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IEEE Std 1082™

Guide for incorporating human reliability analysis into probabilistic risk assessments for nuclear power generating stations and other nuclear facilities

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Contents

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

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IEEE Std 1082™-2017
(Revision of IEEE Std 1082-1997)

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

Sponsor

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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

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).

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/).

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.

2. Definitions, acronyms, and abbreviations

2.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[5]

NOTE—Several terms used in this guide and in the field of HRA are important, yet are ambiguous in common usage or not used frequently enough to be well known. They are defined in this clause for the use in understanding and following this guide.[6]

basic event: An element of the probabilistic risk assessment model for which no further decomposition is performed because it is at the limit of resolution consistent with available data.

[5] *IEEE Standards Dictionary Online* subscription is available at: http://dictionary.ieee.org.

[6] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

consequences: The result(s) of (i.e., events that follow and depend upon) a specified event.

cutset: A group of events that, if all occur, would cause occurrence of the top event (the outcome of interest such as that investigated by means of a fault tree).

dependence: The relationship between two or more human failure events, which may result in an adjustment to the model or the human error probability.

design-basis accident: A postulated accident that a nuclear facility must be designed and built to withstand without loss to the systems, structures, and components necessary to help ensure public health and safety.

dominant sequence: A sequence of events that constitutes a dominant contributor to overall risk.

event: (A) Any change in conditions or performance of interest. (B) An occurrence at a specific point in time.[7]

event tree: A graphical representation of the logical progression of the possible scenarios through a multiple series of events that may or may not occur.

fault tree: A graphical representation of an analytical technique whereby an undesired state of a system is specified and the patterns leading to that state can be evaluated to determine how the undesirable system failure can occur.

human action: The observable result (often a bodily movement) of a person's intention.

human error: Failure of human task performance to meet specified criteria of accuracy, completeness, correctness, appropriateness, or timeliness.

human error probability (HEP): The quantitative estimation of the likelihood of a human error.

human failure event (HFE): A basic event that pertains to a human error.

human interaction: A human action or set of actions that affects equipment, response of systems, or other human actions.

human reliability analysis (HRA): Any number of formal approaches and methods used to identify sources of human error and quantify their accompanying human error probabilities.

initiating event: An event either internal or external to the plant that perturbs the steady state operation of the plant by challenging plant control and safety systems whose failure could potentially lead to core damage or release of airborne fission products.

operating crew: Plant personnel working on shift to operate the plant. They include control room personnel and those support personnel who directly support the control room personnel in operating the plant.

performance shaping factor (PSF): A factor that influences human reliability through its effects on performance. These include factors such as environmental conditions, human-system interface design, procedures, training, and supervision.

probabilistic risk assessment (PRA): A qualitative and quantitative assessment of the risk associated with plant operation and maintenance that is measured in terms of frequency of occurrence of risk metrics, such as

[7]This definition differs from the one(s) found in previous IEEE guidance. The current definition has been tailored to match the specific use in human reliability analysis.