



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

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Mr. Sanders is a Senior Consultant with Engineering Systems Inc. (ESi) and has over sixteen years of experience in the design & failure analysis of HVAC, refrigeration, building service piping, and industrial process piping systems. 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 building claims involving hail damage, pipe freezes, water leaks, condensation, and indoor air quality (IAQ). He has testified as a qualified professional engineering expert in both deposition and 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 when investigating system component failures.

**Areas of Specialization**

Heat Transfer, Thermodynamics, and Fluid Mechanics

Heating, Ventilating, and Air Conditioning (HVAC)

Commercial and Industrial Refrigeration

Building Service Piping

Fire Protection Systems

Industrial Process Piping

Heat Exchangers, Piping, Tubing, Insulation Systems, Valves, Fittings, and Fasteners

**Education**

M.S., Mechanical & Aerospace Engineering, University of Missouri, 2008

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

**Professional Engineering (P.E.) Licenses**

State of Alabama License No. 33550-E

State of Arkansas License No. 22353

State of Colorado License No. PE.0063683

State of Florida License No. 91922

State of Illinois License No. 062.064555

State of Michigan License No. 6201311942

State of Missouri License No. 2012000813

State of Nebraska License No. E-20356

State of Texas License No. 133138

NCEES Record Record No. 49228

**Certifications**

Certified Construction Documents Technologist (CDT)

*January 2024*

## **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 – Present  
Research Subcommittee Chair 2019 – 2021

### **International Institute of Ammonia Refrigeration (IIAR)**

### **Construction Specification Institute (CSI)**

### **American Society of Mechanical Engineers (ASME)**

### **National Fire Protection Association (NFPA)**

### **ASM International (ASM)**

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

### **Failure Analysis Society (FAS)**

## **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**

Process Safety Management Audits for Compliance and Continuous Safety Improvement,  
January 18-20, 2023, University of Wisconsin-Madison.

Process Safety Management (PSM) & Risk Management Program (RMP) Guidelines,  
December 19, 2022, IIAR.

Managing Construction Projects, November 23, 2022, HalfMoon Education Inc.

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, Sept. 20, 2017, Fauske & Assoc., LLC

NFPA 652 – An Introduction to Dust Hazard Analysis, Sept. 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, Dec. 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.

## **Classroom Teaching Experience**

### **Engineering Materials**

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.

## 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 66<sup>th</sup> 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 65<sup>th</sup> 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 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 & assist in 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.

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.

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 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-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.

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.

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 ( $\text{NH}_3/\text{CO}_2$ ) 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 components within the facility due to the ammonia leak.

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

### **Building Service 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 numerous failures of plastic piping in 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 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.



Investigated the failure of an expansion tank in a domestic hot water piping system that resulted in extensive water damage to the property. Reviewed construction documents, installation records, local building codes, and manufacturer installation & maintenance instructions to determine causes for the failure of the subject expansion tank.

### **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.



## **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 appliances. Evaluated system design and installation with respect applicable codes & standards, and determined 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.