

Exponent®
Engineering & Scientific Consulting

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Professional Profile

Alex Hudgins, Ph.D., P.E., is a principal engineer in Exponent's Metallurgical & Corrosion Engineering practice with over 15 years of experience in metallurgical failure analysis, corrosion, and fracture mechanics for gas and electric utilities, pipeline operators, the oil and gas industry, data center operators, renewable energy clients, and many others.

Dr. Hudgins advises utility companies, energy infrastructure operators, law firms, insurance carriers, and other clients on the cause of metallurgical failures, material and component degradation, failure prevention and the prevention of degradation, and associated risk. Often these take the form of pipeline integrity management, data center cooling system reliability, wind turbine failure analysis, and corrosion risk modeling. Dr. Hudgins brings metallurgical fundamentals to complex failure analysis challenges and provides technically rigorous consulting for new product development, asset integrity programs, and expert analysis and testimony in support of litigation and dispute matters.

Pipeline Integrity Management & Failure Analysis

Dr. Hudgins has expertise in pipeline failure analysis and integrity management for natural gas and liquid pipeline operators, addressing the full spectrum of failure mechanisms that challenge pipeline system integrity — including stress corrosion cracking (SCC), fatigue and corrosion fatigue, manufacturing defects, long seam weld anomalies, mechanical damage, hydrogen embrittlement, and third-party damage, among others. His pipeline work encompasses proactive integrity management consulting, including MAOP validation, crack assessment, fatigue threat analysis, and fitness-for-service evaluations under applicable PHMSA regulations and API standards, as well as failure investigation following in-service leaks, ruptures, and explosions. He has conducted health and condition assessments of corrosion control programs, evaluated compliance with code requirements, consistency with industry best practices, and supported utility clients in understanding and managing their metallurgical risks across their asset portfolios.

Dr. Hudgins has published extensively on pipeline failure and integrity topics in leading industry journals and conferences, including the ASM Handbook, the ASME International Pipeline Conference, Journal of Failure Analysis and Prevention, and the American Gas Association (AGA). He is a member of the AGA Transmission Integrity Management Program (TIMP) Committee, attending and presenting on a regular basis. He has served as an instructor for pipeline integrity management courses.

Oil and Gas, Refineries

In addition to pipelines, Dr. Hudgins has experience with upstream and downstream oil and gas (O&G) assets and operations. His work has involved assessment of down-hole coiled tubing and corrosion and cracking of casings and tubing. He has performed numerous analyses on refinery piping and

components, from failure analysis investigations to positive material identification (PMI) evaluations. Degradation modes analyzed in this context have included erosion corrosion, sulfidation corrosion, hardware failures, and many others. Many of these investigations have been in the dispute context, arising as a result from a loss.

Electric Utility Metallurgy & Risk

Dr. Hudgins is a recognized metallurgical expert for electric utility clients, providing asset integrity and failure analysis consulting for transmission and distribution infrastructure. His electric utility work spans failure investigation, risk assessment, corrosion evaluation, and asset condition assessment for both electric transmission and distribution structures and related assets (guys, hardware, etc.). He has performed failure mode and effects analysis (FMEA) for overhead electric transmission structures, covered conductors, and other electric assets; built and contributed to numerous risk models including atmospheric and below grade corrosion models and wire down models; and performed electrical and mechanical testing of covered and bare conductors and protection devices.

Dr. Hudgins engages directly with the technical communities that shape the future direction of corrosion and integrity management programs for electric utilities. He has presented on the corrosion and integrity challenges facing overhead electric infrastructure at the CEATI International Transmission and Distribution Conference, and he has contributed to covered conductor effectiveness testing for wildfire mitigation.

Data Center Cooling System Performance & Reliability

Dr. Hudgins provides metallurgical and corrosion consulting for data center cooling system performance and reliability. His data center work addresses corrosion challenges, materials selection questions, reliability, and failure analysis of data center cooling infrastructure and components. He performs assessments of cooling system components such as cold plates, manifolds, quick disconnects, heat sinks, and related components that experience demanding thermal environments. Dr. Hudgins moderated and presented at the May 2025 webinar on key considerations in data center design, construction, and operation — one of the first Exponent presentations addressing this emerging area.

Wind Turbine Failure Analysis

Dr. Hudgins provides metallurgical failure analysis and corrosion expertise for wind turbine owners, operators, and manufacturers, addressing the mechanical and environmental degradation mechanisms that lead to wind turbine component failures. His wind turbine work encompasses failure analysis of turbine main shaft bearings, blade bearings, and other structural components, with a focus on identifying the metallurgical and corrosion degradation mechanisms — fatigue, stress corrosion cracking, fretting, wear, and environmental degradation — that drive failures in wind energy systems.

Metallurgical Failure Analysis

Dr. Hudgins offers broad metallurgical failure analysis expertise across a wide range of industries and component types, applying fractography, scanning electron microscopy (SEM), optical microscopy, x-ray diffraction, microhardness testing, nanoindentation, and analytical modeling to identify the root cause of failures in metals and alloy components. His failure analysis experience spans infrastructure, transportation, oil and gas, and industrial equipment — from rail axle failures to metallurgical defects in offshore drilling platforms and blowout preventer components. This breadth of experience, combined with his deep fundamental engineering expertise, makes Dr. Hudgins a versatile metallurgical expert capable of addressing complex failure analysis challenges across a wide range of client industries and dispute contexts.

Academic Credentials & Professional Honors

Ph.D., Metallurgical and Materials Engineering, Colorado School of Mines, 2010

B.S., Materials Science and Engineering, Lehigh University, 2005

President and Member, Alpha Sigma Mu Pennsylvania Epsilon Chapter, The International Professional Honor Society for Materials Science and Engineering, 2004-2005

Recipient, Allen S. Quier Prize, Lehigh University Materials Science and Engineering Department, 2005

Member, Phi Sigma Pi National Honor Society, 2003-2005

Licenses and Certifications

Professional Engineer Metallurgical, California, #1972

Professional Affiliations

ASM International, American Society of Metals (member)

TMS, The Minerals, Metals, and Materials Society (member)

American Gas Association — AGA (member - Transmission Integrity Management Committee)

American Water Works Association — AWWA (member)

Publications

Hudgins, A., Slone, C.E., Cline, C.T., Taylor, N. et al. "Effects of Fracture Surface Cleaning on the Integrity and Preservation of Steel Fracture Features," J Fail. Anal. and Preven. (2026).

Davis B, Patrick B, Hudgins A, Watson H, Wang L, Zirkle T, Bhargava Y. 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; 1345-1372.

Liu C, Hudgins A, James B. Failure analysis of a ruptured pipeline. Journal of Failure Analysis and Prevention 2024; 24:2575-2582.

Georgin B, Bowers M, Hudgins A, Chy H, Luy A. Testing the effectiveness of covered conductors for wildfire mitigation. CIGRE Conference Paper: Paris Session, August 25-30 2024; B2 PS3, Paper 10327.

Jain L, Vest L, Gonzales R, Hudgins A, Stamps R. Line pipe DC-ERW long seam weld anomaly investigation. AMPP Conference Paper: New Orleans, LA, March 3-7, 2024; 51324-21182-SG.

Davis, B, Hudgins, A, Bhargava, Y, Patrick, B, Myca, M. Fatigue threat to natural gas pipelines: an analysis approach. Proceedings of the ASME 2022 14th International Pipeline Conference, IPC 2022, Calgary Alberta, Canada, September 26-30, 2022; IPC2022-87283.

Hudgins A, Roepke C, James B, Kondori B, Whitley B. Failures of pipelines. In: Miller BA, Shipley RJ, Parrington RJ, Dennies DP, editors. Analysis and Prevention of Component and Equipment Failures. ASM Handbook. Volume 11A, ASM International 2021.

Hudgins AW, Matlock DK. The effects of property differences in multiphase sheet steels on local

formability. Materials Science & Engineering A 2016; 654:169-176.

James B, Hudgins A. Failure analysis of oil and gas transmission lines. In: Makhlouf H, Aliofkhazraei M, editors. Handbook of Materials Failure Analysis with Case Studies from the Oil and Gas Industry, Elsevier 2015.

Hudgins AW, James B. Fatigue of threaded fasteners. In: Advanced Materials & Processes. ASM International 2014; 172(8):18-22.

Hudgins AW. Shear failures in bending of advanced high strength steels. Ph.D. dissertation, Colorado School of Mines 2010.

Hudgins AW, Matlock DK, Speer JG, Van Tyne CJ. Predicting instability at die radii in advanced high strength steels. J Mater Process Technol 2010; 210(5):741-750.

Hudgins A, Myca K, Davis B, Bhargava Y. A systematic approach to pipeline fatigue analysis. American Gas Association (AGA) Transmission Integrity Mega Rule Implementation Webinar, October 15, 2020.

Hudgins AW, Matlock DK, Speer JG. Shear failures in bending of advanced high strength steels. Proceedings, International Deep Drawing Research Group Conference, Golden, CO, 2009; 53-64.

Hudgins AW, Matlock DK, Speer JG, Fekete JR, Walp MS. The susceptibility to shear fracture in bending of advanced high strength sheet steels. Proceedings, MS&T Conference, Detroit, MI, 2007; 145-157.

Bykowski M, Hudgins AW, Deacon R, Marder A. Failure analysis of the Space Shuttle Columbia RCC leading edge. J Fail Anal Prev 2006; 6(1):39-45.

Presentations and Professional Classes

Hudgins A, Lau E, Murphy P, moderated by Hung W. Key considerations in data center design, construction & operation. Webinar, May 14th, 2025.

Liu C, Davis C, Hudgins A, Neilson H, Ortiz J. Enhanced inspections and technology for wildfire mitigation of transmission assets. Centre for Energy Advancement through Technological Innovation (CEATI) Conference, 2022.

Marquardt A, Hudgins A, Sakamoto M, Bhargava Y. Understanding corrosion of transmission overhead structures for improved lifetime prediction and risk modeling. CEATI International, CEATI 2021 Transmission & Distribution Conference, November 2021.

Hudgins A, Bhargava, Brenk G. Differentiating between low and high frequency ERW pipe. American Gas Association, Transmission Integrity Management Committee Meetings, Orlando FL, October 4, 2021.

Bhargava Y, Hudgins A, Patrick B. Determining growth rates for assessment of stress corrosion cracking on pipelines. American Gas Association Fall 2021 Operations Conference, Orlando FL, October 6, 2021.

Davies W, Wikramanayake E, Wolf M, Hudgins A. Transient effects of injecting green hydrogen into natural gas pipelines. 10th International Congress on Sustainability Science & Engineering, September 13, 2021.

Hudgins A, Myca K, Davis B, Bhargava Y. Mega rule deep dive: engineering analysis, crack-like features, corrosion + seismicity. Western Energy Institute (WEI) Transmission Integrity Webinar, July 13, 2021.

Nirankari V, James B, Van Der Schjiff, Hudgins A. Grooving corrosion: differentiating weld defects from corrosion failure. Materials Science and Technology Conference, Columbus OH, October 17, 2018.

Hudgins A, Davis B. Crack assessment methods. American Gas Association Fall 2018 Transmission Integrity Management Committee Meetings, Fort Worth TX, October 23, 2018.

Hudgins A. Fundamentals of pipeline integrity management: pipeline basics, common failure mechanisms, integrity management, and MAOP establishment. EUCI Class Instructor, Denver, CO, March 16, 2017.

Hudgins A, Bhargava Y. Susceptibility of natural gas pipelines to stress corrosion cracking. American Gas Association Spring 2017 Operators Meeting, Orlando FL, May 4, 2017.

Hudgins A, Davis B. A metallurgical and fracture mechanics approach to understanding crack-like defects. American Gas Association Transmission Integrity Management Workshop, Pittsburgh, PA, June 14, 2017.

Hudgins A, Bhargava Y. The Implications of the proposed rule changes for corrosion control practices: what it means to operators and contractors. API Inspection Summit, February 2, 2017.

Birringer R, Hudgins A, James B. Case study of a natural pipeline explosion caused by a combination of manufacturing defects and environmental factors. Materials Science and Technology Conference, Salt Lake City, UT, October 24, 2016.

James B, Hudgins A. Fracture mechanics and crack management for natural gas operators. American Gas Association Fall Operators Meeting, Nashville TN, September 13, 2016.

Hudgins A. Medical device design and failure analysis. ASM International Class Instructor, Santa Clara CA, August 2016.

Hudgins A. Metal fracture and fractography. Stanford University, May 6, 2016.

Hudgins A. Pipelines 201: pipeline basics, common failure mechanisms, integrity management. MAOP establishment, and asset management. EUCI Class Instructor, Houston, TX, March 2016.

Hudgins AW, Matlock DK, Speer JG. International Deep Drawing Research Group, Golden CO, June 1-3, 2009.

Hudgins AW, Matlock DK, Van Tyne CJ. North American Deep Drawing Research Group, Cleveland, OH, November 19, 2008.

Hudgins AW, Matlock DK, Speer JG, Fekete JR, Walp MS. Materials Science and Technology, Detroit, MI, September 16-20, 2007.

Project Experience

Pipeline Integrity Management & Failure Analysis

Dr. Hudgins has led numerous high-profile pipeline failure analysis investigations, often starting in the hours following an incident with on-site presence. He has also supported integrity management programs for natural gas and liquid transmission pipeline operators, investigating overpressure events, manufacturing defects, environmental degradation, and regulatory compliance challenges.

- Performed numerous pipeline failure analysis investigations on gas and liquid lines; investigated in-service leaks and ruptures resulting from environmental degradation, manufacturing defects, fatigue cracking, third-party damage, and many damage mechanisms.

- Performed burst testing of natural gas pipeline segments to determine joint efficiency factors; conducted mechanical testing and analysis to support pipeline integrity programs.
- Examined pipelines that failed during hydrotests and determined the cause of failure; identified contributing factors including long seam defects and mechanical damage through metallurgical examination and microstructural analysis.
- Performed numerous fatigue threat analyses for natural gas pipelines based on strength testing and in-line-inspection results to understand remaining life of the asset.
- Assisted with MAOP validation for a gas pipeline operator; performed detailed review of historical records including strength test pressure reports and as-built drawings. Developed processes for addressing unknown values and incomplete records. Reported results to support regulatory compliance with PHMSA transmission integrity management requirements.
- Performed health assessments for a gas operator's corrosion control program; evaluated procedures, standards, and field implementation to determine compliance with code requirements and consistency with industry best practices. Identified gaps and provided recommendations for corrective actions.

Oil and Gas, Refineries

Beyond pipelines, Dr. Hudgins has significant experience in both upstream and downstream oil and gas sectors. In O&G industry disputes, Dr. Hudgins has supported owners, operators, service providers, and manufacturers on a variety of issues including piping and related components/assets.

- Analyzed the downhole failure of casing. Cracking of the casing was found to be the result of hydrogen interacting with the high-strength steel.
- Investigated a refinery fire where a failure resulted from sulfidation corrosion on low-silicon carbon steel piping.
- Analyzed the properties of coiled steel tubing for downhole use.
- Assessed the quality and efficacy of a positive material identification (PMI) process at a refinery.
- Performed failure analysis on multiple failed components following a refinery fire.

Electric Utility Metallurgy & Risk

Dr. Hudgins has provided metallurgical consulting to electric utility clients in both failure investigation and asset integrity contexts, helping utility operators understand and manage risks associated with their transmission and distribution infrastructure.

- Developed a risk model to predict corrosion over time of overhead electric transmission structures based on geographic position, asset information, and local weather information. The model was used for improved lifetime prediction and risk modeling, and findings were presented at the CEATI International Transmission and Distribution Conference (2021) in collaboration with utility industry partners.
- Performed analysis on the efficacy of covered conductor for wildfire mitigation of electric transmission assets; coauthored a CIGRE Conference Paper presented at the Paris Session (August 2024) presenting findings on transmission asset protection strategies for utility operators in wildfire-prone regions.

- Performed a failure mode and effects analysis (FMEA) on overhead electric transmission structures and related components to improve inspection processes and identify degradation before catastrophic failure.
- Performed high-power electrical testing on protection devices to understand the effect of different test scenarios and settings on propensity for wire down events.
- Assessed the condition of overhead electric transmission structures with respect to corrosion and potential mitigation options including repair, recoating, or tower replacement.

Data Center Cooling System Performance & Reliability

Dr. Hudgins provides metallurgical and corrosion consulting for data center cooling system performance and reliability, addressing the corrosion, materials, and failure analysis challenges that affect the performance and longevity of cooling infrastructure in data center facilities.

- Performed metallurgical testing and analysis for numerous hyperscalers in the data center space. This work has included vendor comparisons, next-generation product testing, product tear-downs, and failure analysis. Components analyzed include cooling pipes, welds, brazes, manifolds, barbs, quick-disconnects, cold plates, hoses, and related parts.
- Fatigue-tested cooling pipe and manifolds to understand propensity for fatigue cracking under cyclic loading.
- Burst test and pressure cycle tested cooling system pumps to understand failure mode and limits.

Wind Turbine Failure Analysis

Dr. Hudgins provides technical metallurgical consulting expertise for wind turbine owners, operators, and manufacturers, addressing degradation and failure mechanisms that affect turbine main shaft bearings and blade bearings such as corrosion, rolling contact fatigue, overload, and lack of lubrication.

- Investigated white etching cracks (WEC) in main shaft bearing rolling elements.
- Investigated surface-initiated cracks and subsurface initiated cracks in blade bearing components.
- Analyzed claims regarding hardness and material quality in turbine components

Metallurgical Failure Analysis

Dr. Hudgins has performed metallurgical failure analysis investigations across a broad range of industries and component types, applying the full suite of metallurgical characterization and testing methods to determine the root cause of failures in metals, alloys, and engineered components.

- Determined the cause of a rail axle failure that resulted in derailment; identified a combination of corrosion and fatigue as the contributing factors through metallurgical examination and fracture analysis.
- Performed failure analysis investigations on manufacturing equipment including fasteners, bolted connections, and specialty tooling. Determined failure mechanisms and contributing factors to support manufacturing process improvement.
- Investigated the severity of weld defects in newly constructed industrial boilers that contained undercut, porosity, and lack of fusion.
- Analyzed metallurgical issues in novel blowout preventer designs for down-hole applications; examined the response of high-alloy steel to high-strain-rate deformation.

- Examined metallurgical defects in offshore drilling platform rack and pinion systems; determined the cause and contributing factors of the defects through metallurgical examination and materials characterization.
- Analyzed the effect of corrosion on steel plates used for ship building in a dispute between the ship builder and customer.
- Investigated the extent of corrosion on structural steel in a composting facility and provided remediation recommendations.