



STEVEN A. SANDERS, M.S., P.E.
SENIOR CONSULTANT

sasanders@engsys.com

Mr. Sanders is a Senior Consultant with Engineering Systems Inc. (ESi) and has over fourteen years of experience in the design & failure analysis of HVAC, refrigeration, and building & industrial process piping systems & equipment. His expertise lies in investigating failures, assessing design & construction defects, evaluating compliance with building codes & industry standards, and addressing inspection, testing, and maintenance issues. He investigates claims involving hail damage, pipe freezes, water leaks, condensation, mold, and indoor air quality (IAQ). He has testified as a qualified professional engineering expert in both deposition and at trial.

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 and materials selection, investigating failures of system components such as: heat exchangers, piping, tubing, insulation systems, valves, fittings, and fasteners. He is experienced in materials testing and laboratory analysis methods, including mechanical testing, hardness testing, microscopy, metallography, Scanning Electron Microscopy (SEM), and Energy Dispersive Spectroscopy (EDS/EDX).

Areas of Specialization

- Heat Transfer, Thermodynamics, and Fluid Mechanics
- Heating, Ventilating, and Air Conditioning (HVAC)
- Commercial and Industrial Refrigeration
- Building and Process Piping Systems
- Heat Exchangers, Piping, Tubing, Insulation Systems, Valves, Fittings, and Fasteners
- Fire Protection Systems
- Industrial Dust Collection Systems & Dust Hazard Analysis (DHA)
- Materials Testing & Failure Analysis
- Consumer Products and Appliances
- Product Design and Testing

Education

- M.S., Mechanical & Aerospace Engineering, University of Missouri, 2008
- B.S., Mechanical Engineering, Minors in Mathematics & Spanish, University of Missouri, 2006

Licensed Professional Engineer (P.E.)

State of Alabama.....	P.E. License No. 33550-E
State of Florida.....	P.E. License No. 91922
State of Illinois.....	P.E. License No. 062.064555
State of Missouri.....	P.E. License No. 2012000813
State of Texas.....	P.E. License No. 133138
NCEES Record.....	Record No. 49228

January 2022

Professional Affiliations/Honors

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

Mechanical Systems Insulation Technical Committee (TC 1.8), 2015 – Present
Industrial Refrigeration and Piping Systems Technical Committee (TC 10.1), 2015 – Present

American Society of Mechanical Engineers (ASME)

ASM International (ASM)

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

Failure Analysis Society (FAS)

National Fire Protection Association (NFPA)

Positions Held

Engineering Systems Inc., O'Fallon, Missouri

Senior Consultant, 2019 – Present
Senior Staff Consultant, 2015 – 2018
Staff Consultant, 2008 – 2015

University of Missouri, Columbia, Missouri

Teaching & Research Assistant, 2007 – 2008

Continued Education

Principles and Practices of Mechanical Integrity for Industrial Refrigeration Systems, November 2-4, 2021, University of Wisconsin-Madison

Introduction to ANSYS Fluent, May 14-15, 2020, DRD Technology.

Construction Law, January 26, 2018, HalfMoon Education Inc.

Test, Adjust, and Balance Technical Sessions, December 20, 2017, ASHRAE.

NFPA 652 – Advanced Dust Hazard Analysis Workshop, September 20, 2017, Fauske & Assoc., LLC.

NFPA 652 – An Introduction to Dust Hazard Analysis, September 19, 2017, Fauske & Assoc., LLC.

Steam Systems, December 18, 2015, ASHRAE.

Designing Moisture-Resistant Wall & Roof Systems, June 18, 2015, HalfMoon Education Inc.

Case Study: 3 District Energy Systems at Higher Education Campuses, December 5, 2014, ASHRAE.

Corrosion Prevention and Control, November 11, 2014, AIChE.
Polyurethanes (PUR) Academy, September 3-5, 2014, BASF.
Lessons from Failures of Building Envelopes, April 10, 2014, ASCE.
Law of Construction Defects and Failures, April 4, 2014, HalfMoon Education Inc.
Chilled Water Systems, Equipment and Optimization, December 7, 2012, ASHRAE.
Seismic Restraint Design, December 9, 2011, ASHRAE.

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

“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).

Selected Project Experience

HVAC Systems & Equipment

Investigated reported health effects, and alleged excessive humidity and mold growth involving a residential HVAC system. Inspected residence, HVAC units, and replacement HVAC system. Evaluated compliance with local ordinances, codes, industry standards, and recommended practices regarding the design, construction, and remediation of the subject HVAC system. Analyzed recorded humidity levels and factors affecting indoor environmental quality (IEQ).

Investigated reported mold growth within a residence. Inspected the subject residence, HVAC system, plumbing, and appliances. Evaluated historical home construction, maintenance, and known water incidents to determine source for moisture that caused the reported mold growth.

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.

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 moisture and mold found within roof and wall cavities at a multistory hotel. Reviewed project drawings, analyzed building construction & materials, and performed thermal and psychrometric analyses to determine cause(s) for the moisture-related issues.

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 and assist in optimal equipment selection.

Investigated 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 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 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.

Developed prototype system-level liquid cooling solutions for next-generation workstation computers. Researched, designed, manufactured, tested, and optimized custom heat transfer components. Developed computer model to predict component & system thermal hydraulic 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 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-heave 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.

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.

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 at a food production facility. Assessed extent of damage and scope of work for repairs. Evaluated claims of corrosion to equipment, piping, and other 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.

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 failures, analyzed the design and performance of refrigeration liquid level switches. Modeled switch operation & provided recommendations to improve switch performance and reliability.

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.

Building Piping Systems & Equipment

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.

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 with respect to design and construction changes.

Evaluated the installation of a residential sump pump that allegedly failed and caused significant water damage. Inspected the subject sump pump, reviewed contractor records and product literature, and determined the causes contributing to the failure of the sump pump.

Industrial Process Systems & Equipment

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.

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 local codes & applicable standards.

Investigated numerous accidental activations of water-based fire protection sprinklers in the proximity of building heating appliances. Analyzed system design and installation to determine compliance with local codes and applicable standards, and determine cause(s) for sprinkler activation.

Investigated 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 new type of 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.

Consumer Products & Appliances

Tested the impact performance of eyewear (i.e. spectacles, goggles and face shields) against various projectiles and flying debris (e.g. BB's, tool shards, table saw blade teeth, projectile ricochet, etc.)

Tested the performance and analyzed the design of various outdoor recreation/sporting good products such as: football helmet snaps, camping chairs, stools, cots, hiking poles, sports nets and sleeping bags.

Assisted a consumer product company in developing test methods to compare the performance of rubber latches from multiple vendors. Performed laboratory testing to identify/confirm latch material. Designed custom accelerated life and low-temperature testing to evaluate product performance.

Investigated a personal injury due to the tip-over of a newspaper vending machine at a restaurant. Analyzed machine design & stability, performed stability testing, and determined causes for the tip-over accident.

Investigated several injuries involving the use of extension ladders. Reviewed accident descriptions and accounts. Established manner in which the subject ladders had to have been used to result in the accidents as they were described to have occurred.

Investigated a workplace accident at an industrial facility involving the operation of a custom-made manlift. Evaluated manlift design and operation. Reviewed accident description and accounts. Established manner in which the manlift had to have been operated to cause the accident as described.

Classroom Teaching Experience

Served as graduate classroom and laboratory teaching assistant and lecturer for topics including the basic structure property relationships and mechanical properties of polymers, composites, metals, and their alloys