

Mr. Sanders is a Senior Consultant and Director with Engineering Systems Inc. (ESi). He has over eighteen years of experience in the design & failure analysis of HVAC, refrigeration, plumbing, and building service piping systems. His expertise lies in evaluating design & construction defects, adherence to engineering design standard-of-care, compliance with building codes & industry standards, and inspection, testing, and maintenance related issues. He has testified as a qualified professional engineering expert in both deposition and at trial.

Mr. Sanders routinely leads multidisciplinary teams to investigate matters with compounding issues. With a background in both thermal-fluids and materials sciences, Mr. Sanders analyzes failures of entire systems, as well as individual components and pieces of equipment. He consults on issues involving corrosion, materials degradation, and materials selection when investigating system component failures. He also investigates building claims involving hail damage, pipe freezes, water leaks, condensation, and indoor air quality (IAQ).

Education

MS, Mechanical & Aerospace Engineering. University of Missouri. 2008

BS, Mechanical Engineering, Minors in Mathematics & Spanish. University of Missouri. 2006

Licenses & Certifications

- State of Alabama P.E. License 33550-E
- State of Arkansas P.E. License 22353
- State of Colorado P.E. License PE.0063683
- State of Florida P.E. License 91922
- State of Illinois P.E. License 062.064555
- State of Indiana P.E. License PE12600832
- State of Michigan P.E. License 6201311942
- State of Missouri P.E. License 2012000813

Contact Information

sasanders@engsys.com

(636) 240-6095

ESi – St. Louis

1053 Cave Springs Road, Suite 302
St. Peters, MO 63376

Areas of Specialization

- Heating, Ventilating, and Air Conditioning (HVAC)
- Refrigeration
- Plumbing & Building Service Piping
- Fire Protection Systems
- Industrial Process Piping Systems
- Heat Exchangers, Piping, Tubing, Insulation Systems, Valves, Fittings, and Fasteners

- State of Nebraska P.E. License E-20356
 - State of New Mexico P.E. License 30763
 - State of Texas P.E. License 133138
 - NCEES Record 49228
 - Certified Construction Documents Technologist (CDT)
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Positions Held

Engineering Systems Inc., O'Fallon, Missouri

- Senior Consultant & Director, 2024 – Present
- Senior Consultant, 2019 – 2024
- Senior Staff Consultant, 2015 – 2018
- Staff Consultant, 2008 – 2015

University of Missouri, Columbia, Missouri

- Teaching & Research Assistant, 2007 – 2008
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Continuing Education

- **Engineering Calculations for PSM & RMP** – University of Wisconsin-Madison, 2024
 - **Process Safety Management Audits for Compliance and Continuous Safety Improvement** – University of Wisconsin-Madison, 2023
 - **Process Safety Management (PSM) & Risk Management Program (RMP) Guidelines** – IIAR, 2022
 - **Managing Construction Projects** – Halfmoon Education Inc., 2022
 - **Principles and Practices of Mechanical Integrity for Industrial Refrigeration Systems** – University of Wisconsin-Madison, 2021
 - **Introduction to ANSYS Fluent** – DRD Technology, 2020
 - **Construction Law** – Halfmoon Education Inc., 2018
 - **Test, Adjust, and Balance Technical Sessions** – ASHRAE, 2017
 - **NFPA 652-Advanced Dust Hazard Analysis Workshop** – Fauske & Associates, LLC, 2017
 - **NFPA 652-An Introduction to Dust Hazard Analysis** – Fauske & Associates, LLC, 2017
 - **Steam Systems** – ASHRAE, 2015
 - **Designing Moisture-Resistant Wall & Roof Systems** – Halfmoon Education Inc., 2015
 - **Case Study: 3 District Energy Systems at Higher Education Campuses** – ASHRAE, 2014
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- **Corrosion Prevention and Control** – AIChE, 2014
- **Polyurethanes (PUR) Academy** – BASF, 2014
- **Lessons from Failures of Building Envelopes** – ASCE, 2014
- **Law of Construction Defects and Failures** – Halfmoon Education Inc., 2014
- **Chilled Water Systems, Equipment and Optimization** – ASHRAE, 2012
- **Seismic Restraint Design** – ASHRAE, 2011

Professional Affiliations/Honors

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE)

- Mechanical Systems Insulation Technical Committee (TC 1.8), 2015 – Present
- Custom Engineered Refrigeration Systems (TC 10.1), 2015 – Present
 - Chair 2023 – 2025
 - Research Subcommittee Chair 2019 – 2021

International Institute of All-Natural Refrigeration (IIAR)

ASM International (ASM)

- Peer Reviewer, Journal of Failure Analysis and Prevention, 2012 – Present

American Society of Mechanical Engineers (ASME)

Construction Specification Institute (CSI)

Failure Analysis Society (FAS)

National Fire Protection Association (NFPA)

Project Experience

Investigations

HVAC Systems & Equipment

- Led a multidisciplinary team investigating reported refrigerant leaks and corrosion failures of pre-insulated HVAC refrigerant line sets at a multistory, 300-room residential building. Inspected the subject property to document HVAC system condition and installation means & methods. Analyzed contract and construction documents from design & construction of the subject property; maintenance records for the HVAC systems; and HVAC system & component product literature. Performed chemical and metallurgical testing of subject and exemplar insulated line sets. Identified multiple failure modes and causes for the reported refrigerant leaks and corrosion failures.
- Investigated reported health effects, and alleged excessive humidity and mold growth in several residential buildings. Inspected residences, HVAC units, and replacement HVAC systems. Evaluated compliance with

local ordinances, codes, industry standards, and recommended practices regarding the design, construction, and remediation of the subject HVAC systems. Analyzed recorded humidity levels and factors affecting indoor environmental quality (IEQ).

- Investigated reported moisture intrusion and excessive humidity issues in several educational facilities. Evaluated building construction, HVAC system design, and operation. Analyzed HVAC system controls, historical operational data, and weather data to determine causes for moisture and humidity issues.
- Investigated moisture and mold found within roof and wall cavities in several multistory hotels. Reviewed project drawings, analyzed building construction & materials, and performed thermal and psychrometric analyses to determine cause(s) for the moisture-related issues.
- Investigated multiple incidents of carbon monoxide poisoning from various residential fuel gas-fired appliances. Evaluated compliance with local ordinances, codes, industry standards, and recommended practices regarding the installation, inspection, maintenance, and testing of the gas-fired appliances.
- Investigated building mechanical system issues at a cannabis production facility as part of a multidisciplinary team. Evaluated design deficiencies in the HVAC, chilled water, and hot water systems in the central energy plant serving the facility. Assisted in evaluating design and performance issues with the HVAC systems serving the grow spaces within the facility.
- Led a multidisciplinary investigation of alleged design and construction defects in the ventilation systems of several swine facilities. Evaluated roles and responsibilities of various contractors, and analyzed airflow through the buildings' air filtration systems
- Provided design consultation for the replacement of an existing chiller plant at a commercial facility. Analyzed the historical energy consumption of the existing chiller plant to determine the required cooling capacity for the replacement chiller plant & assist in equipment selection.
- Investigated a leak from a hydronic air conditioning unit which resulted in significant property damage. Evaluated unit design, manufacture, installation, and testing. Assessed building HVAC system design, controls, alarms, and sequences of operation to determine the cause of excessive flooding.
- Investigated the freeze failure of a chilled water coil in a rooftop HVAC unit during construction of a hotel which caused extensive water damage to the property. Analyzed the design, controls, sequences of operation, and historical operational data for the HVAC system. Evaluated compliance of installing mechanical contractor with requirements in contract documents, applicable codes, and industry standards.
- Investigated the failure of the pneumatic HVAC control system for an indoor performing arts theatre. Assessed system design and performance, as well as determined the cause of failure.
- Investigated the inflation failure of a commercial roof by the HVAC system during building renovations. Reviewed project contracts, building/system drawings, project communications, photos, and inspection reports to evaluate the HVAC system design and determine the cause of the failure.
- Evaluated the condition of HVAC and fire suppression systems & equipment at a restaurant following a kitchen fire. Determined scope of work for remediation of the mechanical systems and addressed corrosion concerns regarding activation of the fire suppression systems within the restaurant.

- Investigated numerous failures reportedly due to corrosion of air conditioning heat exchangers (evaporator & condenser coils) and refrigerant piping/tubing. Analyzed equipment design, manufacture, installation, and operation. Performed testing and laboratory analyses to determine cause(s) for the failures.
- Analyzed corrosion failures of residential gas-fired furnace heat exchangers. Reviewed equipment design, manufacture, installation, and operation. Performed laboratory analyses to determine cause(s) for the failures.
- Evaluated the effect of hail damage on cooling capacity and efficiency of HVAC units. Determined whether observed damage was consistent with reported hail event. Evaluated condition of units, remaining service life with respect to typical service life, and recommendations for repair/replacement.
- Analyzed the design of air-source heat pump pool heaters and internal components, identified potential design changes to improve unit operation & performance.

Refrigeration Systems & Equipment

- Collaborated with a multidisciplinary team and led the thermal design & development of a fleet of next-generation refrigerated boxcars. Conducted heat transfer analyses, performed laboratory testing, and developed an instrumentation package to measure the thermal performance of refrigerated boxcars in both laboratory and real-world (service) conditions. Researched, developed, and tested thermally superior construction materials and railcar design concepts. Helped oversee implementation of thermal improvements in both prototype and production railcars, with significant thermal performance improvement measured and verified through both laboratory and real-world testing.
- Investigated the catastrophic failure of refrigerant piping in a commercial refrigeration system due to over-pressurization. Evaluated the design, construction, condition, and maintenance history of the subject refrigeration system. Modeled refrigeration system performance based on operational data to determine the cause of the incident.
- Investigated the frost-heave failure of a spiral freezer in a food production facility. Reviewed system drawings, O&M records, photos, and inspection reports. Assessed freezer design, construction, operation, inspection, and maintenance. Determined causes contributing to frost heave failure.
- Investigated the frost-heavy failure of a concrete floor in a food distribution facility. Reviewed building drawings, inspected the subject warehouse, analyzed floor construction and insulation materials. Determined root cause for failure of the warehouse floor.
- Investigated the failure of a refrigeration system at a food production facility. Inspected the subject facility and refrigeration equipment. Analyzed system design, operation, and construction documents to determine cause(s) contributing to reported system malperformance.
- Investigated the failure of an ammonia refrigeration system at a food distribution facility. Performed failure analysis on the refrigerant control valve responsible for the system failure. Assessed the design, construction, and condition of the subject warehouse and refrigeration system. Evaluated applicable codes, standards, and operation & maintenance (O&M) management program for the facility.

- Investigated the failure of an ammonia/carbon dioxide (NH_3/CO_2) cascade refrigeration system at a food production facility. Performed failure analysis on the cascade heat exchanger, analyzed heat exchanger design and manufacture. Assessed the design and operation of the cascade refrigeration system.
- Investigated a catastrophic leak from an ammonia refrigeration system during a construction project at an operating food distribution facility. Evaluated roles and responsibilities of various involved parties, requirements for Process Safety Management (PSM), and requirements in industry standards regarding decommissioning and managing the mechanical integrity of the subject ammonia refrigeration system.
- Investigated a catastrophic leak from an ammonia refrigeration system at a food production facility. Assessed extent of damage and scope of work for repairs. Evaluated claims of corrosion to equipment, piping, and components within the facility due to the ammonia leak.
- Investigated a catastrophic leak from an ammonia refrigeration system at a food distribution facility. Analyzed system design, operational data, and maintenance records to determine the root cause for the system failure. Assessed adequacy of system inspection, testing, and maintenance with respect to local codes & industry standards.
- Evaluated corroded piping and degraded insulation system of an industrial ammonia refrigeration system. Assessed mechanical integrity of refrigerant piping, proposed scope of work for system repairs, and adequacy of system inspection & maintenance with respect to local codes & industry standards.
- Performed cooling load calculations and evaluated the adequacy of the design & construction of a refrigeration system at a retail food facility with reported operational issues.
- Performed failure analysis of a corroded fitting in an industrial ammonia refrigeration system and assessed the formation of condensation on system piping in the refrigerated space.
- Investigated failures, analyzed the design and performance of refrigeration liquid level switches. Modeled switch operation & provided recommendations to improve switch performance and reliability.

Plumbing and Building Service Piping Systems & Equipment

- Led a multidisciplinary team investigating reported pitting corrosion in buried steam piping at a healthcare facility. Analyzed piping samples to determine the corrosion mechanisms at issue and cause for the piping failures.
- Investigated multiple corrosion failures of insulated steam piping in underground tunnels that were part of a university's campus heating system. Reviewed construction documents and evaluated system design, construction, and operation to determine causes responsible for the pipe corrosion failures.
- Investigated numerous freeze failures and subsequent leaks from water-filled piping in residential and commercial buildings. Inspected the subject buildings and affected piping systems. Reviewed historical weather data and performed heat transfer analyses to determine when piping froze and leaked.
- Evaluated freeze and subsequent water damage to various systems and equipment at a water bottling facility. Inspected the subject facility and damaged equipment to determine the scope of damages. Reviewed historical weather data to determine when freeze and subsequent damage occurred.

- Evaluated reported plumbing leaks at a multistory residential facility. Analyzed project drawings, specifications, construction documents, and contractor communications to locate and identify cause(s) for water damages and project delays.
- Investigated failures of plastic piping in domestic water piping systems at several multi-story hotels and residential buildings. Analyzed historical operational data of the domestic water plumbing systems and municipal water supply. Evaluated the engineering standard of care for the design of the domestic water plumbing system, as well as compliance of the plumbing system design, installation, operation, and maintenance with contract documents, applicable building codes, industry standards, and manufacturer instructions.
- Investigated numerous failures of plastic piping in residential domestic hot water piping systems. Evaluated hot water system operation and compliance of design/installation with applicable building codes, industry standards, and manufacturer instructions to determine the cause of failure.
- Investigated multiple failures of expansion tanks in domestic hot water piping systems that resulted in extensive water damage. Analyzed expansion tank installation and corrosion damage, reviewed construction documents, installation records, local building codes, and manufacturer installation & maintenance instructions to determine causes for the failure of the subject expansion tank.
- Investigated a series of reported failures of plastic drain/waste piping at a condominium complex. Reviewed project drawings, specifications, contracts, construction documents, and expert reports. Assessed responsibility for the pipe failures due to design and construction changes.

Fire Protection Systems & Equipment

- Investigated failures of numerous water-based fire sprinkler systems at residential, commercial, and industrial facilities. Analyzed system design, inspection, testing, and maintenance records, and fire alarm/signaling records to determine cause(s) for the failures. Assessed system testing, inspection and maintenance compliance with codes & applicable standards.
- Investigated numerous accidental activations of water-based fire protection sprinklers in the proximity of building heating systems & equipment. Evaluated system design and installation with respect applicable codes & standards and determined cause(s) for sprinkler activation.
- Investigated freeze failures of water-filled ("wet pipe") and "dry pipe" fire sprinkler piping systems. Assessed the design & construction of the buildings and their fire protection systems, and compliance with local codes & applicable standards to identify cause(s) of the freeze failures.
- Investigated a freeze failure of a water-filled, CPVC sprinkler pipe adjacent to a dry horizontal sidewall sprinkler. Reviewed system design, drawings and construction documents. Assessed system design/construction adequacy and compliance with local codes and applicable standards. Conducted laboratory testing to demonstrate adequacy of sprinkler design/construction against freezing.
- Assisted a company developing a hypoxic fire protection system by providing design review/analysis and developing a computer model for analyzing installation-specific system performance. Reviewed drawings & requirements for potential installations and developed custom system designs for each.

Industrial Process Piping Systems & Equipment

- Investigated extensive corrosion within process piping systems at a petrochemical facility in support of an international arbitration dispute. Analyzed contract documents, construction documents, project drawings, specifications, and applicable industry standards. Evaluated piping system engineering design and pipe flushing, cleaning, and drying with respect to project requirements to identify the causes for the corrosion that occurred.
- Investigated a catastrophic failure of large diameter process piping at a manufacturing facility. Determined the root cause for the piping failure, the extent of damage resulting from the failure, and provided technical guidance for facility piping system repair/redesign efforts.
- Investigated the failures of pressure vessels and shell-and-tube heat exchangers at a landfill gas processing facility. Analyzed system & equipment design, operation, inspection, testing, and maintenance records to determine root causes for the equipment failures.
- Investigated damage to process steam piping and air-cooled heat exchangers at a power generation facility. Analyzed system & equipment design and historical operational data to determine the root cause for the damage.
- Evaluated damage to and repairability of a liquid natural gas (LNG) storage tank that was accidentally dropped during a crane lift. Reviewed pressure vessel design and manufacture, incident description and documentation, and proposed repair scope of work. Coordinated with LNG facility personnel and contractors to achieve an effective repair to the tank with reasonable costs in a timely manner.
- Performed failure and materials analysis of corroded ethanol vaporizer heat exchanger tubes. Researched and recommended alternative materials for increased corrosion resistance.
- Evaluated the design & performance of industrial dust collection and pneumatic scrap conveyance systems.
- Performed failure and stress analyses on hydraulic fitting brazed connections.
- Performed failure analysis of a hydraulic fitting in a dry ice block press. Analyzed press design & operation.
- Investigated the failure of a rotating joint in process steam equipment. Analyzed component deformation, damage and wear patterns. Identified the failure mode and causes contributing to the joint failure.

Publications

“Corrosion of Sulfur Removal Tanks Used in the Processing of Landfill Gas,” E.L. Solomon, A.M. Pettinger, J.R. Babcock, **S.A. Sanders**, and J.L. McDougall, ASM Journal of Failure Analysis and Prevention, Online, February 2021.

“Household Cooking Range Tipover Accident Reconstruction Case Study,” D.B. Brickman and **S.A. Sanders**, ASCE-ASME Journal of Risk and Uncertainty in Engineering Systems, Part B: Mechanical Engineering, Volume 2, June 2016.

“Safety Glasses: Preventing Eye Injuries from Carbide Tips,” **S.A. Sanders**, C. C. Bigelow and F.E. Schmidt, Professional Safety, April 2015.

“Household Range Tipover Accident Reconstruction Case Study,” D.B. Brickman and **S.A. Sanders**, Proceedings of the International Mechanical Engineering Congress and Exposition, IMECE2014-36421, November 2014.

“Corrosion Failure of a Threaded Fitting in an Ammonia Refrigeration System,” **S.A. Sanders**, M.E. Stevenson, G.J. Novak and R. Pape, ASM Journal of Failure Analysis and Prevention, Volume 14, Issue 3, June 2014.

“Failure Analysis of Ethanol Vaporizer Heat Exchanger Tubes,” **S.A. Sanders** and H.C. Iwand, ASM Journal of Failure Analysis and Prevention, Volume 13, Issue 3, June 2013.

“Failure Analysis of Hydraulic Fitting Brazed Connections,” M.E. Stevenson, M.D. Hayes, J.L. McDougall, and **S.A. Sanders**, ASM Journal of Failure Analysis and Prevention, Volume 12, Issue 2, April 2012.

Presentations

“Maintaining HVAC Systems Serving Worship Spaces” **S.A. Sanders**, Conference for Catholic Facility Management, Baltimore, MD, May 2, 2023.

“Under Pressure – Investigating Pipe Freezes” **S.A. Sanders**, Greater St. Louis Claims Association, St. Louis, MO, March 2, 2022.

“Evaluating Code Compliance of Residential HVAC Equipment Selection” **S.A. Sanders**, University of Minnesota 66th Annual Institute for Building Officials, January 10, 2022.

“Sticks & Bricks – HVAC/MEP” **S.A. Sanders**, Construction Law Essentials regional program of the ABA Forum on Construction Law, Seattle, WA, September 30 – October 1, 2021.

“Letting Off Steam: Lessons Learned from a Complicated Large Loss” **S.A. Sanders**, C.C. Bigelow, M. Dunn, Missouri Organization of Defense Lawyers, Online, July 15, 2021.

“Mitigating Catastrophic Losses” **S.A. Sanders** & S.M. Wade, CLM St. Louis Chapter, St. Louis, MO, June 1, 2021.

“MN Building Codes and Mechanical Maintenance Requirements” A.J. Thielen, **S.A. Sanders**, and K.P. Departhy, University of Minnesota 65th Annual Institute for Building Officials, January 12, 2021.

“Unique Conditions of Microbial Influenced Corrosion” D.J. Medlin, C.C. Bigelow, **S.A. Sanders** and J.D. Fuerst, ASM MS&T15, Columbus, OH, October 5, 2015.

“HVAC Fundamentals for Insurance and Litigation Personnel” **S.A. Sanders**, (Multiple).

“Investigating Building Piping Failures” **S.A. Sanders**, (Multiple).

“Water-Based Fire Sprinkler Systems and their Insurance/Legal Implications” **S.A. Sanders**, (Multiple).