



**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 ten years of experience in the design & failure analysis of HVAC, refrigeration, fire protection, dust collection, and building piping systems. He is routinely called-upon to assess design and construction defects, code compliance, and to evaluate the standard of care regarding inspection, testing, and maintenance issues.

With a background in both thermal-fluids and materials sciences, Mr. Sanders analyzes failures of entire systems, as well as those of system components and equipment. He consults on issues involving corrosion and materials selection, and investigates failures of individual 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).

In addition to his investigative projects, Mr. Sanders works directly with both product manufacturers and industrial clients to improve the performance and reliability of their products. From reviewing product design and manufacture, to analyzing failures and performing customized testing, he helps clients better understand the factors affecting their product's performance and implement cost-effective solutions to the problems they face.

**Areas of Specialization**

- Heat Transfer, Thermodynamics, and Fluid Mechanics
- Materials Testing & Failure Analysis
- Heating, Ventilating, and Air Conditioning (HVAC) & Indoor Environmental Quality (IEQ)
- Commercial and Industrial Refrigeration
- Heat Exchangers, Piping, Tubing, Insulation Systems, Valves, Fittings, and Fasteners
- Fire Protection Systems
- Industrial Dust Collection Systems & Dust Hazard Analysis (DHA)
- Industrial Machinery Accident Investigation and 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 Missouri	License No. 2012000813
State of Illinois	License No. 062.064555
State of Alabama	License No. 33550-E
State of Texas	License No. 133138
NCEES Record	Record No. 49228

*February 2019*

## **Professional Affiliations/Honors**

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

Mechanical Systems Insulation Technical Committee (TC 1.8), 2015 – Present  
Refrigerant Piping, Controls, and Accessories Technical Committee (TC 10.3), 2015 – Present  
TC 10.3 Research Subcommittee Chair, 2016 – 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**

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.  
Buildings in Balance: IEQ and Energy Efficiency, April 17, 2014, ASHRAE.  
Lessons from Failures of Building Envelopes, April 10, 2014, ASCE.  
Law of Construction Defects and Failures, April 4, 2014, HalfMoon Education Inc.  
Assessing Building Energy Performance, April 18, 2013, ASHRAE.  
Chilled Water Systems, Equipment and Optimization, December 7, 2012, ASHRAE.  
Dedicated Outdoor Air Systems, April 19, 2012, ASHRAE.  
Seismic Restraint Design, December 9, 2011, ASHRAE.

## Publications

“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, Vol. 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, Vol. 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, Vol. 12, Issue 2, April 2012

## Presentations

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

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

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

“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.

## 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.

## **Selected Project Experience**

### **HVAC Systems & Equipment**

Investigated reports of carbon monoxide poisoning from various residential fuel gas-fired appliances. Analyzed the design, installation and operation of various fuel gas-fired appliances.

Evaluated code compliance of a residential HVAC system following fatal carbon monoxide poisoning of occupants. Reviewed local ordinances, codes, standards and recommended practices to establish the standard of care for the inspection & testing of the home's gas-fired appliances and HVAC system.

Investigated reported health effects, and alleged excessive humidity and mold growth in a residential HVAC system. Inspected residence, HVAC units, and replacement HVAC system. Reviewed applicable ordinances, codes, standards & recommended practices to establish the standard of care for the design, construction, & remediation of the subject HVAC system. Evaluated recorded humidity levels and factors affecting indoor environmental quality (IEQ).

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.

Investigated alleged vandalism to geothermal HVAC equipment, resulting in reported system mal-performance. Assessed system design, reported problems and subsequent repair efforts.

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.

Investigated a leak from a glycol-cooled 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.

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, optimized, manufactured, and tested custom heat transfer components. Developed computer model to predict component & system thermal hydraulic performance.

### **Refrigeration Systems & Equipment**

Investigated the frost-heave failure of a spiral freezer in a food processing 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 ventilated floor in a frozen food warehouse. Reviewed building drawings, inspected the subject warehouse, analyzed floor construction and insulation materials. Determined root cause for failure of the concrete warehouse floor.

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.

Investigated the failure of an ammonia/carbon dioxide (NH<sub>3</sub>/CO<sub>2</sub>) 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 the failure of an ammonia refrigeration system at a refrigerated food storage 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, industry standards, and the operation and maintenance (O&M) management program for the refrigeration system.

### **Fire Protection Systems & Equipment**

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.

Investigated the failure of a water-based, dry-pipe fire sprinkler system at an industrial facility. Reviewed system design, system inspection & testing documents and alarm monitoring company records. Assessed system testing, inspection and maintenance compliance with local codes and applicable standards.

Investigated a water-based fire sprinkler system failure in a regional mall. Reviewed system design, drawings and maintenance records, as well as fire alarm/signaling system records.

Investigated series of water-based fire sprinkler failures in a high-rise condominium building. Reviewed system design, drawings and maintenance records. Conducted laboratory testing to evaluate sprinkler performance.

Investigated the failure of a water-based fire sprinkler in a condominium building. Reviewed system design, drawings, and sprinkler head installation. Assessed sprinkler head installation compliance with local codes and applicable standards.

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.

### **Building Piping Systems & Equipment**

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 freeze failure of plastic water piping within a commercial office. Inspected the subject building, HVAC system, and water piping. Determined the failure mode of and root cause for the subject water piping.

Investigated the alleged freeze failure of water piping installed within an attic. Reviewed historical local weather data and performed heat transfer analysis to determine how long it would take for the subject pipe to freeze when exposed to the reported weather conditions.

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**

Analyzed the effect of hail damage on the performance of process piping insulation at petrochemical facility.

Performed failure analysis of corroded pipe section in a process ammonia system.

Performed failure and materials analysis of corroded ethanol vaporizer heat exchanger tubes. Researched and recommended alternative materials for increased corrosion resistance.

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.

Evaluated the design and performance of an industrial pneumatic scrap/dust conveyance system.

Analyzed the design of an inflation system for a field-deployable military aircraft fuel tank system and optimized system duct and fitting design to minimize inflation/deflation time.

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.

**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.)

Performed failure analysis of wire mesh face shield due to impact from a foreign object. Determined if subject face shield met specification and evaluated potential alternative face shields.

Tested the performance and analyzed the design of various outdoor recreation/sporting good products such as: 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 the failure of snap fasteners on protective sport helmets. Evaluated snap design, materials and manufacture. Compared subject snaps to previous version and competitor snaps. Identified material issue and recommended corrective course of action to client.

Investigated a personal injury involving the use of an extension ladder against a modular structure. Analyzed structure design. Reviewed accident description and accounts. Established manner in which the subject ladder had to have been used to result in the accident as it was described to have occurred.

Investigated a personal injury involving the use of an extension ladder inside a residence. Reviewed accident description and accounts. Established manner in which the subject ladder had to have been used to result in the accident as it was described to have occurred.

Investigated a personal injury resulting from the reported tip-over of a newspaper vending machine at a restaurant. Inspected the subject machine, analyzed its design and stability, performed testing to measure its stability, and determined the causes for the tip-over accident.