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Guide for Incorporating Human Reliability Analysis into Probabilistic Risk Assessments for Nuclear Power Generating Stations and Other Nuclear Facilities

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IEEE Guide for Incorporating Human Reliability Analysis into Probabilistic Risk Assessments for Nuclear Power Generating Stations and Other Nuclear Facilities

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Abstract: A structured framework for the incorporation of human reliability analysis (HRA) into probabilistic risk assessments (PRAs) is provided in this guide. To enhance the analysis of human/system interactions in PRAs, to help ensure reproducible conclusions, and to standardize the documentation of such assessments are the purposes of this guide. To do this, a specific HRA framework is developed from standard practices. The HRA framework is neutral with respect to specific HRA methods.

Keywords: HRA, human reliability analysis, IEEE 1082™, PRA, probabilistic risk assessment

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IEEE Introduction

This introduction is not part of IEEE Std 1082-2017, Guide for Incorporating Human Reliability Analysis into Probabilistic Risk Assessments for Nuclear Power Generating Stations and Other Nuclear Facilities.

Any process that requires manual control to minimize public risk will require a high level of human reliability. This reliability can be evaluated through the systematic application of a probabilistic risk assessment (PRA). However, such an assessment requires a detailed understanding of human performance and human reliability methods to form a reasonable reliability estimate.

The initial risk assessment made in the nuclear power plant industry, WASH-1400 [B17], recognized the need for a discipline of human reliability analysis (HRA) to be systematically incorporated within the PRA enterprise.[1] But the methodology—both analyzing human failure events and identifying and incorporating them appropriately in the PRA—was new, incomplete, and in several ways inadequate.

The limitations of the understanding of human reliability in the mid-1970s were vividly demonstrated by the accident at Three Mile Island (TMI). Following TMI, the United States Nuclear Regulatory Commission (NRC), in conjunction with The Institute of Electrical and Electronics Engineers (IEEE), immediately called for a conference on the human factor issues raised by TMI.[2] This conference has subsequently become a series. Parallel to the initiation of the conference, Subcommittee 7, Human Factors and Control Facilities of the IEEE Nuclear Power Engineering Committee began discussing the standardization of HRA technology. The PRA/HRA interface of incorporating and performing an HRA in the context of a PRA was recognized as the most mature of the efforts of HRA. A guide, the least mandating of the IEEE standards documents, was approved as an IEEE standards project in 1984. The guide was revised in 1997.

This guide outlines the steps necessary to include human reliability in risk assessments. The intent of the guide is not to discuss the details of specific HRA methods, but rather to affirm a method-neutral framework for using a diverse range of HRA methods to support PRA. Since human error has been found to be an important contributor to risk, this guide underscores the systematic integration of the HRA at the earliest stages and throughout the PRA.

Since the 1997 revision of IEEE Std 1082™, there have been significant developments in HRA methods, theories, and practices. A working group (WG) was convened in 2012 to reaffirm the guide. This WG found numerous cases where the 1997 standard contained outdated references or failed to consider now-commonplace aspects of HRA. The WG, however, confirmed the underlying practice of HRA espoused in IEEE Std 1082-1997 is still contemporary and relevant to HRA practice. The WG has updated the guide, to the extent necessary to reflect important advances in HRA. Thus, the framework for conducting HRA found in IEEE Std 1082-1997 remains intact in this revision but has been augmented with references to contemporary issues and practices.

IEEE Std 1082 remains a unique, concise guide for specifying the framework for conducting HRA as part of PRA. Additional standard guidance documents are available beyond IEEE Std 1082. For example, the Electric Power Research Institute (EPRI) released the Systematic Human Action Reliability Procedure (SHARP) and revised SHARP1 approach [B4], which describes a detailed process of integrating quantitative HRA into PRA, mirroring parts of IEEE Std 1082.[3] The American Society of Mechanical Engineers (ASME) has created the Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications [B1], which outlines high level requirements for HRAs to be included in PRAs. The NRC published Good Practices for Implementing Human Reliability Analysis [B13], which serves as a reference for desirable, but not required aspects of HRA. These three guidelines and numerous recommended practices found in specific HRA methods and texts, complement, but do not replace, IEEE Std 1082. For example, SHARP1 [B4] elaborates on quantifying the HRA for inclusion in PRA but does not include the entire HRA

[1]The numbers in brackets correspond to those of the bibliography in Annex B.
[2]NUREG publications are available from the U.S. Nuclear Regulatory Commission (http://www.nrc.gov).
[3]EPRI publications are available from the Electric Power Research Institute (http://epri.com).

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process of IEEE Std 1082. The ASME PRA standard [B1] articulates quality requirements for HRA but does not specify how the HRA should be conducted.[4] NRC's good practices [B13] parallel many aspects of IEEE Std 1082 but does not provide an overall process flow for conducting HRA. IEEE Std 1082 remains relevant as an overarching standard framework for conducting HRA.

IEEE Std 1082 is a method-neutral approach. It is beyond the scope of this guide to enumerate how the guidance can be tied into different HRA methods. Recent reviews of HRA methods may be found in [B1], [B3], [B14], [B15], and [B16]. HRA method development has been extensive, with new approaches that address cognition, context, errors of commission, as well as approaches that span simplified HRA quantification, to dynamic models of human performance. The framework for integrating HRA into PRA as outlined in this guide should apply across HRA methods, although some adaptations may be necessary to meet the unique requirements of specific methods. Such adaptations, especially when using simplified HRA methods, should not come as efficiencies at the expense of performing an integrated and complete HRA process.

[4]ASME publications are available from the American Society of Mechanical Engineers (http://www.asme.org/).

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IEEE Guide for Incorporating Human Reliability Analysis into Probabilistic Risk Assessments for Nuclear Power Generating Stations and Other Nuclear Facilities

1. Overview

1.1 Scope

This guide provides a structured framework for the incorporation of human reliability analysis (HRA) into probabilistic risk assessments (PRAs).

1.2 Purpose

The purpose of this guide is to enhance the analysis of human-system interactions in PRAs, to help ensure reproducible conclusions, and to standardize the documentation of such assessments. To do this, a specific HRA framework is developed from standard practices to serve as a benchmark to assess alternative ways of incorporating HRA into PRA.

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