu M. A scientific methodology for investigation of a lithium ion battery failure. 2007 International Conference on Portable Information Devices, Orlando, FL, March 2007.

Hayes TA, Rosen RS, Kassner ME. Creep fracture of zirconium alloys. J Nuc Mater 2006; 353:109–118.

Hayes TA, Kassner ME. Creep of zirconium and zirconium alloys. Metall and Mater Trans 2006; 37A:2389–2396.

Hayes TA, Kassner ME. Creep of zirconium and zirconium alloys. Proceedings, Symposium Sponsored by Materials Science and Technology, Creep Deformation and Fracture, Design, and Life Extension, pp. 13–25, Pittsburgh, PA, September 25–28, 2005.

Hayes TA, Rosen RS, Kassner ME. Creep fracture of zirconium alloys. Proceedings, Symposium Sponsored by Materials Science and Technology, Creep Deformation and Fracture, Design, and Life Extension, pp. 27–39, Pittsburgh, PA, September 25–28, 2005.

Hayes TA. Creep and creep fracture of zirconium and zirconium alloys. Ph.D. Dissertation, University of California, San Diego, 2004, 391 pp.

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  $\alpha$ -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  $\alpha$ -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, 8<sup>th</sup> 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, 8<sup>th</sup> 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.

Hayes TA, Rosen RS, Kassner ME. Critical analysis of interim dry storage temperature limits for zircaloy-clad spent nuclear fuel based on diffusion-controlled cavity growth. Lawrence Livermore National Laboratory, Report UCRL-ID-131098, 145 pp, December 1999.

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**

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.

### **Presentations**

Hayes TA, Mikolajzak 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.

Mergele 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. 4<sup>th</sup> 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).

Hayes TA. Analysis of dry storage temperature limits for Zircaloy-clad spent nuclear fuel based on diffusion-controlled cavity growth. Scientific Basis for Nuclear Waste Management XXIII, Materials Research Society, Boston, MA, 2000.

Hayes TA. Steady state creep of Zirconium at high and intermediate temperatures. Plastic and Viscoelastic Response of Materials and Metal Forming, Whistler, Canada, July 16–20, 1999.

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

## **Deposition /Trial Testimony**

### **Depositions**

*Little v. RMC Pacific Materials, Inc.*, Superior Court of the State of California, County of Alameda, Case No. RG 05200168, May 2007.

*McGraw v. MGM Grand*, District Court, Clark County, Nevada, Case No. A482311, Dept. N. II, May 2007.

*Diggs v. Li*, Superior Court of California, County of Alameda – Northern District, Case No. RG06277195, December 2006.

*Campagnone v. Enjoyable Pools*, Superior Court of the State of California, Sacramento County, Case No. 04AS00851, October 2006.

*Legoff v. Gromis*, Superior Court for California, Los Angeles County, Case No. SC 079898, November 2004.

*Nagle v. Oshiro*, Superior Court for California, Kern County, Case No. S-1500-CV-251339-AEW, August 2004.

*Ramos v. California Redevelopment Agency*, Superior Court for California, Los Angeles County, Case No. BC252420, June 2004.

*Benedict v. Prestige*, Superior Court for California, Sacramento County, Case No. 01AS01632, December 2003.

*Jaime v. Costco*, Superior Court for California, Santa Barbara County, Case No. 1097238, February 2003.

*Benedict v. Prestige*, Superior Court for California, Sacramento County, Case No. 01AS01632, January 2003.

*Mingo v. Smiley*, Superior Court for California, Los Angeles County, Case No. LC057094, October 2002.

*Welch v. KB Toys*, Superior Court for California, Orange County, Case No. OOCC11591, February 2002.

*Gifford v. Jordano*, Superior Court for California, Santa Barbara County, Ancapa Division, California, Case No. SB228646, October 2001.

### **Trials and Arbitrations**

*Little v. RMC Pacific Materials, Inc.*, Superior Court of the State of California, County of Alameda, Case No. RG 05200168, June 2007.

*Campagnone v. Enjoyable Pools*, Superior Court of the State of California, Sacramento County, Case No. 04AS00851, November 2006.

*People of the State of California v. Iniguez*, Superior Court for California, Los Angeles County, Long Beach, Case No. NA061212, March 2005.

*Legoff v. Gromis*, Superior Court for California, Los Angeles County, Case No. SC 079898, February 2005.

*HEP v. Whitton*, District Court for Nevada, Clark County, Case No. A422584, February 2005.

*Gifford v. Jordano*, Superior Court for California, Santa Barbara County, Ancapa Division, California, Case No. SB228646, January 2002.