



Exponent®

Engineering & Scientific Consulting

Rita Kirchhofer, Ph.D., P.E., CWI

Managing Engineer | Materials and Corrosion Engineering

Denver

+1-303-802-3438 tel | rkirchhofer@exponent.com

## Professional Profile

Dr. Kirchhofer's expertise is in evaluation of failure mechanisms, determining root cause(s) of failure, and applying these principles to failure analysis and integrity assessment of components, equipment, and structures.

Dr. Kirchhofer's focus includes the mechanical behavior of materials (strength, fracture, and fatigue), fractography, materials structure-property relationships, corrosion performance, materials testing as applied to material selection, and materials characterization.

Dr. Kirchhofer is experienced in the investigation and evaluation of structural components, gantries and cranes, chemical and power plant components, oil and gas transportation pipelines, process piping, pressure vessels, reactor vessels, power generation, electric transmission, and transportation/automotive. Her experience also involves reviewing and applying industry codes and standards (e.g., ASME, ASTM, API, EN, ISO) for pipelines, pressure vessels, and structures. In addition, she has worked in product development, design of experiments, and reliability improvements through mitigation of failure modes.

She also has extensive knowledge of materials systems that encompass ferrous alloys, stainless steels, superalloys, non-ferrous alloys, and ceramic materials. Dr. Kirchhofer applies this knowledge to assess material performance in various service conditions and to understand and optimize the material processing-performance relationship.

Dr. Kirchhofer received her Ph.D. in Materials Science and M.S. in Metallurgical and Materials Engineering from Colorado School of Mines. In addition, Dr. Kirchhofer is a licensed Professional Engineer in the field of Metallurgical Engineering in various states. She is also a Certified Welding Inspector by the American Welding Society (AWS).

## Academic Credentials & Professional Honors

Ph.D., Materials Science, Colorado School of Mines, 2014

M.S., Metallurgical and Materials Engineering, Colorado School of Mines, 2011

B.S., Materials Science and Engineering, University of California, Davis, 2004

B.S., Mechanical Engineering, University of California, Davis, 2004

## Licenses and Certifications

Professional Engineer Metallurgical, California, #2015

Professional Engineer, Colorado, #PE.0045977

Professional Engineer Metallurgical, Nevada, #029797

American Welding Society Certified Welding Inspector (CWI)

Professional Engineer Metallurgical and Materials (WA)

## Prior Experience

Senior Materials & Forensic Engineer, Intertek AIM, 2016-2017

Senior Engineer, Bloom Energy, 2014-2016

Materials Research Fellow (Contractor), Idaho National Laboratories, 2009-2011

Materials Engineer, Anamet Inc., 2005-2008

## Professional Affiliations

Co-organizer for ASME Pressure Vessel & Piping, Materials and Manufacturing Committee

ASM International

American Society of Mechanical Engineers — ASME

American Welding Society — AWS

National Association of Corrosion Engineers International — NACE

## Languages

Spanish

## Publications

Kirchhofer R, Vaillancourt H, Garner M, Cipolla RC, "Dealloying of As-Welded Microstructures in Aluminum Bronzes in Essential Cooling Water Service". Proceedings of the ASME 2017 Pressure Vessels and Piping Conference, PVP 2017, July 16-20, 2017, Waikoloa, HI.

Kirchhofer R, Diercks DR, Gorman BP, "Near Atomic Scale Quantification of a Diffusive Phase Transformation in (Zn,Mg)O/Al<sub>2</sub>O<sub>3</sub> Using Dynamic Atom Probe Tomography". Journal of Materials Research 2015, 30 (8):1137-1147.

Kirchhofer R, Diercks DR, Gorman BP, Ihlefeld JF, Kotula PG, Shelton Ct, Brennecke GL, "Quantifying Compositional Homogeneity in Pb(Zr,Ti)O<sub>3</sub> Using Atom Probe Tomography". Journal of the American Ceramic Society 2014, 97 (9):2677-2697.

Sanford NA, Blanchard PT, Brubaker M, Bertness KA, Roshko A, Schlager JB, Kirchhofer R, Diercks DR, Gorman BP, "Laser-Assisted Atom probe Tomography of MBE Grown GaN Nanowires Heterostructures", Physica Status Solidi C 2014, 11(3):608-612.

Diercks DR, Gorman BP, Kirchhofer R, Sanford NA, Bertness K, Brubaker M, "Atom Probe Tomography Evaporation Behavior of C-Axis GaN Nanowires: Crystallographic, Stoichiometric, and Detection Efficiency Aspects", Journal of Applied Physics 2013, 114 (184903).

Kirchhofer R, Teague MC, Gorman BP, "Thermal Effects on Mass and Spatial Resolution During Laser Pulse Atom Probe Tomography of Cerium Oxide", Journal of Nuclear Materials 2013, 436 (1-3):23-28.

Kirchhofer R, Hunn JD, Demkowicz PA, Cole JI, Gorman BP, "Microstructure of TRISO Coated Particles from the AGR-1 Experiment: SiC Grain Size and Grain Boundary Character", Journal of Nuclear Materials 2013, 432 (1-3):127-134.

## **Presentations**

Kirchhofer R, Vaillancourt H, Garner M, Cipolla RC. Dealloying of As-Welded Microstructures in Aluminum Bronzes in Essential Cooling Water Service. Presentation, ASME Pressure Vessels and Piping Conference, PVP, Waikoloa, HI, 2017.

Kirchhofer R, Lanthorn G, Vaillancourt H, Lee C. Special Consideration for dissimilar metal welds: design, fabrication, and repair for power plants in flexible operation. Presentation, EPRI Workshop on Dissimilar Welds in High Temperature Applications, ASME Pressure Vessel and Piping, Waikoloa Village, HI, 2017.

R Kirchhofer R, Diercks DR, Gorman BP, Brennecke G. Atomic Scale Composition Profiling of Ferroelectrics via Laser-Pulsed Atom Probe Tomography and Cross-correlative Transmission Electron Microscopy. Presentation, Microscopy and Microanalysis, Indianapolis, IN, 2013.

Kirchhofer R, Diercks DR, Gorman BP. Atomic Scale Composition Profiling of Ferroelectrics via Laser-Pulsed Atom Probe Tomography and Cross-correlative Transmission Electron Microscopy. Poster Presentation, Materials Research Society, San Francisco, CA, 2013.

Diercks DR, Kirchhofer R, Brubaker M, Bertness K, Sanford NA, Gorman BP. Characterization of GaN Nanowires via Laser Pulsed Atom Probe Tomography and Transmission Electron Microscopy. Presentation, Electronic Materials Conference, Electronic Materials Conference, State College, PA, 2012.

Kirchhofer R, Diercks DR, Teague MC, Gorman BP. Lateral Thermal Transport in Laser-Assisted APT of Oxides. Presentation, International Field Emission Symposium, International Field Emission Symposium, Tuscaloosa, AL, 2012.

Kirchhofer R, Diercks DR, Gorman BP. Development of a Dynamic Atom Probe Tomography System at the Colorado School of Mines. Poster Presentation, American Vacuum Society, AVS-Rocky Mountain Chapter, Westminster, CO, 2012.

Kirchhofer R, Reimanis IE, Demkowicz PA, Cole JI, Hunn JD, Gorman BP. Microstructural Characterization of the Silicon Carbide Layer in AGR-1 Fuel Variants. Presentation, Second Workshop on HTGR SiC Materials Properties, Idaho Falls, ID, 2012.

Kirchhofer R, Teague MC, Gorman BP. Laser-Assisted Atom Probe Analysis of Ceria as Surrogate Materials for Ceramic Nuclear Fuels. Poster Presentation, Microscopy and Microanalysis, Nashville, TN, 2011.

Kirchhofer R, Hansford B, Reimanis IE, Gorman BP. Characterization of Stresses in the SiC Layer of TRISO Particles. Presentation, Microscopy & Microanalysis, Portland, OR. 2010.

Kirchhofer R, Gorman BP. EBSD Characterization of the Silicon Carbide Layer of TRISO Particles

Prepared in a FIB. Poster Presentation, Microbeam Analysis Society on Electron Backscattered Diffraction, Madison, WI, 2010.

Kirchhofer R, Porter T, and Kennett S. Torsional Failures in Hollow Axle Shafts from an F1000 Race Car: Presentation, ASM IMAT, New Orleans, LA, 2022.

## Project Experience

### Failure Analysis

Steam and Gas Turbines Failures – Investigated failures of turbine blades due to fatigue resulting from poor design and failures due to debris caused by poor steam quality. In gas turbines, determined the root cause of failures in stationary blades, rotating blades, and combustors in the hot-gas path. Part of the analyses included evaluation of historical operation data, maintenance and operation records, and manufacturing information.

Heat exchangers – Investigated corrosion in heat exchangers in petrochemical processing. Evaluated the contribution of material selection, service history, and contaminants to the observed corrosion.

Piping in Power Industry– Performed metallurgical evaluation to determine failure cause in large-bore girth welds, dissimilar metal failures, and attachments in combined cycle plants. Investigated corrosion, flow accelerated corrosion (FAC), pitting, caustic corrosion, etc. of tubing in boilers and heat recovery steam generators.

Piping in Petrochemical and Gas Transmission Service – Evaluated inner-diameter pitting and microbiologically induced corrosion (MIC), and outer-diameter corrosion under insulation in pipeline.

Jacketed Pressure Vessels – Investigated the corrosion-fatigue failure of a chilled jacketed vessel in the chemical processing industry. Evaluated the contribution of a change in cooling water treatment in the acceleration of the failure and assessed the potential for microbiologically induced corrosion.

Welded Structures – Investigated the collapse of a structural welds due to undersized welds and poor weld workmanship.

Composite Materials in Wind Energy Convertors – Determined the failure mechanism, rate of degradation, and mitigation for erosion and cracking in wind convertor blades.

Castings – Performed failure investigations of a large-section aluminum casting for cryogenic applications and steel castings used in pump housing, valves, and impellers. Evaluated material compositions, casting defects, and heat treatments to mitigate future failures.

Gantry Crane Collapse – Investigate collapse of moveable gantry crane that failed while in use. Determine cause of failure was due to welding defects.

Gangway Collapse – Determine failure mode of aluminum gantry crane failure on a naval vessel. Established failure mode and requirements for inspection / testing of gangway in accordance with appropriate industry and regulatory standards.

### Asset Integrity Management

Development of enhanced inspection cycles for management of large in fractures (and networks) employed in electric power transmission. Employed knowledge of failure modes, frequencies, and risk assessment to developed enhanced inspection scopes and for maintenance.

Carried out asset integrity management evaluation based on inspection data and performed risk-based inspection ranking in accordance with API 580 / API 581. Risk-based inspection assessment applied to high energy piping, petrochemical, and explosive manufacturing industries.

Performed metallurgical evaluations of buried and above ground piping to determine active damage mechanisms and risk ranking to perform fitness-for-service assessment (ASME FFS-1).

Performed weld inspections and piping condition assessments in Grade 91 high energy piping systems for combined cycle power plants and the heat recovery steam generators (HRSG) per ASME B31.1 standards and EPRI guidelines.

## **Product Development**

Developed failure modes and effect analysis (FMEA) diagrams for product risk assessment and to determine appropriate test methods for component validation for fuel cell stacks, structural ceramic channels, heat exchangers, pressurized vessels, and others.

Performed materials selection and validation for new product designs and improvement of existing components including ceramic channels, powder-metal interconnect plates, and nickel alloy vessels.

Consulted on best materials for non-metallic components in power transmission systems, metallic and non-metallic components for weight reduction in HVAC units, and non-ferrous alloys for heat exchangers, tanks, and pipelines in petrochemical industry.

## **Reliability Testing**

Developed testing protocols for highly-accelerated life test (HALT) and highly-accelerated stress test (HAST) for components and assemblies in high temperature service. Applied reliability testing methodologies to benchmark design changes, quantify improvements, and to assess refurbished components.

Evaluated metal-ceramic brazed joints in ceramic insulators for electrical and structural integrity at high temperature and high applied voltage service.

Tested high temperature degradation mechanisms in nickel alloys used in heat exchangers and vessels for natural gas and reformed methane service.

## **Editorships & Editorial Review Boards**

Engineering Failure Analysis Journal (Elsevier), Subject Editor for Materials and Corrosion

## **Peer Reviews**

Engineering Failure Analysis Journal

Journal of the American Ceramic Society — JACerS

The International Research and Review Journal for Microscopy — Micron

Journal of Nuclear Materials

Journal of Materials Research

Journal of Pressure Vessel Technology

## Deposition & Trial Testimony

### **Deposition Testimony**

Nelson vs US, United States District Court for the District of Oregon, case number 3:19-cv-01761-HZ, October 13, 2021.

### **Trial Testimony**

Nelson vs US, United States District Court for the District of Oregon, case number 3:19-cv-01761-HZ, January 13, 2022.