

## 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

# Reliability Engineering And Risk Assessment

**C. Guedes Soares**



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

**Reliability Engineering and Risk Assessment** Ernest J. Henley, Hiromitsu Kumamoto, 1981 Reliability and Risk Assessment John D. Andrews, T. R. Moss, 1993 Accidents at process plants such as Windscale Piper Alpha and Chernobyl have created worldwide concern over the risks involved in operating hazardous plant Thorough procedures for the assessment and reliability testing of safety systems are now in great demand Reliability and Risk Assessment provides a full theoretical background to the techniques used in this field of engineering and discusses how these methods are applied in practice The authors show how these methods can be used to improve not only the safety records but also the efficiency productivity and profitability of processing plants Reliability and Risk Assessment is intended primarily as a reference for professional engineers but will also prove invaluable for postgraduate students involved in reliability and risk assessment research

*Reliability and Risk Analysis* Mohammad Modarres, Katrina Groth, 2023-04-26 Completely updated for a new edition this book introduces reliability and risks analysis for both practicing engineers and engineering students at the undergraduate and graduate levels Since reliability analysis is a multidisciplinary subject this book draws together a wide range of topics and presents them in a way that applies to most engineering disciplines What Every Engineer Should Know About Reliability and Risk Analysis Second Edition emphasizes an introduction and explanation of the practical methods used in reliability and risk studies with a discussion of their uses and limitations It offers basic and advanced methods in reliability analysis that are commonly used in daily practice and provides methods that address unique topics such as dependent failure analysis importance analysis and analysis of repairable systems The book goes on to present a comprehensive overview of modern probabilistic life assessment methods such as Bayesian estimation system reliability analysis and human reliability End of chapter problems and a solutions manual are available to support any course adoptions This book is refined simple and focuses on fundamentals The audience is the beginner with no background in reliability engineering and rudimentary knowledge of probability and statistics It can be used by new practitioners undergraduates and first year graduate students

**Reliability Engineering and Risk Analysis** Mohammad Modarres, Mark P. Kaminskiy, Vasilii Krivtsov, 2009-09-22 Tools to Proactively Predict Failure The prediction of failures involves uncertainty and problems associated with failures are inherently probabilistic Their solution requires optimal tools to analyze strength of evidence and understand failure events and processes to gauge confidence in a design s reliability Reliability Engineering and Risk Analysis A Practical Guide Second Edition has already introduced a generation of engineers to the practical methods and techniques used in reliability and risk studies applicable to numerous disciplines Written for both practicing professionals and engineering students this comprehensive overview of reliability and risk analysis techniques has been fully updated expanded and revised to meet current needs It concentrates on reliability analysis of complex systems and their components and also presents basic risk analysis techniques Since reliability analysis is a multi disciplinary subject the scope of this book applies to most engineering

disciplines and its content is primarily based on the materials used in undergraduate and graduate level courses at the University of Maryland This book has greatly benefited from its authors industrial experience It balances a mixture of basic theory and applications and presents a large number of examples to illustrate various technical subjects A proven educational tool this bestselling classic will serve anyone working on real life failure analysis and prediction problems

**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

Applied Reliability Engineering and Risk Analysis Ilia B. Frenkel, Alex Karagrigoriou, Anatoly Lisnianski, Andre V. Kleyner, 2013-08-22 This complete resource on the theory and applications of reliability engineering probabilistic models and risk analysis consolidates all the latest research presenting the most up to date developments in this field With comprehensive coverage of the theoretical and practical issues of both classic and modern topics it also provides a unique commemoration to the centennial of the birth of Boris Gnedenko one of the most prominent reliability scientists of the twentieth century Key features include expert treatment of probabilistic models and statistical inference from leading scientists researchers and practitioners in their respective reliability fields detailed coverage of multi state system reliability maintenance models statistical inference in reliability systemability physics of failures and reliability demonstration many examples and engineering case studies to illustrate the theoretical results and their practical applications in industry Applied Reliability Engineering and Risk Analysis is one of the first works to treat the important areas of degradation analysis multi state system reliability networks and large scale systems in one comprehensive volume It is an essential reference for engineers and scientists involved in reliability analysis applied probability and statistics reliability engineering and maintenance logistics and quality control It is also a useful resource for graduate students specialising in reliability analysis and applied probability and statistics Dedicated to the Centennial of the birth of

Boris Gnedenko renowned Russian mathematician and reliability theorist *Computational Methods For Reliability And Risk Analysis* Enrico Zio, 2009-01-22 This book illustrates a number of modelling and computational techniques for addressing relevant issues in reliability and risk analysis In particular it provides i a basic illustration of some methods used in reliability and risk analysis for modelling the stochastic failure and repair behaviour of systems e g the Markov and Monte Carlo simulation methods ii an introduction to Genetic Algorithms tailored to their application for RAMS Reliability Availability Maintainability and Safety optimization iii an introduction to key issues of system reliability and risk analysis like dependent failures and importance measures and iv a presentation of the issue of uncertainty and of the techniques of sensitivity and uncertainty analysis used in support of reliability and risk analysis The book provides a technical basis for senior undergraduate or graduate courses and a reference for researchers and practitioners in the field of reliability and risk analysis Several practical examples are included to demonstrate the application of the concepts and techniques in practice

**Reliability Engineering and Risk Analysis** Mohammad Modarres, 1999 *Advances in Safety and Reliability* C.

Guedes Soares, 1997-06-19 These three volumes comprise the papers presented at the ESREL 97 International Conference on Safety and Reliability held in Lisbon Portugal 17 20 June 1997 The purpose of the annual ESREL conferences is to provide a forum for the presentation of technical and scientific papers covering both methods and applications of safety and reliability to a wide range of industrial sectors and technical disciplines and in so doing to enhance cross fertilization between them A broad view is taken of safety and reliability which includes probabilistically based methods or more generally methods that deal with the quantification of the uncertainty in the knowledge of the real world and with decision making under this uncertainty The areas covered include design and product liability availability reliability and maintainability assessment and management of risks to technical systems health and the environment and mathematical methods of reliability and statistical analysis of data The organization of the book closely follows the sessions of the conference with each of the three volumes containing papers from two parallel sessions comprising a total of 270 papers by authors from 35 countries *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 **An Introduction To The Basics Of Reliability And Risk Analysis** Enrico Zio, 2007-02-28 The necessity of expertise for tackling the complicated and multidisciplinary issues of safety and risk has slowly permeated into all engineering applications so that risk analysis and management has gained a relevant role both as a tool in support of plant design and as an indispensable means for emergency planning in accidental situations This entails the acquisition of appropriate reliability modeling and risk analysis tools to complement the basic and specific engineering knowledge for the technological area of application Aimed at providing an organic view of the subject this book provides an introduction to the principal concepts and issues related to the safety of modern industrial activities It also illustrates the classical techniques for reliability analysis and risk assessment

used in current practice      **What Every Engineer Should Know about Reliability and Risk Analysis** MOHAMMAD. MODARRES,2023      Safety and Risk Modeling and Its Applications Hoang Pham,2011-09-08 Safety and Risk Modeling presents the latest theories and methods of safety and risk with an emphasis on safety and risk in modeling It covers applications in several areas including transportations and security risk assessments as well as applications related to current topics in safety and risk Safety and Risk Modeling is a valuable resource for understanding the latest developments in both qualitative and quantitative methods of safety and risk analysis and their applications in operating environments Each chapter has been written by active researchers or experienced practitioners to bridge the gap between theory and practice and to trigger new research challenges in safety and risk Topics include safety engineering system maintenance safety in design failure analysis and risk concept and modelling Postgraduate students researchers and practitioners in many fields of engineering operations research management and statistics will find Safety and Risk Modeling a state of the art survey of reliability and quality in design and practice      Systems Reliability and Risk Analysis E.G. Frankel,2011-12-08 Ernst G Frankel This book has its origin in lecture notes developed over several years for use in a course in Systems Reliability for engineers concerned with the design of physical systems such as civil structures power plants and transport vehicles of all types Increasing public concern with the reliability of systems for reasons of human safety environmental protection and acceptable investment risk limitations has resulted in an increasing interest by engineers in the formal application of reliability theory to engineering design At the same time there is a demand for more effective approaches to the design of procedures for the operation and use of man made systems and more meaningful assessment of the risks introduction and use of such a system poses both when operating as designed and when operating at below design performance The purpose of the book is to provide a sound yet practical introduction to reliability analysis and risk assessment which can be used by professionals in engineering planning management and economics to improve the design operation and risk assessment of systems of interest The text should be useful for students in many disciplines and is designed for fourth year undergraduates or first year graduate students I would like to acknowledge the help of many of my graduate students who contributed to the development of this book by offering comments and criticism Similarly I would like to thank Mrs      **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 risk assessment (tennessee, 1977.f),1977      Safety, Reliability and Risk Analysis R.D.J.M. Steenbergen,P.H.A.J.M. van Gelder,S. Miraglia,A.C.W.M. Vrouwenvelder,2013-09-18 Methods of risk and reliability analysis are becoming increasingly important as decision support tools in various fields of engineering Safety Reliability and Risk Analysis Beyond the Horizon covers a wide range of topics for which risk analysis forms an indispensable field of knowledge to ensure sufficient safety      **Reliability and Risk Assessment in Engineering**

Vijay Kumar Gupta, Prabhakar V. Varde, P. K. Kankar, Narendra Joshi, 2020-05-08 This volume is a collection of articles on reliability and safety engineering presented during INCRS 2018 The articles cover a variety of topics such as big data analytics and their applications in reliability assessment and condition monitoring health monitoring management diagnostics and prognostics of mechanical systems design for reliability and optimization and machine learning for industrial applications A special aspect of this volume is the coverage of performance failure and reliability issues in electrical distribution systems This book will be a useful reference for graduate students researchers and professionals working in the area of reliability assessment condition monitoring and predictive maintenance

**Reliability Engineering and Risk Analysis** Mohammad Modarres, 2009 *Safety and Reliability. Theory and Applications* Marko Cepin, Radim Bris, 2017-06-14 Safety and Reliability Theory and Applications contains the contributions presented at the 27th European Safety and Reliability Conference ESREL 2017 Portoro Slovenia June 18 22 2017 The book covers a wide range of topics including Accident and Incident modelling Economic Analysis in Risk Management Foundational Issues in Risk Assessment and Management Human Factors and Human Reliability Maintenance Modeling and Applications Mathematical Methods in Reliability and Safety Prognostics and System Health Management Resilience Engineering Risk Assessment Risk Management Simulation for Safety and Reliability Analysis Structural Reliability System Reliability and Uncertainty Analysis Selected special sessions include contributions on the Marie Skłodowska Curie innovative training network in structural safety risk approaches in insurance and finance sectors dynamic reliability and probabilistic safety assessment Bayesian and statistical methods reliability data and testing organizational factors and safety culture software reliability and safety probabilistic methods applied to power systems socio technical economic systems advanced safety assessment methodologies extended Probabilistic Safety Assessment reliability availability maintainability and safety in railways theory big data risk analysis and management and model based reliability and safety engineering Safety and Reliability Theory and Applications will be of interest to professionals and academics working in a wide range of industrial and governmental sectors including Aeronautics and Aerospace Automotive Engineering Civil Engineering Electrical and Electronic Engineering Energy Production and Distribution Environmental Engineering Information Technology and Telecommunications Critical Infrastructures Insurance and Finance Manufacturing Marine Industry Mechanical Engineering Natural Hazards Nuclear Engineering Offshore Oil and Gas Security and Protection Transportation and Policy Making

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