

## USE OF RELIABILITY ENGINEERING TOOLS IN SAFETY AND RISK ASSESSMENT OF NUCLEAR FACILITIES

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### ABSTRACT

Safety, reliability and availability are fundamental criteria in design, construction and operation of nuclear facilities, as nuclear power plants. Deterministic and probabilistic risk assessments of such facilities are required by regulatory authorities in order to meet licensing regulations, contributing to assure safety, as well as reduce costs and environmental impacts. Probabilistic Risk Assessment has become an important part of licensing requirements of the nuclear power plants in Brazil and in the world. Risk can be defined as a qualitative and/or quantitative assessment of accident sequence frequencies (or probabilities) and their consequences. Risk management is a systematic application of management policies, procedures and practices to identify, analyze, plan, implement, control, communicate and document risks. Several tools and computer codes must be combined, in order to estimate both probabilities and consequences of accidents. Event Tree Analysis (ETA), Fault Tree Analysis (FTA), Reliability Block Diagrams (RBD), and Markov models are examples of evaluation tools that can support the safety and risk assessment for analyzing process systems, identifying potential accidents, and estimating consequences. Because of complexity of such analyzes, specialized computer codes are required, such as the reliability engineering software develop by Reliasoft<sup>®</sup> Corporation, BlockSim (FTA, RBD and Markov models), RENO (ETA and consequence assessment), Weibull++ (life data and uncertainty analysis), and Xfmea (qualitative risk assessment) are some codes that can be highlighted. This work describes an integrated approach using these tools and software to carry out reliability, safety, and risk assessment of nuclear facilities, as well as, and application example.

### 1. INTRODUCTION

Improvements on safety, reliability and availability contribute to safe design and operation of nuclear facilities, such Nuclear Power Plants (NPPs). A plant operated with good procedures provides safety, which can be defined as eliminating those conditions that can cause death, injury, occupational illness or damage to or loss of equipment or property, to an acceptable level of risk. Deterministic and probabilistic risk assessments of such facilities are required by regulatory authorities in order to meet licensing regulations, contributing to assure safety, as well as reduce costs and environmental impacts. Probabilistic Risk Assessment (sometimes named Probabilistic Safety Analysis) has become an important part of licensing requirements of the nuclear power plants in Brazil and in the world [1].

The term safety includes hazard identification, technical evaluation, and the design of new engineering features to prevent loss. Accident prevention using appropriate technologies

# Nuclear Systems Reliability Engineering And Risk Assessment

**Ajit Kumar Verma, Srividya Ajit, Durga  
Rao Karanki**



## **Nuclear Systems Reliability Engineering And Risk Assessment:**

**Nuclear Systems Reliability Engineering and Risk Assessment** Jerry B. Fussell, Gary R. Burdick, 1977-01-01

**Nuclear Systems Reliability Engineering and Risk Assessment** G. R. Burdick, Jerry B. Fussell, 1977 Nuclear Systems Reliability Engineering and Risk Assessment : Papers [from the International Conference on Nuclear Systems Reliability Engineering and Risk Assessment] Held in Gatlinburg, Tennessee, June 20-24, 1977 gatlinburg International conference on nuclear systems reliability engineering and riskassessment (tennessee, 1977.f), 1977 **Nuclear Systems Reliability Engineering and Risk Assessment** J. B. Fussell, G. R. Burdick, 1977 *Nuclear Systems Reliability Engineering and Risk Assessment*, 1977 *Nuclear Systems Reliability Engineering and Risk Assessment* J. B. Fussell, 1977 INTERNATIONAL CONFERENCE ON NUCLEAR SYSTEMS RELIABILITY ENGINEERING AND RISK ASSESSMENT. GATLINBURG, TENN., 20-24 JUNE 1977 J.B. FUSSELL, G.R. BURDICK, 1977 **Risk-Based Engineering** Prabhakar V.

Varde, Michael G. Pecht, 2018-04-19 The book comprehensively covers the various aspects of risk modeling and analysis in technological contexts It pursues a systems approach to modeling risk and reliability concerns in engineering and covers the key concepts of risk analysis and mathematical tools used to assess and account for risk in engineering problems The relevance of incorporating risk based structures in design and operations is also stressed with special emphasis on the human factor and behavioral risks The book uses the nuclear plant an extremely complex and high precision engineering environment as an example to develop the concepts discussed The core mechanical electronic and physical aspects of such a complex system offer an excellent platform for analyzing and creating risk based models The book also provides real time case studies in a separate section to demonstrate the use of this approach There are many limitations when it comes to applications of risk based approaches to engineering problems The book is structured and written in a way that addresses these key gap areas to help optimize the overall methodology This book serves as a textbook for graduate and advanced undergraduate courses on risk and reliability in engineering It can also be used outside the classroom for professional development courses aimed at practicing engineers or as an introduction to risk based engineering for professionals researchers and students interested in the field *System Reliability Theory* Marvin Rausand, Anne Barros, Arnljot Hoyland, 2020-10-08 Handbook and reference for industrial statisticians and system reliability engineers *System Reliability Theory Models Statistical Methods and Applications* Third Edition presents an updated and revised look at system reliability theory modeling and analytical methods The new edition is based on feedback to the second edition from numerous students professors researchers and industries around the world New sections and chapters are added together with new real world industry examples and standards and problems are revised and updated *System Reliability Theory* covers a broad and deep array of system reliability topics including In depth discussion of failures and failure modes The main system reliability assessment methods Common cause failure modeling Deterioration modeling Maintenance modeling and assessment using

Python code Bayesian probability and methods Life data analysis using R Perfect for undergraduate and graduate students taking courses in reliability engineering this book also serves as a reference and resource for practicing statisticians and engineers Throughout the book has a practical focus incorporating industry feedback and real world industry problems and examples

**Encyclopedia of Quantitative Risk Analysis and Assessment**, 2008-09-02 Leading the way in this field the Encyclopedia of Quantitative Risk Analysis and Assessment is the first publication to offer a modern comprehensive and in depth resource to the huge variety of disciplines involved A truly international work its coverage ranges across risk issues pertinent to life scientists engineers policy makers healthcare professionals the finance industry the military and practising statisticians Drawing on the expertise of world renowned authors and editors in this field this title provides up to date material on drug safety investment theory public policy applications transportation safety public perception of risk epidemiological risk national defence and security critical infrastructure and program management This major publication is easily accessible for all those involved in the field of risk assessment and analysis For ease of use it is available in print and online

Reliability and Safety Engineering Ajit Kumar Verma, Srividya Ajit, Durga Rao Karanki, 2015-09-28 Reliability and safety are core issues that must be addressed throughout the life cycle of engineering systems Reliability and Safety Engineering presents an overview of the basic concepts together with simple and practical illustrations The authors present reliability terminology in various engineering fields viz electronics engineering software engineering mechanical engineering structural engineering and power systems engineering The book describes the latest applications in the area of probabilistic safety assessment such as technical specification optimization risk monitoring and risk informed in service inspection Reliability and safety studies must inevitably deal with uncertainty so the book includes uncertainty propagation methods Monte Carlo simulation fuzzy arithmetic Dempster Shafer theory and probability bounds Reliability and Safety Engineering also highlights advances in system reliability and safety assessment including dynamic system modeling and uncertainty management Case studies from typical nuclear power plants as well as from structural software and electronic systems are also discussed Reliability and Safety Engineering combines discussions of the existing literature on basic concepts and applications with state of the art methods used in reliability and risk assessment of engineering systems It is designed to assist practicing engineers students and researchers in the areas of reliability engineering and risk analysis

Energy Research Abstracts, 1983

Risk Assessment Marvin Rausand, Stein Haugen, 2020-02-19 Introduces risk assessment with key theories proven methods and state of the art applications Risk Assessment Theory Methods and Applications remains one of the few textbooks to address current risk analysis and risk assessment with an emphasis on the possibility of sudden major accidents across various areas of practice from machinery and manufacturing processes to nuclear power plants and transportation systems Updated to align with ISO 31000 and other amended standards this all new 2nd Edition discusses the main ideas and techniques for assessing risk today The book begins with an introduction of risk analysis assessment and

management and includes a new section on the history of risk analysis. It covers hazards and threats, how to measure and evaluate risk, and risk management. It also adds new sections on risk governance and risk informed decision making, combining accident theories and criteria for evaluating data sources and subjective probabilities. The risk assessment process is covered, as are how to establish context, planning and preparing, and identification, analysis, and evaluation of risk. Risk Assessment also offers new coverage of safe job analysis and semi quantitative methods, and it discusses barrier management and HRA methods for offshore application. Finally, it looks at dynamic risk analysis, security, and life cycle use of risk. Serves as a practical and modern guide to the current applications of risk analysis and assessment, supports key standards, and supplements legislation related to risk analysis. Updated and revised to align with ISO 31000 Risk Management and other new standards, and includes new chapters on security, dynamic risk analysis, as well as life cycle use of risk analysis. Provides in depth coverage on hazard identification, methodologically outlining the steps for use of checklists, conducting preliminary hazard analysis, and job safety analysis. Presents new coverage on the history of risk analysis, criteria for evaluating data sources, risk informed decision making, subjective probabilities, semi quantitative methods, and barrier management. Contains more applications and examples, new and revised problems throughout, and detailed appendices that outline key terms and acronyms. Supplemented with a book companion website containing Solutions to problems, presentation material, and an Instructor Manual. Risk Assessment: Theory, Methods, and Applications, Second Edition, is ideal for courses on risk analysis, risk assessment, and systems engineering at the upper undergraduate and graduate levels. It is also an excellent reference and resource for engineers, researchers, consultants, and practitioners who carry out risk assessment techniques in their everyday work.

Risk Assessment Methods V.T. Covello, M.W. Merkhoher, 2013-06-29. Much has already been written about risk assessment. Epidemiologists write books on how risk assessment is used to explore the factors that influence the distribution of disease in populations of people. Toxicologists write books on how risk assessment involves exposing animals to risk agents and concluding from the results what risks people might experience if similarly exposed. Engineers write books on how risk assessment is utilized to estimate the risks of constructing a new facility, such as a nuclear power plant. Statisticians write books on how risk assessment may be used to analyze mortality or accident data to determine risks. There are already many books on risk assessment; the trouble is that they all seem to be about different subjects. This book takes another approach. It brings together all the methods for assessing risk into a common framework, thus demonstrating how the various methods relate to one another. This produces four important benefits. First, it provides a comprehensive reference for risk assessment. This one source offers readers concise explanations of the many methods currently available for describing and quantifying diverse types of risks. Second, it consistently evaluates and compares available risk assessment methods and identifies their specific strengths and limitations. Understanding the limitations of risk assessment methods is important. The field is still in its infancy, and the problems with available methods are disappointingly numerous. At the same time, risk

assessment is being used      **Advanced Concepts In Nuclear Energy Risk Assessment And Management** Tunc Aldemir, 2018-04-25 Over the past 30 years numerous concerns have been raised in the literature regarding the capability of static modeling approaches such as the event tree ET fault tree FT methodology to adequately account for the impact of process hardware software firmware human interactions on nuclear power plant safety assessment and methodologies to augment the ET FT approach have been proposed Often referred to as dynamic probabilistic risk safety assessment DPRA DPSA methodologies which use a time dependent phenomenological model of system evolution along with a model of its stochastic behavior to model for possible dependencies among failure events The book contains a collection of papers that describe at existing plant level applicable DPRA DPSA tools as well as techniques that can be used to augment the ET FT approach when needed      *Nuclear Safety*, 1978      *The Monte Carlo Simulation Method for System Reliability and Risk Analysis* Enrico Zio, 2012-11-02 Monte Carlo simulation is one of the best tools for performing realistic analysis of complex systems as it allows most of the limiting assumptions on system behavior to be relaxed The Monte Carlo Simulation Method for System Reliability and Risk Analysis comprehensively illustrates the Monte Carlo simulation method and its application to reliability and system engineering Readers are given a sound understanding of the fundamentals of Monte Carlo sampling and simulation and its application for realistic system modeling Whilst many of the topics rely on a high level understanding of calculus probability and statistics simple academic examples will be provided in support to the explanation of the theoretical foundations to facilitate comprehension of the subject matter Case studies will be introduced to provide the practical value of the most advanced techniques This detailed approach makes The Monte Carlo Simulation Method for System Reliability and Risk Analysis a key reference for senior undergraduate and graduate students as well as researchers and practitioners It provides a powerful tool for all those involved in system analysis for reliability maintenance and risk evaluations      **Optimizing Community Infrastructure** Ryan Colker, 2019-10-14 Optimizing Community Infrastructure Resilience in the Face of Shocks and Stresses examines the resilience measures being deployed within individual disciplines and sectors and how multi stakeholder efforts can catalyze action to address global challenges in preparedness and disaster and hazard mitigation The book provides a theoretical framework to advance thinking on creating resilient inclusive sustainable and safe communities Users will find an accurate and up to date guide for working on the development implementation monitoring and assessment of policies programs and projects related to community resilience Provides updated information on resilience especially on infrastructure finance land use standards and policies Includes case studies that illustrate how communities have increased their resilience to natural and other disasters Analyzes the institutional political social and economic dimensions of resilience at the community level Illustrates the interdependencies and interconnectedness of infrastructure systems and how community resilience relies on a holistic approach Examines responses to emerging risks associated with climate change      **Game Theoretic Risk Analysis of Security Threats** Vicki M. Bier, M.

Naceur Azaiez, 2008-10-20 Game Theoretic Risk Analysis of Security Threats introduces reliability and risk analysis in the face of threats by intelligent agents More specifically game theoretic models are developed for identifying optimal and or equilibrium defense and attack strategies in systems of varying degrees of complexity The book covers applications to networks including problems in both telecommunications and transportation However the book s primary focus is to integrate game theory and reliability methodologies into a set of techniques to predict detect diminish and stop intentional attacks at targets that vary in complexity In this book Bier and Azaiez highlight work by researchers who combine reliability and risk analysis with game theory methods to create a set of functional tools that can be used to offset intentional intelligent threats including threats of terrorism and war These tools will help to address problems of global security and facilitate more cost effective defensive investments      Proceedings of the National Conference on Mathematical and Computational Models ,2001

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