

ANS HFICD

SPRING 2017 NEWSLETTER

<http://hfcd.ans.org>

10TH NPIC-HMIT TOPICAL MEETING



HFICD is pleased to host the 10th International Topical Meeting on Nuclear Plant Instrumentation and Control and Human Machine Interface Technologies (NPIC-HMIT) at the ANS Annual meeting in San Francisco, 11-15 June 2017. Join your I&C and HF/HMI colleagues for nine plenary speakers, nine panel sessions, and 255 technical presentations.

The plenary program includes international experts in instrumentation and controls, human factors, and human machine interface, including speakers from Department of Energy Office of Nuclear Energy, Nuclear Regulatory Commission, NuScale Power, Southern Nuclear, and the International Atomic Energy Agency.

In addition to the robust schedule of technical paper presentations, nine panel sessions provide an opportunity to interact with leading researchers, funders, and practitioners in nuclear I&C and HMI/HF. Session topics include I&C for dry cask storage; the future generation of I&C specialists; NRC regulations for human factors and human machine interface; robotics for maintenance in advanced reactors; and

I&C research sponsored by DOE-NE, NRC, and EPRI. Several panels devoted to various aspects of digital I&C include human factors engineering for digital controls and control rooms; NRC regulations for digital I&C systems; and digital I&C applications in operating facilities. In addition to the NPIC/HMIT tracks, there will be two general HF/I&C sessions and a panel on cybersecurity in the main conference.

Join us for the meeting banquet on Tuesday evening at 7:00 PM in the Grand Ballroom B/C. Robert Stone, director of *Pandora's Promise*, will give the banquet talk. We will also be presenting our division awards and recognizing division members recently elevated to ANS Fellows. It promises to be an exciting dinner for all. Tickets for the banquet can be purchased on site at the registration desk.

The embedded topical will be preceded by a two-day training course on digital I&C qualification and licensing on Saturday and Sunday, June 10-11, described on page 10 of this newsletter. Seats are still available; register for the training course at npic-hmit2017.org.

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THOUGHTS FROM THE CHAIR

—Jamie Coble



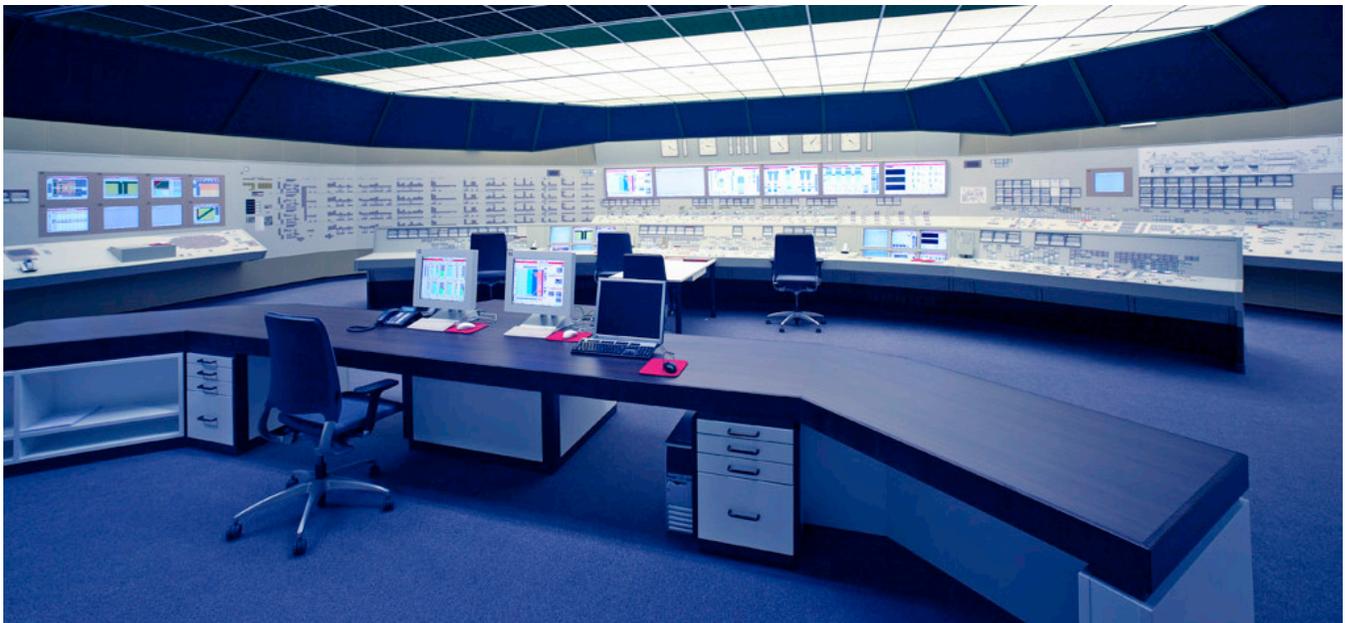
Greetings, HFICD members. We've had an exciting year in 2016-2017 and accomplished a lot as a division. We have established the Joseph Naser Undergraduate Scholarship (see page 4 for an introduction to the inaugural winner) and the Ted Quinn Early Career Award. We are hosting the 10th NPIC-HMIT conference at the 2017 ANS Annual Meeting. We continue to have strong membership as a division and are investigating programs to continue to grow our numbers with utilities, industry, government agencies and research enterprises.

Thank you for allowing me to serve as the HFICD chair over the last year. I have greatly enjoyed working closely with our outstanding division to continue to establish our division as the leading voice in ANS for

advancing and promoting measurement and control technologies and the interface between operators, controls, and instrumentation. I&C and HF advances represent the greatest opportunity for controlling the day-to-day costs of nuclear power in the United States and internationally; we are leading the charge to support economic deployment of NPPs. I look forward to continuing to work with you all to *deliver the nuclear promise* worldwide. I hope that you all will join me in supporting the HFICD by volunteering for one of our standing committees, supporting the planning of NPIC-HMIT 2019, and presenting your good works at future ANS national meetings and topical.

Kind Regards,

Jamie Coble
University of Tennessee
HFICD Chair, 2016-2017





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2017 UHRIG FELLOW: FAN ZHANG



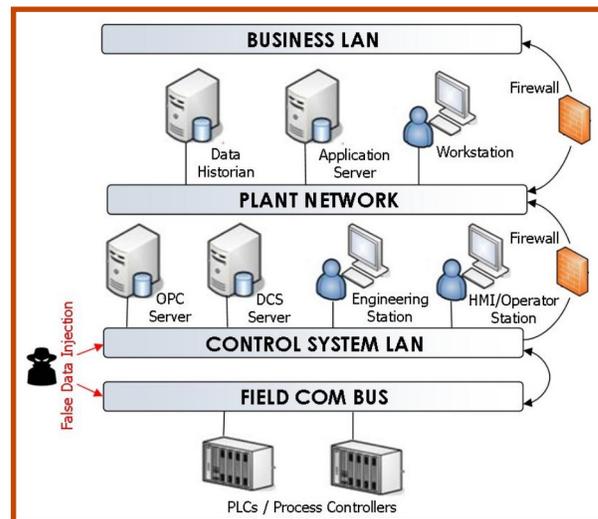
Cybersecurity for Nuclear Power Plants

Fan Zhang, a PhD student at the University of Tennessee-Knoxville, was selected as the 2017 Robert E. Uhrig Graduate Fellowship recipient. Zhang completed her undergraduate degree at North China Electric

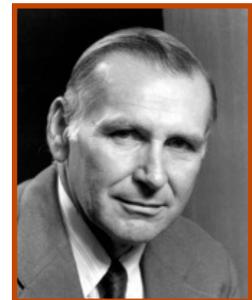
Power University in Nuclear Engineering and Technology in 2013 and her Master of Engineering degree in Nuclear Energy Science and Engineering from the same school in 2016. She began her PhD work in Nuclear Engineering at UTK in August, 2016 working with Dr. Jamie Coble and Dr. Wes Hines on developing a high fidelity simulation model of a once-through steam generator in MATLAB/Simulink. Her research has recently shifted focus to cybersecurity applications in nuclear power plants and other industrial systems. Zhang describes her research interests below.

The rapid proliferation of internet threats will bring more demand for cybersecurity in the industry and the current implementation of Supervisory Control and Data Acquisition (SCADA) systems in nuclear power plant, which introduces some unique security vulnerabilities created by both human workers, operators and software implementation and opens the door to a host of threats, which if exploited can cause failures in the I&C system. In my opinion the significance and the need for combination of cybersecurity with I&C of NPPs is substantial and not sufficient research has been done in this field yet. So, I would like to do research on it and contribute to promote this cross-discipline area. I would like to develop a real-time intrusion detection system (IDS) for SCADA system in practical use. The data will be analyzed once received based on pattern recognition

methods. The most useful method will be chosen for distinguishing different SCADA attacks on-line, such as tempering and deny of service (DOS).



HFICD established the Robert Uhrig Graduate Fellowship in 2014 to honor the career and achievements of Dr. Bob Uhrig. Dr. Uhrig led a distinguished career at University of Florida, Florida Power and Light, Oak Ridge National Laboratory, and the University of Tennessee-Knoxville. Dr. Uhrig's work prior to his retirement in 2002 was primarily in the development and application of artificial intelligence in nuclear power systems. Applications for the Robert Uhrig Graduate Fellowship are due each year on February 1. Graduate students pursuing research in instrumentation and controls and/or human factors and human-machine interface are encouraged to apply.

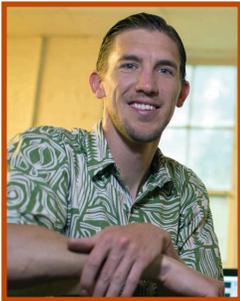




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2017 NASER SCHOLAR: AUSTIN SAINT-VINCENT



Austin Saint-Vincent was selected as the inaugural Joseph Naser Undergraduate Scholarship winner. Saint-Vincent is a rising Senior at the University of Tennessee-Knoxville, where he works with Dr. Jamie Coble in research related to online monitoring

and equipment condition assessment.

“The prognostics group gathers data from industry related equipment/systems (motors, bearings, pumps, flow loops, etc.) and attempts to identify trends and modes of failure in those components,” Saint-Vincent said. “The goal is to develop predictive technology that industry can employ to increase the longevity and decrease superfluous expenditure in the maintenance of their equipment/system components.”

Before enrolling at the University of Tennessee, Saint-Vincent enlisted in the United States Navy where he served in the Reactor Controls division of the Nuclear Navy.

After completing his BS in May, 2018, Saint-Vincent hopes to move into the nuclear industry workforce

with a focus on international applications of I&C: “As the nuclear age progresses, developing countries will desire to be a part of it. I am fond of travel and have done much already. If the chance arises to assimilate new I&C technologies internationally, it would be all the better. There are many new reactor types and plant models that are up-and-coming. The need for more advanced safety and control instrumentation has never been more pressing.”

HFICD established the Joseph Naser Undergraduate Scholarship in 2016 to honor the past chair upon his retirement after 42 years with the Electric Power Research Institute. Dr. Naser dedicated much of his career to studying human factors, behavioral



sciences, and instrumentation systems for nuclear plant operations and control room design. Applications for the Joseph Naser Undergraduate Scholarship are due each year on February 1. Undergraduate students interested in instrumentation and controls and/or human factors are encouraged to apply.





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HFICD STUDENT BEST PAPER AWARDS

2017 ANS STUDENT CONFERENCE



Gokhan Corak
Penn State University

Penn State Breazeale Reactor Control System Replacement: System Development and Hardware-In-The-Loop Testing

The current reactor control system used at the Penn State Radiation Science and Engineering Center (RSEC) was installed in 1991. Due to its age, repairs and maintenance are increasing in cost and system components

are becoming obsolete. To avoid future problems, arrangements were made at the RSEC to begin the process of transitioning towards a new and potentially more-robust control system. Schneider Electric Inc. donated a Foxboro distributed control system to the RSEC for instrumentation and control education and as an option for the inevitable control system replacement.

A LabVIEW program was developed to simulate the PSU TRIGA reactor behavior and for Hardware-In-The-Loop (HIL) testing of control algorithms in the Foxboro equipment. This simulation was based on point kinetics and core-averaged thermal-hydraulic equations. Variables, such as relative neutron concentration, fuel temperature, and coolant temperature, were calculated by numerically integrating the corresponding differential equations using Euler integration. Data necessary for validating the HIL reactor model was obtained from reactor operating data. A National Instruments compact real-time input-output (cRIO) controller with a 40 MHz real-time processor runs the TRIGA model, and a high-speed Field Programmable Gate Array (FPGA) is used for input/output signal operations. LabVIEW transfers the resulting data to the cRIO's FPGA hardware and NI I/O modules, which is the interface to the Foxboro equipment. The cRIO outputs voltage or current for use by the Foxboro.

In addition to developing the reactor simulation and HIL testing capabilities, control system logic was implemented in the Foxboro Control System language using Foxboro's Integrated Control Configurator (ICC). All the necessary blocks for control system implementation, such as the calculation (CALCA), logic (OR, AND) and analog input/output blocks were combined and configured using the ICC. The PID block controls the TRIGA reactor power by calculating the difference between desired power level (i.e., setpoint) and actual power level, processing the error, and sending a positive or negative velocity demand to each control rod. To control the reactor simulation using the Foxboro, a graphical user interface (GUI) was created using Foxboro software FoxDraw and FoxView. The GUI was made similar to the existing control console interface so that operators would adapt quickly to the new system with minimal training. The interface has power and temperature indicators, control rod push buttons, control rod positions, manual/automatic mode buttons, 1-2-3 rod automatic mode selection and a SCRAM button to safely shutdown the reactor (simulation). Every component in the GUI has been connected to code running in the Foxboro Control system. Additional control features included in the Foxboro software are a control rod leveling algorithm and a reactor start-up rate controller (SUR). A TRICON safety system has also been added to the system to perform baseline safety functions.

HIL testing showed that the Foxboro controller could effectively reject disturbances and follow setpoint changes. These results match well with the performance of the existing control console at the RSEC, and suggest that the Foxboro would be an excellent candidate for a future replacement.



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HFICD STUDENT BEST PAPER AWARDS 2017 ANS STUDENT CONFERENCE



Lee Maccarone
University of Pittsburgh

An Investigation into the Unobservable Subspace of a Steam Generator System for Minimizing Cyber-Threats

By nature, nuclear power plants are vulnerable to several types, or classes of cyber-attacks. This work examined a specific class of cyber-attack in which the attacker compromised a system measurement and injected slight modifications to system control signals. We demonstrated that an agent with the ability to mask only one measurement in a U-tube steam generator system can have a significant impact on plant operation.

This work was conducted using a linear, time-invariant (LTI) state-space model of a U-tube steam generator in a PWR. The system measurements consist of the narrow range water level and wide range water level. According to the Kalman Decomposition Theorem (KDT), any LTI dynamic system can be decomposed in terms of the system's observability and controllability. By applying the KDT to the steam generator model, we uncovered a controllable but unobservable subspace that could be targeted in a cyber-attack.

We examined the effect of losing each individual measurement by applying the KDT to the resulting state-space systems. Compromising the narrow range measurement had a significant effect on the system, as only one out of four states retained observability. The narrow range water level measurement is

representative of both the mixture level of water and steam in the tube bundle and the downcomer water level. If the downcomer water level is too high, the exiting steam will become too moist, thereby reducing both turbine efficiency and the lifetime of the turbine blades. We simulated the effect of an attacker modifying the steam flow rate control signal such that the signal modifications would not exceed an alarm threshold monitored by an operator. Although these injections were small, they drove the unobservable states to unexpected values.

In this work, we have demonstrated how a cyber-attack that targets only one measurement in the steam generator system uncovers a fully controllable but unobservable space in this dynamic system. By applying the Kalman Decomposition Theorem, we have uncovered this nullspace where controller design can be implemented for attacking the steam generator system.

Visit us on the web at <http://hficd.ans.org>. Find more information about HFICD, read our past newsletters, or volunteer for one of our standing committees. Questions or comments? Use the *Contact Us* link.





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WHO IS HFICD?

The Human Factors, Instrumentation & Controls Division (HFICD) of the American Nuclear Society (ANS) is devoted to the human component of nuclear energy, along with the underlying instrumentation, control, and human-machine interface technologies. It is the leading division for advancing and promoting measurement and control technologies and the interface between operators, controls and instruments.

HFICD has been part of the ANS since 1979, when the Technical Group for Human Factors was formed. The Group became a division in 1985 and was broadened to include Instrumentation & Controls in 2008. Today, the HFICD has nearly 700 members, representing approximately 6% of ANS membership. Division members are found across all sectors of the nuclear field from utility, manufacturing, suppliers, consulting companies, national laboratories, government agencies, students, and educational institutions.

The current membership of HFICD is dominated by utilities and consulting companies, with roughly 15% of membership each.

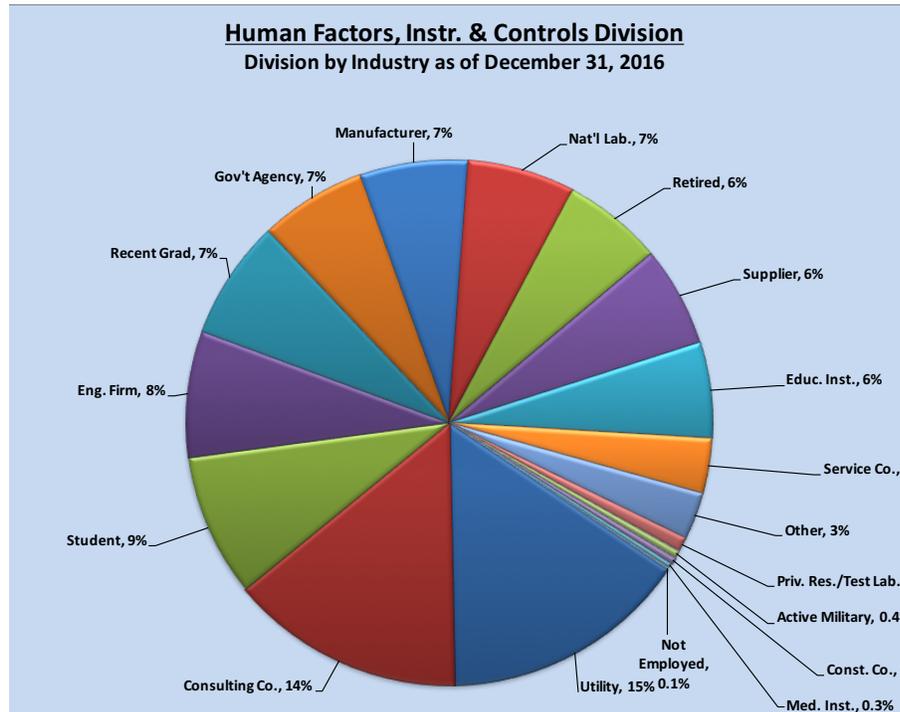
The HFICD focuses on the information processing, control, and human system interaction aspects of nuclear systems. This includes the sensors that transduce physical processes into signals, monitoring, control and communications systems that process data into information and manage control and protective actions, the interfaces that display plant operational and health information, and the human cognitive capabilities that enable perception and interpretation of

information.

HFICD has four primary missions:

- Provide a forum for the exchange of technical information for practitioners within the field
- Provide mechanisms for training and education for individuals entering the field or practitioners improving their skills
- Serve as an advocated for advancing HFIC technology and/or practice within the nuclear arena
- Serve as a point-of-access for external inquiries into nuclear HFIC technology and/or practices

If you have any suggestions for programs to help achieve these goals or want to volunteer to support HFICD, please contact Jamie Coble (jamie@utk.edu) to discuss new and ongoing initiatives.





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2016-2017 HFICD OFFICIALS

OFFICERS



Jamie B. Coble
CHAIR
Assistant Professor
Department of Nuclear Engineering
University of Tennessee



Sacit M. Cetiner
1st VICE CHAIR
R&D Staff
Oak Ridge National Laboratory



Raymond Herb
2nd VICE CHAIR
Southern Company



Brent D. Shumaker
SECRETARY
Senior Systems Engineer
AMS Corporation



Mehdi Tadjalli
TREASURER
Chief Engineer and Director
Enercon Federal Services, Inc.

EXECUTIVE COMMITTEE (NEW MEMBERS)



Johanna Oxstrand
Human Factors Scientist
Idaho National Laboratory



Richard Wood
Professor
University of Tennessee



Ted Quinn
President
Technology Resources

See the special section of the June 2017 issue of *Nuclear News* on human factors and instrumentation and controls for the latest advances in IEC cybersecurity standards, digital instrumentation modernization regulations from USNRC, and INL's research in human factors of control room modernization.

PAST HFICD CHAIRS



Sean M. Smith
2015-2016 CHAIR
Embedded Software Engineer
Lockheed Martin Corp.



John Mahoney
2014-2015 CHAIR
President and COO
High Expectations International, LLC



Joseph Naser
2013-2014 CHAIR
Retired
formerly, EPRI



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HFICD Executive Committee

2016-2017 Student Representative

Zach Welz, University of Tennessee

Term Ending in 2017

Leroy Hardin
J. Wesley Hines
Raymond Herb
Kathryn McCarthy
John O'Hara

Term Ending in 2018

Vivek Agarwal
Gordon Clepton
M. Steve Coppock
Julia Forbes
Matthew Humberstone

Term Ending in 2019

Johanna Oxstrand
(Edward) Ted Quinn
Richard Wood

Staff Liaison

Valerie Vasilievas

Board Liaison

Daniel Churchman

Ex Officio

Hans D. Gougar
Sean Smith

Upcoming ANS Meetings

2017 ANS Annual Meeting

10th NPIC-HMIT Embedded Topical Meeting

JUNE 11-15, 2017

"Innovating Nuclear Power"

San Francisco, CA
Hyatt Regency San Francisco

- Division Program Committee Meeting:
Sunday June 11 from 11am - 12pm
Pacific I
- Division Executive Committee Meeting:
Sunday June 11 from 12pm - 2:30pm
Pacific I

Utility Working Conference and Vendor Technology Expo

AUGUST 6-9, 2017

"The Nuclear Option - Clean, Safe, Reliable & Affordable"

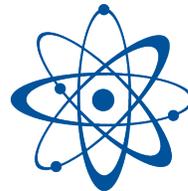
Amelia Island, Florida
Omni Amelia Island Plantation

2017 ANS Winter Meeting and Nuclear Technology Expo

OCTOBER 29 - NOVEMBER 2, 2017

"Generations in Collaboration: Building for Tomorrow"

Washington, D.C.
Marriott Wardman Park



HFICD



2-DAY TRAINING COURSE ANS

Helping Deliver on the Nuclear Promise: Digital I&C Licensing and Qualification Workshop

In Conjunction with the 2017 NPIC & HMIT Conference

June 10-11, 2017

• San Francisco, California

• Hyatt Regency Hotel

KEY COURSE TOPICS - DAY 1

- *Digital I&C Qualification Standards and Guidelines*
- *Commercial Grade Dedication*
- *Electromagnetic Compatibility Considerations*
- *Common Cause Failures*
- *Software Reliability Testing*
- *Cyber Security*
- *Sensor and Cable Considerations*
- *Digital I&C Implementation*

KEY COURSE TOPICS - DAY 2

- *Importance of Digital Licensing*
- *Nuclear Energy Institute Perspective*
- *Cyber Concerns from an NRC Standpoint*
- *NRC Regulatory Framework for Digital Upgrades*
- *Vendor Experiences with Digital I&C*
 - *Westinghouse*
 - *AREVA*
 - *Schneider Electric*
 - *Lockheed Martin*
- *Overview from a Nuclear Utility Perspective*
- *International Activities in the Area of Digital I&C*

The various topics of this course will be taught by subject matter experts within the nuclear industry including regulatory agencies, international organizations, national laboratories, universities, and utilities.

LOCATION AND TIME

The course will be held at the Hyatt Regency Hotel in San Francisco, California on the weekend prior to the NPIC & HMIT 2017 Conference—

Saturday, June 10, 2017 (8:00 a.m. – 5:00 p.m.)

Sunday, June 11, 2017 (8:00 a.m. – 5:00 p.m.)

WHO SHOULD ATTEND

This course is designed for technical and management personnel in utilities, vendors, government, national labs, and universities to learn the very basics of nuclear power plant digital I&C qualification and the licensing process. Industry operating experience will be presented throughout the course.

COURSE COORDINATORS



Ted Quinn
Technology Resources



Chad Kiger
AMS Corporation



Vic Fregonese
Nuclear Energy Institute

REGISTRATION FEE

The fee for the course is \$400, which includes course materials, coffee breaks, lunches, and a certificate of attendance. You can register for the training course alone or for both the course and conference at www.npic-hmit2017.org or at www.ans.org.