

Exponent®
Engineering & Scientific Consulting

Kaitlin Spak, Ph.D., P.E.

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Professional Profile

Kaitlin Spak, Ph.D., P.E., is a principal engineer at Exponent with over a decade of experience in mechanical failure investigations, evaluation of dynamic systems and products, and deep expertise in vibration analysis. She specializes in root-cause analysis, litigation support and expert testimony, pipeline integrity, and vibration and data monitoring across industrial, energy, automotive, and consumer products industries.

Dr. Spak has applied her engineering skills to projects involving pipeline joint failures; drilling and mining operations; industrial machinery; heavy equipment; engine failures; commercial and passenger vehicle design, analysis, accidents, and failures; bearing analysis; operational data analysis; consumer products and appliances; and equestrian tack. Dr. Spak uses both experimentation and theoretical approaches to solve engineering problems. She has directed and conducted proactive product development work as well as reactive failure analysis and litigation work, including preparation of expert reports, patent and other intellectual property claims analyses, support of international arbitrations, and root-cause analyses.

Root-Cause Analysis – Mechanical Engineering Expert

Dr. Spak has performed failure investigations and root-cause analyses for systems ranging from natural gas pipelines to power transmission lines and from appliance motors to industrial engines. She has developed tests and evaluation criteria to answer critical questions regarding product design, development, and failure. Her experience over a range of industries is connected through her understanding of mechanical systems of all types and ability to identify the core mechanical principles and the investigations needed to determine their condition.

Dr. Spak has extensive experience in root-cause failure analyses for mechanical systems of all types, using systematic and understandable methods to provide conclusive results when possible and eliminating extraneous possibilities if a conclusive result is unobtainable.

Structural Dynamics and Vibration Expert

Dr. Spak specializes in the mechanical engineering of systems and structures, with specialized knowledge of vibration characterization and broad experience in analysis of machines and dynamic systems. As a Category IV Certified Vibration Analyst, the highest level of certification offered by the Vibration Institute, she has extensive experience in instrumenting and conducting dynamic tests and analyzing vibration and operational data. Dr. Spak supports both proactive and reactive work involving vibration analysis, including instrumenting equipment, collecting data, analyzing data, and evaluating the information gathered to provide actionable paths. Dr. Spak also leads teams in acoustic analyses for sound evaluation, including measurement and analysis of noise levels and sound performance for industrial purposes and product performance.

Dr. Spak teaches for the Vibration Institute, where her credentials and real-world experience are appreciated by both beginner and advanced students alike.

Vehicle Dynamics and Noise Expertise

Dr. Spak is a licensed racecar driver, having competed in both time trials with production cars and wheel-to-wheel racing with Formula cars, and has combined her vibration training with vehicle dynamics education and experience to provide expertise related to vehicle dynamics and noise, vibration, and harshness issues. Access to Exponent's test track allows Dr. Spak to develop and perform unique vehicle testing and comparison protocols, while testing she has performed in real-world environments allows data collection for testing and validation purposes during vehicle development.

Pipeline Failures and Root-Cause Analysis

Dr. Spak has developed test plans and protocols for pipeline investigations for plastic and steel pipe. She has extensive experience conducting failure investigations and experiments to analyze piping systems and improve pipeline construction and maintenance procedures. Her work in this area has led to industry improvements and standards that have improved pipeline safety.

Consumer Product Design Review and Analysis

Dr. Spak spent much of her early career at Exponent evaluating consumer products, including both proactive work through the design and development stage and reactive work for product liability considerations and intellectual property analysis. Through extensive product analysis combined with engineering training and application of engineering principles, she developed insightful analysis methods that include bespoke and targeted testing to answer the specific questions that drive decision making. Dr. Spak's consumer product experience spans appliances, power tools, children's toys, robots, electronics, sporting goods, recreational equipment, furniture, and more.

International Arbitrations and Testifying Expertise

In addition to the proactive work Dr. Spak has performed across industries, she has testified as an engineering expert both domestically and internationally. She has prepared expert reports for state and federal matters and international disputes and arbitrations in areas of mechanical engineering, failure analysis, intellectual property, product liability, EPC (engineering, procurement, and construction) contracts, automotive matters, pipeline failures, and more.

Prior Experiences

Before joining Exponent, Dr. Spak's work at NASA's Jet Propulsion Laboratory (JPL) included investigating the dynamic response of spaceflight cables and developing analytical models to predict the effect of adding cables to space structures. During this research, Dr. Spak developed methods for cable testing and cabled structure models that include the effects of bakeout, variable bending stiffness, and hysteretic damping. While at JPL, she also assisted with the work of the Advanced Deployable Structures group, set up testing for modal analysis of space and rover assemblies, and served as a resident cable expert for design teams.

Before JPL, Dr. Spak worked at the Center for Intelligent Materials and Smart Structures at Virginia Tech, working with piezoelectric actuators and developing an active clearance control mechanism for jet engines. Her graduate work included courses in finite element analysis, instrumentation, fluid dynamics, active materials and smart structures, fuel cell systems, rotor dynamics, and mathematical methods.

She also has past work experience in industry including design of electronic housing, button panels, and backplane cards for broadcasting routers, troubleshooting of customer product issues, and product prototype development and design. Dr. Spak also has coursework and competitive experience in communications and public speaking. She has years of shop experience in design and fabrication of metal art and furniture and is familiar with a variety of machining and manufacturing methods.

Outside of the office, Dr. Spak spends her time racing cars and riding horses competitively, both activities that provide greater insight into mechanical equipment failures and require an exceptional ability to think and react quickly.

Academic Credentials & Professional Honors

Ph.D., Mechanical Engineering, Virginia Polytechnic Institute and State Univ, 2014

B.S., Mechanical Engineering, California Polytechnic State University, SLO, 2010

NASA Space Technology Research Fellow, 2011-2014

ASME Bruce J. Heim Foundation Scholarship

AIAA San Gabriel Valley Section Student Scholarship

Virginia Space Grant Consortium Fellow

Pratt Fellow

Raytheon University Design Competition, First Place

Outstanding Senior for Contributions to the Objectives and Public Image of the University, Cal Poly, SLO

Tau Beta Pi Dodson Scholar

Tau Beta Pi National Committee Chair

Licenses and Certifications

Professional Engineer, Arizona, #81919

Professional Engineer, Colorado, #PE.0054045

Professional Engineer Mechanical, Nevada, #029603

Professional Engineer, New York, #109318

Professional Engineer, Wyoming, #PE 20123

Vibration Analyst, Vibration Institute Category IV Certified

Sports Car Club of America Full Competition License

Northwestern University Center for Public Safety, Traffic Crash Reconstruction for Engineers

National Auto Sport Association Time Trial Racing License

USPC National H (Equine Knowledge and Management) and C3 (Riding Skill) Ratings

Vibration Analyst, Vibration Institute Category I, II, III, and IV Certified

Prior Experience

NASA Jet Propulsion Laboratory, 2012-2014

Center for Intelligent Material Systems and Structures, Virginia Tech, 2010-2011

Miranda Technologies, 2007-2009

Professional Affiliations

Vibration Institute

American Institute of Aeronautics and Astronautics

Society for Experimental Mechanics

American Society of Mechanical Engineers

Tau Beta Pi Engineering Honor Society

Society of Automotive Engineers

AIAA Structural Dynamics Technical Committee Member

SAE Light Vehicle Exterior Sound Committee Member

United States Eventing Association Cross-Country Safety Subcommittee Member

Publications

Spak KS, Schumacher R. SAE Light Vehicle Exterior Sound Level History. SAE International Journal of Advances and Current Practices in Mobility, 2021, DOI: https://doi.org/10.4271/2021-01-1120

Spak K, Klopp RW. Traces of bentonite prevent bonding of electrofusion pipeline joints. Pipeline & Gas Journal, December 2017, pp. 50-52.

Spak KS. Modal comparison of stock and performance brake rotors. Proceedings of the 36th International Modal Analysis Conference, #90, Orlando, FL, 2018.

Spak KS, Agnes GS, Inman DJ. Modeling vibration response and damping of cables and cabled structures. Journal of Sound and Vibration 2015; 336:240-256. DOI:10.1016/j.jsv.2014.10.009

Spak KS, Agnes GS, Inman DJ. Bakeout effects on dynamic response of spaceflight cables. Journal of Spacecraft and Rockets 2014; 51(5):1721-1734. DOI: 10.2514/1.A32780

Spak KS, Agnes GS, Inman DJ. Parameters for modeling stranded cables as structural beams. Experimental Mechanics 2014; 54(9):1613-1626. DOI: 10.1007/s11340-014-9941-8

Spak KS, Agnes GS, Inman DJ. Modeling vibration response and damping of cables and cabled structures. Journal of Sound and Vibration 2015; Vol. 336: 240-256. DOI: 10.1016/j.jsv.2014.10.009.

Spak KS, Agnes GS, Inman, DJ. Cable modeling and internal damping developments. Applied Mechanics Reviews 2013; 65(1): 1-18. DOI:10.1115/1.4023489.

Conference Proceedings and Presentations

Spak KS. Vibration analysis for performance brake rotor damage detection. 38th SEM International Modal Analysis Conference, #7610, Houston, TX, 2020.

Spak KS. Analysis of nonlinear behavior in machine monitoring diagnostic plots. 34th SEM International Modal Analysis Conference, #219, Orlando, FL, 2016.

Spak KS. From client to conclusion: translating the language of vibration. 34th SEM International Modal Analysis Conference, #9, Orlando, FL, 2016.

Spak KS, Agnes GS, Inman DJ. Experimental and theoretical analysis of cabled beams. Proceedings, AIAA SciTech 56th AIAA/ASMEASCE/AHS/SC Structures, Structural Dynamics, and Materials Conference, AIAA-2015-0690, Kissimmee, FL, 2015.

Spak KS, Agnes GS, Inman DJ. Cable parameters for homogenous cable-beam models for space structures. Proceedings, 32nd IMAC, A Conference on Structural Dynamics, SEM International Modal Analysis Conference, #17, Orlando, FL, 2014.

Spak KS, Agnes GS, Inman DJ. Inclusion of shear effects, tension, and damping in a DTF beam model for cable modeling. Proceedings, AIAA SciTech 55th AIAA/ASMEASCE/AHS/SC Structures, Structural Dynamics, and Materials Conference, AIAA-2014-0491, National Harbor, MD, 2014.

Spak KS, Agnes GS, Inman DJ. Comparison of damping models for space flight cables. Proceedings, 31st IMAC, A Conference on Structural Dynamics, Volume 4, Chapter 21, SEM International Modal Analysis Conference, # 77, Garden Grove, CA, 2013.

Spak KS, Agnes GS, Inman DJ. Toward modeling of cable harnessed structures: Cable damping experiments. Proceedings, AIAA 54th AIAA/ASMEASCE/AHS/SC Structures, Structural Dynamics, and Materials Conference, AIAA-2013-1889, Boston, MA, 2013.

Spak KS, Agnes GS, Inman DJ. Effect of bakeout on space flight cable stiffness. SEM International Student Paper Competition and Annual Conference, #535, Lombard, IL, 2013.

Spak KS, Inman DJ. Space flight cable model development. Virginia Space Grant Consortium Student Research Conference, Norfolk, VA, 2013.

Spak KS, Inman DJ. Model development for cable harnessed beams. Virginia Space Grant Consortium Student Research Conference, Williamsburg, VA, 2012.

Project Experience

Vehicles and Engines

- Instrumented bus drivetrains and analyzed vibration and sound data to determine the root cause of an unusual noise that was preventing vehicle customer acceptance and distribution.
- Performed oil consumption analysis, accident review, vehicle condition, and price comparisons of a passenger vehicle for litigation purposes.

- Investigated condition and reviewed specifications and requirements to determine root cause of bursting of a hydraulic hose on a construction vehicle.
- Evaluated data and consumer perception of vehicle sound and fuel economy changes following repairs and modifications to vehicle.
- Evaluated vehicle sounds and performed vehicle sound testing for regulatory compliance purposes.
- Evaluated engine sounds and developed algorithms and classification schemes for engine fault diagnostics. Led a team to analyze representative vehicles and test consumer vehicles.
- Performed inspection and root-cause analysis of engine failures at cogeneration plants running on digester gas.
- Reviewed ambulance accident data recorder outputs.

Vibration and Sound Analysis

- Measured and analyzed vibrations of a hoist gear on a dredging barge to identify the cause of excessive vibration.
- Instrumented an industrial wood grinder to determine whether impacts on one area of the machine could be significant at a different location and whether the magnitude of the impact was sufficient to dislodge a safety mechanism.
- Analyzed vibrations from an ultrasonic resonator for food processing to optimize the energy input; provided further engineering support in design and prototype construction and evaluated regulations for such equipment.
- Developed appropriate accelerated life testing procedures for a commercial robot based on recorded data from a prototype; recommended the appropriate instrumentation for test data collection and supported testing through conclusion.
- Performed a design review for an industrial lettuce dryer and performed calculations to determine appropriate dampers to be used to mitigate vibration.
- Used laser Doppler vibrometer for modal analysis and frequency comparisons of consumer electronics to determine root cause of failures.
- Used vibration data in conjunction with finite element modeling to compare performance in terms of fatigue resistance for different crimping closures for refrigeration systems.
- Analyzed turbomachinery condition monitoring data for fault conditions and maintenance requirements.
- Inspected and evaluated likely impact of shipping and handling procedures on high-value computer servers.
- Performed vibration modeling and analysis of cable-dressed space structures to identify modal changes and frequency shifts.
- Analyzed truck-mounted broadcasting routers to characterize vehicle vibration that was causing lost connections.
- Evaluated vibration and sound at utility facilities, processing plants, and manufacturing sites.

Gas Distribution Pipelines and Components

- Directed excavation and evidence collection from failure site.

- Collected and analyzed data to identify acoustic resonances as the cause of failure on gas pipelines; performed evaluations of vibration levels on small-bore connections on gas pipelines to identify areas at risk of failure.
- Designed tests to evaluate the integrity of pipeline components damaged in fires and directed a team to perform testing and material analysis for such components.
- Designed experiments and oversaw testing to investigate the effect of common plumbers' drain rooters on cross-bored pipelines.
- Applied standards and regulations to calculate acceptable operating pressures for components manufactured with deviations from nominal specifications.
- Designed and performed tests and analyzed test results and field failures to determine cause of electrofusion joint failures.
- Performed electrofusion and heat fusion joint qualification testing.
- Designed new cap lock for a chlorine gas plant to prevent valves from opening, used on over 1,500 valves.

Livestock and Equestrian

- Inspected and analyzed equestrian equipment components for root cause of failure.
- Determined value for lost breeding material of livestock.
- Livestock judging and evaluation.

Industrial Mining and Processing

- Analyzed operational data and causes of a sinkhole related to solution salt mine collapse.
- Evaluated plant condition and mechanical component failures and suitability of rotating equipment for chemical processing plant.
- Evaluated extent of modularization expected for industrial mine process plant equipment and compared expectations and contract requirements to the modules delivered.
- Supported engineering analysis for international arbitrations related to alleged defects in industrial processing plants.

Intellectual Property

- Analyzed computer lock mechanisms for design and functionality.
- Designed and performed nondestructive testing of a robotic toy to show how the drive mechanism worked and how that drive system compared to competitors' products and patent language.
- Evaluated spring design in magnetic cartridges and prepared claim charts to analyze prior art and accused products for patent validity and infringement.
- Evaluated medical instrument and procedure involving light transmission through blood for measurement of blood sedimentation for intellectual property considerations.
- Evaluated high-capacity magazines with respect to patent claims to investigate infringement claims in litigation.
- Provided claim construction expertise for technical matters and testified in Markman hearings related to claim construction.

- Analyzed products with respect to design and utility patents.

Consumer Products

- Performed engineering reviews of products, including kitchen appliances, vehicle accessories, sporting goods, and furniture, to provide input for product recall decisions.
- Provided the mechanical engineering input to failure modes and effects analysis (FMEA) for at least nine unique consumer electronics products.
- Determined effect of mechanical failures for lighting systems and determined mitigating design and assembly changes to reduce occurrences.
- Evaluated root cause of injury and assessed alleged design defects in hand-held power tools.
- Designed tests and analyzed potentially hazardous mechanical failures of kitchen blenders.
- Tested infant bassinets for sound-mitigation properties.
- Evaluated structural fitness, failures, and soundness for use for various chairs, hammocks, and furniture supports.
- Evaluated potential mechanical hazards of products intended for infants and children.
- Provided mechanical and material testing and analyses to discover root cause of failure of recreational toys and outdoor products.

Peer Reviews

China Ocean Engineering

Engineering Structures

International Journal of Mechanical Sciences

IEEE Access

Journal of Applied and Computational Mechanics

Journal of Cardiac Surgery

Journal of Sound and Vibration

Journal of Spacecraft and Rockets

Journal of Vibration and Acoustics

Meccanica

NASA SPIRES Reviewer

Structural Control and Health Monitoring