

Exponent®
Engineering & Scientific Consulting

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Professional Profile

Dr. Zirkle specializes in the reliability assessment and failure analysis of mechanical systems across a range of industries with a particular focus on renewable and non-renewable energy, transportation, machine safety, and manufacturing. Dr. Zirkle assists clients in these industries in a range of contexts, including design optimization, regulatory compliance, and intellectual property disputes. He provides valuable insights to clients by leveraging diverse methods of investigation including computer and statistical analysis, laboratory and site inspections, and regulations, codes, and standards evaluation.

Renewable Energy

Dr. Zirkle performs engineering assessments of mechanical systems used to generate renewable energy, including wind turbines, water turbines, and solar panels. He consults on the mechanical integrity of these systems in the context of applicable standards, expected design life, maintenance, and operational conditions for life cycle assessment. Insights provided by Dr. Zirkle have been used to identify and address factors that reduce the power generation capability of renewable energy systems.

Non-renewable Energy

Dr. Zirkle evaluates mechanical systems used for non-renewable energy, especially in the context of aging infrastructure and failure analysis. For example, he has helped clients develop procedures to navigate the complex federal regulatory environment for hazardous material transport. He has also performed detailed analysis of laboratory data for gas turbine failures. Dr. Zirkle's work in this area has been employed to evaluate natural gas pipelines for regulatory compliance and to inform root cause analyses for arbitration proceedings.

Machine Safety

Dr. Zirkle performs engineering analyses of industrial and construction equipment, particularly in the context of machine safeguarding and machine failure. Previous investigations have involved saws, presses, forklifts, cranes, drilling equipment, and personnel lifts, amongst other equipment. Dr. Zirkle assists clients by performing structural strength analyses, evaluating equipment operator training, and assessing equipment maintenance and standard of care.

Transportation

Dr. Zirkle's experience in transportation is primarily related to engineering assessments for rail and automotive systems. For example, he has conducted structural strength analysis of both as-designed and in-use railcars in the context of available standards and guidance documents. Dr. Zirkle has also

performed assessments related to automobile personal injury incidents that involved mechanical systems such as parking brakes and cargo straps.

Manufacturing

Dr. Zirkle is experienced in evaluating premature component failure that resulted from manufacturing in a variety of industries. In particular, he has assessed machining processes and associated quality assurance/quality checking practices. Dr. Zirkle's insights have helped clients identify the root cause of component failure and the most effective containment and corrective actions in view of manufacturing constraints.

Prior to joining Exponent, Dr. Zirkle received his Ph.D. in Mechanical Engineering from the Georgia Institute of Technology. He researched the failure of stainless steel structures exposed to damaging hydrogen environments in nuclear energy applications. Dr. Zirkle translated these findings to the engineering component level, enabling precise root cause failure analysis and informing hierarchical nuclear energy design processes. In addition to his graduate research, he has also conducted research at the National Institute of Standards and Technology and Sandia National Laboratories, investigating light-based surface roughness characterization and topology optimization, respectively.

Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, Georgia Institute of Technology, 2022

M.S., Mechanical Engineering, Georgia Institute of Technology, 2020

B.S., Mechanical Engineering, Walla Walla University, 2017

President's Fellowship, Mechanical Engineering, Georgia Institute of Technology, 2017-2021

Licenses and Certifications

Professional Engineer Mechanical, Delaware, #29639

Prior Experience

Intern, QuesTek Innovations, January – May 2022

Visiting researcher, Sandia National Laboratories, June – August 2017

Summer research fellow, National Institute of Standards and Technology, June – August 2016

Publications

Ding K, Zirkle T, Liu X, Castelluccio G, Miller B, Wormald J, Anglin B, Webb T, McDowell D, Zhu T. "Crystal plasticity modeling of ratchetting in FCC alloys," International Journal of Plasticity, 2026 March 1, 198:104611. DOI: 10.1016/j.ijplas.2026.104611

Bhargava Y, Davis B, Hudgins A, Patrick B, Wang L, Watson H, and Zirkle T. Identification of Factors to Determine Statistically Appropriate and Conservative CVN Toughness Values for Transmission Pipelines. 37th International Pipeline Pigging and Integrity Management Conference, January 2025, p. 1345-1372.

Zirkle T, Zhu T, McDowell D. "Multiscale Modeling of Hydrogen-Affected Crack Tip Damage Using Fully Coupled Chemo-Mechanical Crystal Plasticity Framework for Austenitic Stainless Steel," International Journal for Multiscale Computational Engineering, 2023, 21:42488. DOI:

10.1615/IntJMultCompEng.2022042488

Zirkle T, McDowell DL. Modeling cyclic deformation of austenitic stainless steels at elevated temperatures using a physically-based mesoscale crystal plasticity framework. Materials Science and Engineering: A. 2022 Jan 14;832:142377.

Zirkle T, McDowell DL. Analysis of monotonic and cyclic crack tip plasticity for a stationary crack tip in a FCC crystal. Computational Materials Science. 2022 Feb 1;202:110954.

Zirkle T, Costello L, Zhu T, McDowell DL. Modeling Dislocation-Mediated Hydrogen Transport and Trapping in Face-Centered Cubic Metals. Journal of Engineering Materials and Technology. 2022 Jan 1;144(1).

Zirkle T, Zhu T, McDowell DL. Micromechanical crystal plasticity back stress evolution within FCC dislocation substructure. International Journal of Plasticity. 2021 Nov 1;146:103082.

Zirkle T, Costello L, McDowell DL. Crystal Plasticity Modeling of Hydrogen and Hydrogen-Related Defects in Initial Yield and Plastic Flow of Single-Crystal Stainless Steel 316L. Metallurgical and Materials Transactions A. 2021 Sep;52(9):3961-77.

Presentations

Zirkle T, Whelan G. The Case for Leveraging Advanced Materials Modeling Tools in Failure Analysis. Oral presentation, Extreme Environments, Corrosion, and Performance Durability symposium, International Conference on Advanced Manufacturing (ICAM), Orlando, FL, 2026.

Zirkle T, Rakow J. Wind Energy: Trends and Failure Analysis. Oral presentation, Engineering Professional Development Seminar (EPDS), Menlo Park, CA, May 20, 2026.

Zirkle T, Cheng K, Viz M. Railcar corrosion and erosion: Historical perspectives and modern techniques. Oral presentation, Operations and Maintenance Conference, National Coal Transportation Association (NCTA), San Antonio, TX, 2025.

Zirkle T, Gu T, Anglin B, Geller C, McDowell DL. Crystal plasticity modeling of hydrogen concentration ahead of a crack tip in FCC steel. Oral presentation, 149th Annual Meeting & Exhibition of the Minerals, Metals & Materials Society (TMS), San Diego, CA, 2020.

Zirkle T, Locke B, Anglin B, Geller C, McDowell DL. Numerical methods applications in crystal plasticity finite element method. Poster presentation, Technical Meeting and Exhibition of Materials Science & Technology (MS&T), Portland, OR, 2019.

Peer Reviews

International Journal of Fatigue

Journal of Engineering Materials and Technology