



INNOVATING NUCLEAR TECHNOLOGY

ANALYSIS AND MEASUREMENT SERVICES CORPORATION

## BRENT D. SHUMAKER

### *Senior Engineering Manager*



#### EDUCATION & CERTIFICATIONS

MSc, Computer Science,  
University of Texas–San Antonio  
(2001)

BSc, Electrical Engineering,  
University of Tennessee–Knoxville  
(1997)

Certification—LabVIEW software  
developer (since 2003)

**BRENT D. SHUMAKER** is Senior Engineering Manager at AMS, responsible for leading the development of software applications for instrumentation and control (I&C) system testing in nuclear power plants. A Certified LabVIEW Developer, Mr. Shumaker has been with AMS as a full-time senior engineer since 2001.

Mr. Shumaker is co-author of 6 awarded U.S. patents (with 1 pending), and the co-author of more than 50 journal articles and industry publications, including standards for the International Society of Automation (ISA) and reports for the Electric Power Research Institute (EPRI). Specifically, he is serving as the co-chairman of a standard committee of the ISA updating the 67.06 standard entitled, “Performance Monitoring for Nuclear Safety-Related Instrument Channels in Nuclear Power Plants,” and as a voting member of the 67.04 standard committee on “Setpoints for Nuclear Safety-Related Instrumentation.”

Mr. Shumaker has been involved in numerous industry conferences, serving in various capacities from technical session chair to main presenter. He has also participated in international activities for the International Atomic Energy Agency (IAEA), is a member of the American Nuclear Society (ANS), and a fellow of ISA.

Mr. Shumaker has served as the principal investigator for a number of SBIR projects focused on developing technologies for advanced monitoring and diagnostics of nuclear I&C systems. He is part of an invited team of international experts developing a Nuclear Energy Series document for IAEA entitled, “Dependability Assessment of Software for Safety Instrumentation and Control Systems at Nuclear Power Plants”. In addition, he currently serves as a key team contributor on the DOE Nuclear Energy Enabling Technologies (NEET) project entitled, “Development and Demonstration of a Model Based Assessment Approach for Qualification of Embedded Digital Devices in Nuclear Power Applications,” which is being conducted as a joint effort between AMS and researchers from the University of Tennessee–Knoxville, Ohio State University, and Virginia Commonwealth University.

Prior to joining AMS, Mr. Shumaker worked as a software engineer for the Guidance and Navigation Operations Divisions of Honeywell, Inc. in Clearwater, Florida, where he developed software for real-time embedded inertial navigation systems. He completed his graduate work in Computer Science at the University of Texas–San Antonio in 2001.



## **Professional Affiliations**

- Fellow, International Society of Automation (ISA)
- Member, American Nuclear Society (ANS)
- Second Vice Chair of Human Factors Instrumentation and Control Division (HFICD) of ANS
- Chief Scientific Investigator (CSI) for IAEA Coordinated Research Project on Advanced Surveillance, Diagnostics, and Prognostics Techniques used for Health Monitoring of Systems, Structures and Components in Nuclear Power Plants
- Participated in the writing and review of IAEA Nuclear Energy Series, “On-line Monitoring for Improving Performance of Nuclear Power Plants Part 2: Process and Component Condition Monitoring and Diagnostics”
- Participated in the writing and review of the IAEA Nuclear Energy Series, “Dependability Assessment of Software for Safety Instrumentation and Control Systems at NPPs
- Co-Chair of ISA 67.06 standard committee on “Performance Monitoring for Nuclear Safety-Related Instrument Channels in Nuclear Power Plants”
- Voting member of ISA 67.04 standard committee on “Setpoints for Nuclear Safety-Related Instrumentation”

## **Patents**

### **AWARDED**

Shumaker, B.D., Hashemian, H.M., Morton, G.W., Beverly, D.D., Sexton, C.D., “Automated System for On-Line Monitoring and Diagnostics of Rod Position Indication Coils for Nuclear Power Plants.” Patent No. US 9,697,916 (July 2017).

Morton, G.W., Hashemian, H.M., Shumaker, B.D., Beverly, D.D., Sexton, C.D., “High Resolution Digital Rod Position Indication System for Nuclear Power Plants.” Patent No. US 8,903,033 B2 (December 2014).

Sexton, C.D., Beverly, D.D., Morton, G.W., Hashemian, H.M., Shumaker, B.D., “Control Rod Position Indication Systems and Methods for Nuclear Power Plants.” Patent No. US 8,824,617 B2 (September 2014).

Hashemian, H.M., Morton, G.W., Shumaker, B.D., Beverly, D.D., Sexton, C.D., “Advanced Digital Control Rod Position Indication System with Rod Drop Monitoring for Nuclear Power Plants.” Patent No. US 8,351,561 B2 (January 2013).

Shumaker, B.D., Morton, G.W., Hashemian, H.M., “In-Service Calibration of Temperature Measurement Devices Using Plant Monitoring System Data.” Patent No. US 7,739,067 (June 2010).

Morton, G.W., Shumaker, B.D., Hashemian, H.M., “Cross-Calibration of Plant Instruments with Computer Data.” Patent No. US 7,295,944 (November 2007).

### **PENDING**

Hashemian, H.M., Shumaker, B.D., Morton, G.W., “Systems and Methods of Monitoring Operation of Control Rod Mechanisms of Nuclear Power Plants.” Patent Application Publication No. US 2015/625,005 (June 2017).



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***Brent D. Shumaker***

## **National Conference Presentations**

Morton, G.W., Shumkaer, B.D., McCarter, D.E., Hashemian, H.M., “Pressure Sensing Line Blockage and Degradation in Nuclear Power Plants.” Proceedings of the American Nuclear Society Winter Meeting, Washington, D.C. (November 17–21, 2019).

McConkey, B., Jones, T., Zarb, P., Shumaker, B.D., “Practical Considerations for Intermittent Fault Detection in Nuclear Power Plant Circuits.” Proceedings of the American Nuclear Society Winter Meeting, Washington, D.C. (November 17–21, 2019).

Wood, R., Shumaker, B., Smidts, C., Elks, C., “An Approach to Model-Based Testing of Instrumentation with an Embedded Digital Device.” American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Morton, G., Shumaker, B., McCarter, D., Caylor, S., “Reliability and Fault Tolerance Testing of a Nuclear Power Plant Digital Rod Position Indication Coil Diagnostic System.” American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Shumaker, B., Hashemian, H., “Resolving the Regulatory Issues with Implementation of Online Monitoring Technologies to Extend Calibration Intervals of Process Instruments in Nuclear Power Plants”, American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Shumaker, B., O’Hagan, R., Seals, O., Olson, R., “Applications of On-Line Monitoring Within the Southern Nuclear Fleet”, American Nuclear Society 11th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Orlando, FL (February 9–14, 2019).

Shumaker, B.D., Hashemian, H.M., Kiger, C.J., Hashemian, A.H., “Management of Aging of Reactor Internal Components.” Proceedings of the American Nuclear Society Annual Meeting, Philadelphia, PA (June 17–21, 2018).

Ramuhalli, P., Coble, J., Shumaker, B., “Robust Online Monitoring Technologies for Nuclear Power Plant Sensors.” Proceedings of the American Nuclear Society Annual Meeting, Philadelphia, PA (June 17–21, 2018).

Riggsbee, E.T., Hashemian, A.H., Shumaker, B.D., Tyler, S., Zarb, P.E., “Development of Thermal Transit Flow Measurement for SMRs.” American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).

Erickson, P., O’Hagan, R.D., Shumaker, B.D., Hashemian, H.M., “On-Line Monitoring of I&C Transmitters and Sensors for Calibration Verification and Response Time Testing was Successfully Implemented at ATR.” American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).

Goffin, P., Shumaker, B.D., Hashemian, A.H., Morton, G.W., “On-Line Monitoring for Static and Dynamic Performance Verification of I&C Systems at Sizewell B Nuclear Power Station.” American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).



## *Brent D. Shumaker*

### **NATIONAL CONFERENCE PRESENTATIONS (cont.)**

Morton, G.W., Shumaker, B.D., McCarter, D.E., Caylor, S.D., Rich, J.T., “Application of Quantitative Methods for Reliability Testing of a Nuclear Power Plant Digital Rod Position Indication Diagnostic System.” American Nuclear Society 10th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), San Francisco, CA (June 11–15, 2017).

Shumaker, B.D., McCarter, D.E., Bond, N.A., Hashemian, H.M., “Comparison of Prognostic Techniques for Estimating the Remaining Useful Life of Nuclear Plant Components.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Kapernick, J.R., Upadhyaya, B.R., Eckleberry, T.A., Hines, J.W., Shumaker, B.D., Hashemian, H.M., “Dynamic Modeling of a Small Modular Reactor for Control and Monitoring.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

O’Hagan, R.D., Hashemian, H.M., Shumaker, B.D., Riggsbee, E.T., “Implementation of On-Line Monitoring to Optimize I&C Maintenance: A Case Study.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Riggsbee, E.T., Shumaker, B.D., Hashemian, H.M., Mayo, C.W., “Development and Application of Loose Parts and Acoustical Structural Monitoring During Plant Startup Following Steam Generator Replacement.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Morton, G.W., Shumaker, B.D., Cady, B.H., Hashemian, H.M., “Quantitative Methods for Reliability and Fault Tolerance of Digital Instrumentation and Control Systems.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Thomasson, T.C., Shumaker, B.D., Hashemian, H.M., Kapernick, J.R., Upadhyaya, B.R., Hines, J.W., Keyhani, M., “First Principles Model of a Simulation Flow Loop in Support of On-Line Monitoring Implementation in Next Generation Nuclear Power Plants.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Ramuhalli, P., Konomi, B., Coble, J., Shumaker, B., Lin, G., Hashemian, H.M., “Uncertainty Quantification Methods for Robust Online Monitoring and Recalibration Interval Extension.” American Nuclear Society 9th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human–Machine Interface Technologies (NPIC & HMIT), Charlotte, NC (February 23–26, 2015).

Hashemian, H.M., Morton, G.W., Shumaker, B.D., Caylor, S.D., “On-Line Monitoring with Auto-Regressive Modeling in Boiling Water Reactors.” 2013 American Nuclear Society Annual Meeting, Atlanta, GA (June 16–20, 2013).

Hashemian, H.M., Shumaker, B.D., Ledlow, J.B., O’Hagan, R.D., McCarter, D.E., “Remaining Useful Life Estimation of Electric Cables in Nuclear Power Plants.” 2013 American Nuclear Society Annual Meeting, Atlanta, GA (June 16–20, 2013).

Hashemian, H.M., Mitra, C., Shumaker, B.D., Upadhyaya, B.R., “Online Monitoring in Small Modular Reactors (SMRs).” 2013 American Nuclear Society Annual Meeting, Atlanta, GA (June 16–20, 2013).



***Brent D. Shumaker***

**NATIONAL CONFERENCE PRESENTATIONS (cont.)**

Hashemian, H.M., Shumaker, B.D., O'Hagan, R.D., Ledlow, J.B., McCarter, D.E., "Application of Prognostic Methods for Predicting Remaining Useful Life of Nuclear Plant Equipment and Components." American Nuclear Society 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), San Diego, CA (July 22-26, 2012).

Hashemian, H.M., Shumaker, B.D., Morton, G.W., Caylor, S.D., "On-Line Monitoring Implementation in Boiling Water Reactors." American Nuclear Society 8th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), San Diego, CA (July 22-26, 2012).

Shumaker, B.D., Campbell, C.J., Sexton, C.D., Morton, G.W., McConkey, J.B., Hashemian, H.M., "Cable Condition Monitoring for Nuclear Power Plants." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8-9, 2012).

Coble, J., Ramuhalli, P., Meyer, R., Hashemian, H.M., Shumaker, B., Cummins, D., "Calibration Monitoring for Sensor Calibration Interval Extension." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8-9, 2012).

Hashemian, H.M., Kiger, C.J., Shumaker, B.D., Johnson, W.S., "Expanding the Capabilities of Wireless Condition Monitoring Sensors into the Containment of Pressurized Water Reactors." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8-9, 2012).

Kiger, C.J., Shumaker, B.D., "Managing the Electromagnetic Compatibility and Wireless Coexistence Concerns for the Implementation of Existing and Future Wireless Technologies in Nuclear Power Plants." Future of Instrumentation International Workshop (FIIW), Instruments, Sensors and Measurements for Energy Generation, Delivery and Consumption, Gatlinburg, TN (October 8-9, 2012).

Hashemian, H.M., Shumaker, B.D., Wunderlich, R.J., Caylor, S.D., Morton, G.W., "An Integrated System for Static and Dynamic On-Line Monitoring of Nuclear Power Plant Systems and Components." American Nuclear Society 7th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), held concurrently with the ANS National Meeting, Las Vegas, NV (November 2010).

Hashemian, H.M., Morton, G.W., Caylor, S.D., Shumaker, B.D., "Advanced Digital Rod Position Indication System for Existing and Next Generation Nuclear Reactors." American Nuclear Society 7th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), held concurrently with the ANS National Meeting, Las Vegas, NV (November 2010).

Hashemian, H.M., Kiger, C.J., Seibel, J.C., Shumaker, B.D., Feltus, M.A., "Wireless Technologies for Nuclear Facilities." American Nuclear Society 2009 Annual Meeting, Atlanta, GA (June 14-18, 2009).

Hashemian, H.M., Morton, G.W., Shumaker, B.D., "Advanced Digital Rod Position Indication System for Existing and Next Generation Nuclear Reactors." New Nuclear Frontiers 2009 Conference (30th Annual CNS Conference), Calgary, Canada (May 31-June 3, 2009).

Hashemian, H.M., Kiger, C.J., Morton, G.W., Shumaker, B.D., Carter, C., Feltus, M.A., "Wireless Sensor Applications in Nuclear Power Plants." American Nuclear Society 6th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), Knoxville, TN (April 5-9, 2009).



## *Brent D. Shumaker*

### **NATIONAL CONFERENCE PRESENTATIONS (cont.)**

Morton, G.W., Hashemian, H.M., Shumaker, B.D., Wunderlich, R.J., "Assessing the Dynamic Performance of Sensors in Nuclear Power Plants Using Low Frequency Plant Computer Data." American Nuclear Society 6th International Topical Meeting on Nuclear Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), Knoxville, TN (April 5-9, 2009).

Jarrett, R.A., Hashemian, H.M., Shumaker, B.D., "Integrating On-Line Performance Monitoring in New Nuclear Reactor Designs." 51st ISA Annual Power Industry Division (POWID) Symposium, Scottsdale, AZ (June 2008).

Hashemian, H.M., Shumaker, B.D., Morton, G.W., Kiger, C.J., "Wireless Sensors for Equipment and Process Condition Monitoring in Nuclear Power Plants." 51st ISA Annual Power Industry Division (POWID) Symposium, Scottsdale, AZ (June 2008).

Hashemian, H.M., Shumaker, B.D., Sexton, C.D., Beverly, D.D., Morton, G.W., Riggsbee, E.T., "Neutron Detector Life Extension Through Predictive Maintenance." 17th Annual Joint ISA POWID/EPRI Controls and Instrumentation Conference, Pittsburgh, PA (June 2007).

Shumaker, B.D., Hashemian, H.M., "Comparison of Process Estimation Techniques for On-Line Calibration Monitoring." American Nuclear Society (ANS) International Topical Meeting on Nuclear Power Plant Instrumentation, Control and Human-Machine Interface Technologies (NPIC & HMIT), held concurrently with the ANS National Meeting, Albuquerque, NM (November 2006).

## **Publications**

### **U.S. GOVERNMENT PUBLICATIONS**

Coble, J.B., Meyer, R.M., Ramuhalli, P., Bond, L.J., Hashemian, H.M., Shumaker, B.D., Cummins, D.S., "A Review of Sensor Calibration Monitoring for Calibration Interval Extension in Nuclear Power Plants", Pacific Northwest National Laboratory, Report Number PNNL-21687, U.S. Department of Energy Contract DE-AC05-76RL01830 (August 2012).

### **EPRI REPORTS**

"On-Line Calibration Monitoring of Safety-Related Pressure Transmitters at Watts Bar Unit 1." EPRI Final Report (January 2010).

"Implementation of On-Line Monitoring to Extend the Calibration Interval of Pressure Transmitters in Nuclear Power Plants." EPRI, Palo Alto, CA. 1019188 (December 2009).

"Plant Application of On-Line Monitoring for Calibration Interval Extension of Safety-Related Instruments: Update Report 2008." EPRI, Palo Alto, CA, and British Energy, Suffolk, UK. 1016723 (December 2008).

"Requirements for On-Line Monitoring in Nuclear Power Plants." EPRI, Palo Alto, CA. 1016725 (December 2008).

"Plant Application of On-Line Monitoring for Calibration Interval Extension of Safety-Related Instruments: Volume 3: 2007 Update Report." EPRI, Palo Alto, CA, and British Energy, Suffolk, UK. 1015173 (December 2007).

"Plant Application of On-Line Monitoring for Calibration Interval Extension of Safety-Related Instruments: Volume 1." EPRI, Palo Alto, CA, and British Energy Group PLC, Suffolk, UK. 1013486 (December 2006).

"Plant Application of On-Line Monitoring for Calibration Interval Extension of Safety-Related Instruments: Volume 2." EPRI, Palo Alto, CA, and British Energy Group PLC, Suffolk, UK. 1013486 (December 2006).



**Brent D. Shumaker**

### IAEA PUBLICATIONS

“Advanced Surveillance, Diagnostic and Prognostic Techniques in Monitoring Structures, Systems and Components in Nuclear Power Plants.” IAEA Nuclear Energy Series No NP-T-3.14, Vienna, Austria (September 2013).

“On-Line Monitoring for Improving Performance of Nuclear Power Plants Part 2: Process and Component Condition Monitoring and Diagnostics.” IAEA Nuclear Energy Series No. NP-T-1.2, Vienna, Austria (September 2008).

### INDUSTRY STANDARDS

*(Standards in which Mr. Shumaker has directly contributed.)*

ISA RP67.04.02-2010—“Methodologies for the Determination of Setpoints for Nuclear Safety-Related Instrumentation.” The Instrumentation, Systems, and Automation Society (ISA) (2010).

ANSI/ISA-67.04.01-2006(R2011)—“Setpoints for Nuclear Related Instrumentation.” The Instrumentation, Systems, and Automation Society (ISA) (October 2011).

### JOURNAL & MAGAZINE ARTICLES

Shumaker, B.D., “Extending the Calibration Intervals of Process Instruments.” *Nuclear Plant Journal*, Vol. 36, No. 1 (February 2018).

Shumaker, B.D., Morton, G.W., “Development of an Automated Software Reliability Tester for Digital I&C.” *Transactions of the American Nuclear Society*, Vol. 114, pp. 307–309 (June 2016).

McCarter, D.M., Shumaker, B.D., McConkey, J.B., Hashemian, H.M., “Nuclear Power Plant Instrumentation and Control Cable Prognostics Using Indenter Modulus Measurements.” *International Journal of Prognostics and Health Management*, Vol. 5 (Special Issue Nuclear Energy PHM) 016 (December 2014).

Shumaker, B.D., McCarter, D.M., Hashemian, H.M., O’Hagan, R.D., “Frequency Domain Reflectometry for Remaining Useful Life Estimation of Instrumentation and Control Cables.” Proceedings of the Institution of Mechanical Engineers, Part O: *Journal of Risk and Reliability* (August 2014).

Shumaker, B.D., Ledlow, J.B., O’Hagan, R.D., McCarter, D.E., Hashemian, H.M., “Remaining Useful Life Estimation of Electric Cables in Nuclear Power Plants.” *Chemical Engineering Transactions*, Vol. 33 (September 2013).

Hashemian, H.M., Shumaker, B.D., Morton, G.W., “An Integrated Health Monitoring System for Fission Surface Reactors.” SciVerse Sciences International Forum-2012, *Physics Procedia*, Vol. 38, pp. 164–175 (November 2012).

Coble, J., Meyer, R., Ramuhalli, P., Bond, L., Shumaker, B., Hashemian, H.M., “Extending Sensor Calibration Intervals in Nuclear Power Plants.” *Transactions of the American Nuclear Society*, Vol. 107 (November 2012).

Hashemian, H.M., Kiger, C.J., Morton, G.W., Shumaker, B.D., “Wireless Sensor Applications in Nuclear Power Plants.” *Nuclear Technology*, Vol. 173, No. 1, pp. 8–16 (January 2011).

Hashemian, H.M., Morton, G.W., Shumaker, B.D., Kiger, C.J., “Nuclear Power Comeback Sure to Employ Wireless Tools.” *InTech Magazine*, an ISA publication (January 2009).