Digital Instrumentation And Control Systems In Nuclear Power Plants Safety And Reliability Issues

The nuclear industry and the U.S. Nuclear Regulatory Commission (USNRC) have been working for several years on the development of an adequate process to guide the replacement of aging analog monitoring and control instrumentation in nuclear power plants with modern digital instrumentation without introducing off-setting safety problems. This book identifies criteria for the USNRC's review and acceptance of digital applications in nuclear power plants. It focuses on eight areas: software quality assurance, common-mode software failure potential, systems aspects of digital instrumentation and control technology, human factors and human-machine interfaces, safety and reliability assessment methods, dedication of commercial off-the-shelf hardware and software, the case-by-case licensing process, and the adequacy of technical infrastructure.

"Reliability and Risk Issues in Large Scale Safety-critical Digital Control Systems" provides a comprehensive coverage of reliability issues and their corresponding countermeasures in the field of large-scale digital control systems, from the hardware and software in digital systems to the human operators who supervise the overall process of large-scale systems. Unlike other books which examine theories and issues in individual fields, this book reviews important problems and countermeasures across the fields of software reliability, software verification and validation, digital systems, human factors engineering and human reliability analysis. Divided into four sections dealing with software reliability, digital system reliability, human reliability and human operators in large-scale digital systems, the book offers insights from professional researchers in each specialized field in a diverse yet unified approach.

Integrated digital instrumentation and control (I & C) systems in new and advanced nuclear power plants (NPPs) will support operators in monitoring and controlling the plants. Even though digital systems typically are expected to be reliable, their potential for degradation or failure significantly could affect the operators performance and, consequently, jeopardize plant safety. This U.S. Nuclear Regulatory Commission (NRC) research investigated the effects of degraded I & C systems on human performance and on plant operations. The objective was to develop technical basis and guidance for human factors engineering (HFE) reviews addressing the operator's ability to detect and manage degraded digital I & C conditions. We reviewed pertinent standards and guidelines, empirical studies, and plant operating experience. In addition, we evaluated the potential effects of selected failure modes of the digital feedwater control system of a currently operating pressurized water reactor (PWR) on human-system interfaces (HSIs) and the operators performance. Our findings indicated that I & C degradations are prevalent in plants employing digital systems, and the overall effects on the plant's behavior can be significant, such as causing a reactor trip or equipment to operate unexpectedly. I & C degradations may affect the HSIs used by operators to monitor and control the plant. For example, deterioration of the sensors can complicate the operators interpretation of displays, and sometimes may mislead them by indicating that a process disturbance has occurred. We used the findings as the technical basis upon which to develop HFE review guidance.

Instrumentation and Control of Water and Wastewater Treatment and Transport Systems contains the proceedings of the International Association on Water Pollution Research and Control (IAWPRC) Workshop on Instrumentation and Control of Water and Wastewater Treatment and Transport Systems held in Houston, Texas and Denver, Colorado, from April 27 to May 4, 1985. The papers explore advances in instrumentation and control of water and wastewater treatment and transport systems. This book consists of 122 chapters divided into 18 sections and opens with a brief description of the IAWPRC Study Group on "Instrumentation for On-line Measurement". The discussion then turns to the instrumentation, control, and automation initiatives in various countries such as Germany, Japan, and the UK. The following chapters focus on instrument testing, data acquisition and transmission, and monitoring and control of water transport systems and water treatment plants. Distribution network control for water supply systems is considered, along with telemetry control systems and integrated data systems. The final chapter describes an automatic measuring device which uses a computer and image processing technology for measuring the length of filamentous microorganisms in activated sludge. This monograph will be a useful resource for engineers and those concerned with water pollution control.

This publication describes a process for planning and conducting a project to implement digital instrumentation and control (I&C) systems in the modernization of a nuclear power plant (NPP). Many of the existing NPPs in the world are approaching, or have reached, the midpoint of their design life time, there have been tremendous advances in electronic, computers and networks. These new technologies have been incorporated into the digital I&C hardware and software currently available. Even though advanced digital I&C systems have been used extensively in many other industries, their use in the nuclear industry is still very limited. The complexity of digital I&C systems requires a comprehensive implementation plan to ensure that plant safety is maintained, and this publication presents the experience gained to date. It is intended to be of use to those involved in the design or implementation of such modernization projects.

Plant Hazard Analysis and Safety Instrumentation Systems is the first book to combine coverage of these two integral aspects of running a chemical processing plant. It helps engineers from various disciplines learn how various analysis techniques, international standards, and instrumentation and controls provide layers of protection for basic process control systems, and how, as a result, overall system reliability, availability, dependability, and maintainability can be increased. This step-by-step guide takes readers through the development of safety instrumented systems, also including discussions on cost impact, basics of statistics, and reliability. Swapan Basu brings more than 35 years of industrial experience to this book, using practical examples to demonstrate concepts. Basu links between the SIS requirements and process hazard analysis in order to complete SIS lifecycle implementation and covers safety analysis and realization in control systems, with up-to-date descriptions of modern concepts, such as SIL, SIS, and Fault Tolerance to name a few. In addition, the book addresses security issues that are particularly important for the programmable systems in modern plants, and discusses, at length, hazardous atmospheres and their impact on electrical enclosures and the use of IS circuits. Helps the reader identify which hazard analysis method is the most appropriate (covers ALARP, HAZOP, FMEA, LOPA) Provides tactics on how to implement standards, such as IEC 61508/61511 and ANSI/ISA 84 Presents information on how to conduct safety analysis and realization in control systems and safety instrumentation

This book is an overview of the different paths automation and control engineering have taken lately, from a modern point of view. Built up with example chapters, this book provides some insight into the use of artificial intelligence and control theory in manufacturing, comfort analysis, reliability of modern digital systems, and the use of unusual reference and feedback signals as those coming from the brain. Nonetheless, some chapters are also devoted to a more traditional point of view of control theory, addressing complex problems where human intervention must be limited. Overall, this book is an effort to show that modern automation and control engineering are comprised by many diverse areas, which should interact in order to provide a complete result. In this way, as the systems become more complex and the control objectives more subjective, both, formal analytic and intelligent approaches, should be seen as complementary tools, not unrelated competitors. This books aim is precisely that of showing how broad and diverse the control objectives have become and how the abilities of the control engineer should be extended. This operations manual explains the basic principles of electrical power distribution, automation, and instrumentation in water
distribution, treatment, and storage systems. Chapters cover hydraulic and electrical principles, electric motor controls, measurement instruments and displays, pumps and valves, and automatic and digital controls.

* Covers all aspects of the data acquisition system from design and specification to programming, installation and configuration. * Gives both the novice and experienced user a solid understanding of interfacing the PC and standalone instruments to real-world signals from the laboratory to the industrial plant. * Provides a thorough grasp of PC data acquisition systems and the ability to design, specify, install and configure and program data acquisition systems quickly and effectively. This book focuses on data acquisition and control using the PC and standalone instruments. The PC has made a dramatic impact in the ease with which the technician, scientist and engineer today can set up their own test and measurement system at a remarkably low cost. And this book aims to show you how easy it is with plenty of carefully researched information. The popular IEEE 488 interface is also covered. All aspects of the data acquisition system are included from design and specification to programming, installation and configuration. This book gives both the novice and experienced user a solid understanding of interfacing the PC and standalone instruments to real-world signals from the laboratory to the industrial plant. Once you have read the book, you will have a thorough grasp of PC data acquisition systems and will be able to design, specify, install and configure and program data acquisition systems quickly and effectively. * Covers all aspects of the data acquisition system from design and specification to programming, installation and configuration. * Gives both the novice and experienced user a solid understanding of interfacing the PC and standalone instruments to real-world signals from the laboratory to the industrial plant. * Provides a thorough grasp of PC data acquisition systems and the ability to design, specify, install and configure and program data acquisition systems quickly and effectively.

The majority of instrumentation and control (I&C) equipment in nuclear power plants in the world was designed at least 30 to over 45 years ago with analog and relay components, and in some cases rudimentary digital technology. Today, most of these plants continue to operate with a substantial amount of this original I&C equipment that is or soon will be obsolete resulting in increasing maintenance efforts to sustain acceptable system performance. Decreasing availability of replacement parts, and the accelerating deterioration of the infrastructure of manufacturers that support analog technology, accentuate the obsolescence problems and cause operation and maintenance (O&M) cost increases. License extension means that plants must be supported longer, which will increase obsolescence issues. In addition, older technology limits the possibilities for adding new beneficial capabilities to the plant systems and interfaces. New technology provides the opportunity to improve plant performance, human-system interfaces (HSI) functionality, and reliability; to enhance operator performance and reliability, and to address difficulties in finding young professionals with education and experience with older analog technology. Finally, there may be changes in regulatory requirements that could necessitate modernisation activities.


This publication draws on the results of a technical meeting which addressed key areas of modernization projects for instrumentation and control (I&C) systems in research reactors. The meeting provided a forum for international experts to exchange information on the technical and managerial aspects of I&C systems and modernisation projects specifically related to I&C and to discuss all technical areas relevant to the complex process of research reactor I&C system modernization and the use of digital I&C in new research reactor projects. The publication includes a summary of all papers and provides detailed guidance to research reactor operators intending on upgrading existing facilities from analogue to digital or older digital to newer digital technology, and to governments or agencies seeking to construct a new research facility with the latest digital I&C systems. Report by the World Technology Evaluation Center.

Overview of Data Communications; Basic Data Communication Principles; Physical Serial Communication Standards; Error Detection; Cabling Basics; Electrical Noise and Interference; Modems and Multiplexers; Introduction to Protocols; Open Systems Interconnection Model; Industrial Protocols; HART Protocol; Open Industrial Fieldbus and DeviceNet Systems; Local Area Networks; Appendix A: Numbering Systems; Appendix B: Cyclic Redundancy Check (CRC) Program Listing; Appendix C: Serial Link Design; Glossary. These proceedings present the latest information on software reliability, industrial safety, cyber security, physical protection, testing and verification for nuclear power plants. The papers were selected from more than 80 submissions and presented at the First International Symposium on Software Reliability, Industrial Safety, Cyber Security and Physical Protection for Nuclear Power Plants, held in Yinchuan, China on May 30 - June 1, 2016. The primary aim of this symposium was to provide a platform to facilitate the discussion for comprehension, application and management of digital instrumentation, control systems and technologies in nuclear power plants. The book reflects not only the state of the art and latest trends in nuclear instrumentation and control system technologies, but also China’s increasing influence in this area. It is a valuable resource for both practitioners and academics working in the field of nuclear instrumentation, control systems and other safety-critical systems, as well as nuclear power plant managers, public officials and regulatory authorities.

Accidents and natural disasters involving nuclear power plants such as Chernobyl, Three Mile Island, and the recent meltdown at Fukushima are rare, but their effects are devastating enough to warrant increased vigilance in addressing safety concerns. Nuclear Power Plant Instrumentation and Control Systems for Safety and Security evaluates the risks inherent to nuclear power and methods of preventing accidents through computer control systems and other such emerging technologies. Students and scholars as well as operators and designers will find useful insight into the latest security technologies with the potential to make the future of nuclear energy clean, safe, and reliable. Increasingly, over the last few years, intelligent controllers have been incorporated into control systems. Presently, the numbers and types of intelligent controllers that contain variations of fuzzy logic, neural network, genetic algorithms or some other forms of knowledge based reasoning technology are dramatically rising. However, considering the stability of the system, when such controllers are included it is difficult to analyse and predict system behaviour under unexpected conditions. Leading researchers and industrial practitioners were able to discuss and evaluate current development and future research directions at the first IFAC International Workshop on safety, reliability and applications on emerging intelligent control technology. This publication contains the papers, covering a wide range of topics, presented at the workshop.

This book gathers selected papers from the Second International Symposium on Software Reliability, Industrial Safety, Cyber Security and Physical Protection of Nuclear Power Plant, held in Chengdu, China on August 23–25, 2017. The symposium provided a platform of technical exchange and experience sharing for a broad range of experts, scholars and nuclear power practitioners. The book reflects the state of the art and latest trends in nuclear instrumentation and control system technologies, as well as China’s growing influence in this area. It offers a valuable resource for both practitioners and academics working in the field of nuclear instrumentation, control systems and other safety-critical systems, as well as nuclear power plant managers, public officials and regulatory authorities.

Safety and security are crucial to the operations of nuclear power plants, but cyber threats to these facilities are...
Increasingly, instrumentation and control systems, which play a vital role in the prevention of these incidents, have seen major design modifications with the implementation of digital technologies. Advanced computing systems are assisting in the protection and safety of nuclear power plants; however, significant research on these computational methods is deficient. Cyber Security and Safety of Nuclear Power Plant Instrumentation and Control Systems is a pivotal reference source that provides vital research on the digital developments of instrumentation and control systems for assuring the safety and security of nuclear power plants. While highlighting topics such as accident monitoring systems, classification measures, and UAV fleets, this publication explores individual cases of security breaches as well as future methods of practice. This book is ideally designed for engineers, industry specialists, researchers, policymakers, scientists, academicians, practitioners, and students involved in the development and operation of instrumentation and control systems for nuclear power plants, chemical and petrochemical industries, transport, and medical equipment.

Instrumentation is not a clearly defined subject, having a 'fuzzy' boundary with a number of other disciplines. Often categorized as either 'techniques' or 'applications' this book addresses the various applications that may be needed with reference to the practical techniques that are available for the instrumentation or measurement of a specific physical quantity or quality. This makes it of direct interest to anyone working in the process, control and instrumentation fields where these measurements are essential. * Comprehensive and authoritative collection of technical information * Written by a collection of specialist contributors * Updated to include chapters on the fieldbus standards, reliability, EMC, 'virtual instrumentation', fibre optics, smart and intelligent transmitters, analyzers, level and flow meters, and many more.

This book is a compilation of selected papers from the fifth International Symposium on Software Reliability, Industrial Safety, Cyber Security and Physical protection of Nuclear Power Plant, held in November 2020 in Beijing, China. The purpose of this symposium is to discuss Inspection, test, certification and research for the software and hardware of Instrument and Control (I&C) systems in nuclear power plants (NPP), such as sensors, actuators and control system. It aims to provide a platform of technical exchange and experience sharing for those broad masses of experts and scholars and nuclear power practitioners, and for the combination of production, teaching and research in universities and enterprises to promote the safe development of nuclear power plant. Readers will find a wealth of valuable insights into achieving safer and more efficient instrumentation and control systems.

This book provides a comprehensive overview of the key concerns as well as research challenges in designing secure and resilient Industrial Control Systems (ICS). It will discuss today's state of the art security architectures and couple it with near and long term research needs that compare to the baseline. It will also establish all discussions to generic reference architecture for ICS that reflects and protects high consequence scenarios. Significant strides have been made in making industrial control systems secure. However, increasing connectivity of ICS systems with commodity IT devices and significant human interaction of ICS systems during its operation regularly introduces newer threats to these systems resulting in ICS security defenses always playing catch-up. There is an emerging consensus that it is very important for ICS missions to survive cyber-attacks as well as failures and continue to maintain a certain level and quality of service.

Such resilient ICS design requires one to be proactive in understanding and reasoning about evolving threats to ICS components, their potential effects on the ICS mission’s survivability goals, and identify ways to design secure resilient ICS systems. This book targets primarily educators and researchers working in the area of ICS and Supervisory Control And Data Acquisition (SCADA) systems security and resiliency. Practitioners responsible for security deployment, management and governance in ICS and SCADA systems would also find this book useful. Graduate students will find this book to be a good starting point for research in this area and a reference source.

This book introduces advanced methods of computational and information systems allowing readers to better understand the state-of-the-art design and implementation technology needed to maintain and enhance the safe operation of nuclear power plants. The subjects dealt with in the book are (i) Full digital instrumentation and control systems and human–machine interface technologies (ii) Risk monitoring methods for large and complex plants (iii) Condition monitors for plant components (iv) Virtual and augmented reality for nuclear power plants and (v) Software reliability verification and validation for nuclear power plants. The target readers of this book are Ph.D. students, researchers and engineers in the field of nuclear power engineering.

The nuclear industry and the U.S. Nuclear Regulatory Commission (USNRC) have been working for several years on development of an adequate process to guide the replacement of aging analog monitoring and control instrumentation in nuclear power plants with modern digital instrumentation, without introducing off-setting safety problems. This final report of a two-phased study identifies criteria for the USNRC's review and acceptance of digital applications in nuclear power plants. The book focuses on eight areas: software, quality assurance, common-mode software failure potential, systems aspects of digital instrumentation and control technology, human factors and human-machine interfaces, safety and reliability assessment methods, dedication of commercial off-the-shelf hardware and software, the case-by-case licensing process, and adequacy of technical infrastructure.

With the modernization of existing analogue instrumentation and control (I&C) systems in nuclear power plants through digital I&C technology, and the implementation of digital I&C systems in new plants, the industry is faced with significant challenges. These challenges appear in the form of difficulties in managing the necessarily incremental transition, highly integrated (and interdependent) architectures, the flexible configurability enabled by digital technology, and uncertainty and inconsistency in licensing digital I&C systems and equipment in the different Member States. This publication discusses 17 major issues utilities developers, suppliers and regulatory stakeholders, so that the industry can capture and benefit from shared experience, recent technological developments, and emerging best practices.

New and advanced reactors will use integrated digital instrumentation and control (I & C) systems to support operators in their monitoring and control functions. Even though digital systems are typically highly reliable, their potential for degradation or failure...
could significantly affect operator performance and, consequently, impact plant safety. The U.S. Nuclear Regulatory Commission (NRC) supported this research project to investigate the effects of degraded I & C systems on human performance and plant operations. The objective was to develop human factors engineering (HFE) review guidance addressing the detection and management of degraded digital I & C conditions by plant operators. We reviewed pertinent standards and guidelines, empirical studies, and plant operating experience. In addition, we conducted an evaluation of the potential effects of selected failure modes of the digital feedwater system on human-system interfaces (HSIs) and operator performance. The results indicated that I & C degradations are prevalent in plants employing digital systems and the overall effects on plant behavior can be significant, such as causing a reactor trip or causing equipment to operate unexpectedly. I & C degradations can impact the HSIs used by operators to monitor and control the plant. For example, sensor degradations can make displays difficult to interpret and can sometimes mislead operators by making it appear that a process disturbance has occurred. We used the information obtained as the technical basis upon which to develop HFE review guidance. The guidance addresses the treatment of degraded I & C conditions as part of the design process and the HSI features and functions that support operators to monitor I & C performance and manage I & C degradations when they occur. In addition, we identified topics for future research.