

IEEE Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations

Sponsor

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Abstract: A structured framework for the incorporation of human/system interactions into probabilistic risk assessments is provided.

Keywords: human reliability analysis (HRA), probabilistic risk assessment (PRA)

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Introduction

(This introduction is not part of IEEE Std 1082-1997, IEEE Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations.)

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 factors to form a complete reliability estimate.

The initial risk assessment made in the nuclear power plant industry, WASH-1400, recognized the need for a discipline of human reliability analysis (HRA), systematically incorporated within the PRA enterprise. But the methodology—both of 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 was vividly demonstrated by the accident at Three Mile Island (TMI). Following TMI, the 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. This conference has become a series, the fifth of which was held in Monterey, California, in 1992. Parallel to this activity, Subcommittee 7, Human Factors and Control Facilities, of the Nuclear Power Engineering Committee, began discussing the standardization of the 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.

In recent years, some convergence in the ideas and methods of HRA has occurred. Most PRAs perform HRA in a standard way, even when using approaches as diverse as the Systematic Human Action Reliability Procedure of the Electric Power Research Institute (EPRI) and the Accident Sequence Evaluation Program HRA method of the NRC.

This guide outlines the steps necessary to include human reliability in risk assessments. It is not its intent to discuss the details of HRA methods, since this technology is evolving and cannot be addressed in the needed depth in this guide. The reader is urged to review bibliography entries [B1], [B2], [B5], [B12], and [B22] for this information. 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.

It is anticipated that human reliability technology will not escape controversy in the near future. This is especially true regarding the quantification of Human Error Probabilities, which is not specifically addressed in this guide. In one sense this is a blessing, since it may ensure that the industries do not become complacent to the contribution of people and their actions to the risk spectrum of the technology they work.

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During the initial development of this guide, R. E. Hall was chair of WG7.2 and D. Schurman was secretary. WG7.2 split into WG7.2 and WG7.4. E. M. Dougherty chaired WG7.4, which assumed responsibility for this guide. During the final stages of development, R. E. Hall chaired SC7 and assumed acting chairmanship of WG7.4. During balloting and final editing, R. J. Christensen chaired SC7 and continued with the activi-

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IEEE Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations

1. Overview

1.1 Scope

This guide provides a structured framework for the incorporation of human/system interactions 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 human reliability analysis (HRA) framework is developed from standard practices to serve as a benchmark to assess alternative ways of incorporating HRA into PRA.

2. Definitions

Several terms used in this guide are important, yet are ambiguous in common usage or not used frequently enough to be well known. They are defined in this clause.

2.1 cognitive process: An internal human activity that receives, manipulates, and stores knowledge or information, or that controls actions according to this knowledge.

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

2.3 diagnosis: A cognitive assessment of the state of the system.

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

2.5 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.

2.6 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.

2.7 framework: A conceptual system of tasks or activities used in a specified type of analysis.

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

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

2.10 model: An analog representation, which may be conceptual, qualitative, or quantitative.

2.11 recovery: A set of interactions intended to restore failed equipment or to find alternatives to achieve its function.

2.12 reliability unit: That portion of a system for which a single reliability model is valid, i.e., for which there is a single mechanism of failure.

2.13 rule: (A) A series of steps or activities with a single known or anticipated result. (B) A guideline for acting or planning action.

2.14 skill: A cognitive and/or physical control process so highly practiced as to require little or no conscious supervision.

2.15 system: An integration of parts or constituents, their relationships, their mutual behavior or possible states, and the laws or rules that determine their behavior.

2.16 taxonomy: A classification scheme, or its results.

3. Overview of an integrated HRA

The risk associated with a nuclear power plant is highly dependent on the reliability of people and their interactions with the equipment and controls in the plant. An HRA is an integral part of a Level 1 PRA. In higher level PRAs, Levels 2 and 3, the quality of the analysis, i.e., quantification of human error, is dependent on the analyst's ability to specify scenarios and the expected human actions. This guide provides a specific approach that, if applied, will standardize the integration of HRA into the PRA process. The breakdown and order of the steps presented are not so important; all of the steps and their activities, however, should be found within any HRA.

3.1 Overall evaluation issues

The focus of this guide is restricted to the incorporation of the HRA integrally into a PRA. This includes the following issues:

- a) The compatibility of an HRA with the PRA of which it is a part;
- b) The relationship between the way in which an HRA is performed, its philosophy, and the results or insights that may be obtained;
- c) The flexibility required in the use of behavioral science technologies associated with HRA; and
- d) The limits of an HRA or its results.