Nuclear Engineering and Technology for the 21st Century – Monograph Series

Risk Importance Measures in the Design and Operation of Nuclear Power Plants

Ivan Vrbanic, Pranab Samanta, Ivica Basic

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Series Editors' Preface

Nuclear Engineering and Technology for the 21st Century—Monographs Series

Nuclear engineering and technology play a vital role in achieving low carbon emission goals worldwide, while providing reliable, baseload power to the world economy. Presently over 12 percent of the world's energy needs are satisfied by nuclear power—with 30 countries operating 436 nuclear power plants and 3 countries (France, Slovakia, and Belgium) using nuclear power to provide over half their power needs (source: Nuclear Energy Institute: http://www.nei.org).

The country with the largest number of operational nuclear power plants (the United States) has 102 plants and uses nuclear power to provide over 19 percent of its needs. Concurrently, the advanced nuclear power plant designs are the basis for extensive, ongoing research and development efforts in many countries with the promise of enhanced sustainability, safety, and proliferation-free power-sources with ever-higher operational efficiencies and capacity factors. Consequently, there are many fruitful topics of interest in the nuclear engineering field to be addressed in this exciting monograph series.

The *Nuclear Engineering and Technology for the 21st Century* monograph series provides current and future engineers, researchers, technicians and other professionals and practitioners with practical, concise but key information concerning the nuclear technologies from areas of medical applications, mining, processing and manufacturing, environmental monitoring to safe and energy-efficient plant operation and electricity generation. Each monograph should provide a well rounded and definitive state-of-the-art review of its subject, with a focus on applied research and development, and best industry practices, processes and related technological applications. The series is envisaged as a collection of 80 to 100 pages monograph publications which can stand as the most authoritative source of information on current state of a topic, application or discipline. Core topics include, but are not limited to:

- best practices in power plant operation
- nuclear science and technology in medicine,
- irradiation technologies and applications,

- fuel cycle processes, engineering and technologies,
- nuclear reactor thermal hydraulics and/or neutronics
- materials for current and advance power generation
- nuclear safety and environmental impact
- next generation of nuclear power plants
- radiation in our environment
- radioecology, radiobiology, radiation chemistry

Series Editors:

Dr. Jovica Riznic, Canadian Nuclear Safety Commission
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Abstract

This monograph presents and discusses risk importance measures as quantified by the probabilistic risk assessment (PRA) models of nuclear power plants (NPPs) developed according to the current standards and practices. Usually, PRA tools calculate risk importance measures related to a single "basic event" representing particular failure mode. This is, then, reflected in many current PRA applications. The monograph focuses on the concept of "component-level" importance measures that take into account different failure modes of the component including common-cause failures (CCFs). In opening sections the role of risk assessment in safety analysis of an NPP is introduced and discussion given of "traditional", mainly deterministic, design principles which have been established to assign a level of importance to a particular system, structure or component. This is followed by an overview of main risk importance measures for risk increase and risk decrease from current PRAs. Basic relations which exist among the measures are shown. Some of the current practical applications of risk importance measures from the field of NPP design, operation and regulation are discussed. The core of the monograph provides a discussion on theoretical background and practical aspects of main risk importance measures at the level of "component" as modeled in a PRA, starting from the simplest case, single basic event, and going toward more complex cases with multiple basic events and involvements in CCF groups. The intent is to express the component-level importance measures via the importance measures and probabilities of the underlying single basic events, which are the inputs readily available from a PRA model and its results. Formulas are derived and discussed for some typical cases. The formulas and their results are demonstrated through some practical examples, done by means of a simplified PRA model developed in and run by RiskSpectrum® tool, which are presented in the appendices. The monograph concludes with discussion of limitations of the use of risk importance measures and a summary of component-level importance cases evaluated.