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 making it appear that a process disturbance has occurred. We used the findings as the technical basis upon which to develop HFE review guidance.

The third edition of the book on Industrial Instrumentation and Control is thoroughly revised and reorganized to address the changed curriculum and present needs of students and practicing engineers in the field of instrumentation and control. It now offers a comprehensive coverage of instrumentation and its practical implementation with an excellent balance of theoretical concepts and engineering practice. New to this edition Details the working principles, advantages, disadvantages and applications of each instrument. Extensive coverage of topics such as Electronic measurements and Automatic process control systems for industrial processes. Incorporates computer-aided measurement and control by providing coverage on microprocessor-based control such as programmable logic controllers (PLC’s) and distributed digital control (DDC) systems. Orientation tables have been provided to help reader select right instruments for specific application. Three New chapters on Power and Energy Measurements, Sensors and Transducers, and Application of Control Systems have been added to cover entire gamut of industrial measurement. Topical organization has been done to make it easy for the students to visualize the logical flow of topics. The mathematics of the subject are minimized, and more emphasis is placed on examples that illustrate principles and concepts of great practical importance. Bridges the gap between theoretical learning and practical implementation of instrumentation and control concepts for process industries by means case studies. New to the edition : Three new chapters: Power and Energy Measurements (Chapter 4) Sensors and Transducers (Chapter 15) Application of Control Systems (Chapter 20) Detailed coverage of Microprocessor-based controls (Chapter 17) Three other chapters: Units and Standards of Measurements ; Electronic Measurements; ; Automatic Process Control Systems and Controllers have been thoroughly revised and updated Case studies have been discussed for bridging the gap between theoretical learning and practical implementation. This will help students to revisit the concepts and refresh their overall understanding. New sections on Transfer function, Differential equation and Laplace transform (Chapter 14). Topical organization has been done to make it easy for the students to visualize the logical flow of topics. Pedagogy: An extensive set of review questions (exercises, self check quizzes such as True/False, choosing appropriate answers, and fill-in the blanks) accompanies each chapter and reinforces student’s ability to apply the concepts to real problems. Pedagogy includes: Examples : 58 Short Answer Questions: 218 MCQ’s : 196 True False : 218 Fill in the blanks : 173 Total : 863Static and dynamic calculations for instruments. Process control fundamentals. Digital computation and systems. Characteristics of microprocessors. Software for microprocessors. Development of digital control algorithms. Digital control of instruments (multichannel spectrometer). Advanced digital instrumentation (GC computing and recording). Distributed microprocessor control systems. 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
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. 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. 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. This book presents comprehensive coverage of linear control systems along with an introduction to digital control systems. It is designed for undergraduate courses in control systems taught in departments of electrical engineering, electronics and instrumentation, electronics and communication, instrumentation and control, and computer science and engineering. The text discusses the important concepts of control systems, transfer functions and system components. It describes system stability, employing the Hurwitz–Routh stability criterion, root locus technique, Bode plot, and polar and Nyquist plots. In addition, this student-friendly book features in-depth coverage of controllers, compensators, state-space modelling and discrete time systems. KEY FEATURES • Includes a brief tutorial on MATLAB in an appendix to help students learn how to use it for the analysis and design of control systems. • Provides an abundance of worked-out examples and review questions culled from university examination papers. • Gives answers to selected chapter-end questions at the end of the book. 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. KEY BENEFITS: This manual is designed to provide users with an understanding and appreciation of some of the theoretical concepts behind control system elements and operations, without the need of advanced math and theory. It also presents some of the practical details of how elements of a control system are designed and operated, such as would be gained from on-the-job experience. This middle ground of knowledge enables users to design the elements of a control system from a practical, working perspective, and comprehend how these elements affect overall system operation and tuning. KEY TOPICS: This edition includes treatment of modern fieldbus approaches to networked and distributed control systems. Generally, this guidebook provides an introduction to process control, and covers analog and digital signal conditioning, thermal, mechanical and optical sensors, final control, discrete-state process control, controller principles, analog controllers, digital control and control loop characteristics. MARKET: For those working in measurement and instrumentation and with control systems and PLCs. 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. The objective of this chapter is to discuss two approaches for reliability analysis of digital instrumentation and control systems in nuclear power plants taking into account the regulatory side. Dynamic Flowgraph Methodology (DFM) and Markov/Cell-to-Cell Mapping Technique (CCMT) are discussed and case studies developed are presented. These case studies involve simplified control systems for a steam generator and a pressurizer of a Pressurized Water Reactor (PWR) plant for the purpose of evaluating each method. Advantages and limitations of each approach are addressed. For the DFM approach, three concerns in the literature are addressed: modeling of the system itself, incorporation of the methodology results into existing Probabilistic Safety Assessments (PSA), and identification of software failures. The Markov/CCMT, which has been used in dynamic probabilistic safety assessments, is approached by means of a simplified digitally controlled water volume control system. The Markov/CCMT methodology results in detailed data of the system reliability behavior in relation to time. However, it demands a higher computational effort than usual as the complexity (id est, number of components and failure states) of the system increases. As a regulatory research conclusion, the methodologies presented can be used on PSA risk informed assessment, contributing to the regulatory side. 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. The standard laboratory tools in the modern scientific world include a wide variety of electronic instruments used in measurement and control systems. This book provides a firm foundation in principles, operation, design, and applications of electronic instruments. Commencing with electromechanical instruments, the specialized instruments such as signal analyzers, counters,
signal generators, and digital storage oscilloscope are treated in detail. Good design practices such as grounding and shielding are emphasized. The standards in quality management, basics of testing, compatibility, calibration, traceability, metrology and various ISO 9000 quality assurance guidelines are explained as well. The evolution of communication technology in instrumentation is an important subject. A single chapter is devoted to the study of communication methods used in instrumentation technology. There are some areas where instrumentation needs special type of specifications—one such area is hazardous area. The technology and standards used in hazardous areas are also discussed. An instrumentation engineer is expected to draw and understand the instrumentation drawings. An Appendix explains the symbols and standards used in P&I diagrams with several examples. Besides worked-out examples included throughout, end-of-chapter questions and multiple choice questions are also given to judge the student’s understanding of the subject. Practical and state-of-the-art in approach, this textbook will be useful for students of electrical, electronics, and instrumentation engineering. 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 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 book is a compilation of selected papers from the 3rd International Symposium on Software Reliability, Industrial Safety, Cyber Security and Physical Protection of Nuclear Power Plants, held in Harbin, China on 15th–17th August 2018. The symposium discussed the status quo, technical advances and development direction of digital instrument control technology, software reliability, information security and physical protection in the process of nuclear power development. Offering technical insights and know from leading experts, this book 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. Safety and security are crucial to the operations of nuclear power plants, but cyber threats to these facilities are increasing significantly. 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. 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. At the same time, there have been tremendous advances in electronics, 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. Whether you're designing a new instrumentation and control (I&C) system, or migrating an existing control system along an upgrade path, you need to have a well-conceived design package - the engineering deliverables and the design process that creates them. This book draws on 25 years of design engineering experience from the author to provide you with a roadmap to understanding the design process, the elements of a successful project, the specific issues to address in a well-designed I&C system, and the engineering products that enable practical design and successful maintenance. As nearly $65 billion worth of automation systems near the end of their traditional life cycle, the necessity of understanding the design process has never been more critical to engineers, technicians, and management - this book will help you achieve that understanding. 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. “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. Introduction to Data Acquisition & Control; Analog and Digital Signals; Signal Conditioning; The Personal Computer for Real Time Work; Plug-in Data Acquisition Boards; Serial Data Communications; Distributed & Standalone Loggers/Controllers; IEEE 488 Standard; Ethernet & LAN Systems; The Universal Serial Bus (USB); Specific Techniques; The PCMCIA