18.6 Human Reliability Analysis

A goal of the HFE program is to establish that plant operators can access the required information and controls to safely and efficiently monitor and control the plant processes and equipment. HRA evaluates the potential for human error that may affect plant safety. Thus, HRA is an essential element in achieving the HFE design goal of providing a design that enhances human performance during plant operation.

18.6.1 Objectives and Scope of HRA / HFE Integration

HRA identifies possible human error mechanisms that may affect plant safety. When these risk-significant HAs are determined, they are incorporated into the HFE design process with the objective of providing robust decision making and support for executing actions to the operator performing the risk-significant HA. A well implemented HRA helps achieve the goal of providing an HSI design that minimizes personnel errors for risk-significant HAs, supports the detection of errors, and provides opportunities to recover from errors. As described in NUREG-0711 (Reference 1), HRA provides inputs to most aspects of the HFE design.

The probabilistic risk assessment (PRA) is described in Chapter 19. Risk-significant HAs are identified in the HRA portion of the PRA and are considered in the HFE design. As described in Chapter 19, risk-important HAs are identified by using selected importance measures, HRA sensitivity analyses, and threshold criteria.

The integration of HRA with HFE helps designers confirm that human-error mechanisms are addressed in the design of the HSI to minimize the likelihood of personnel error, and to verify that errors are detected and recoverable.

18.6.2 Methodology

The Implementation Plan for the Integration of Human Reliability Analysis into the HFE Program (Reference 1) describes the methodology for integrating HRA results with the various HFE program elements, which includes:

- A description of how various portions of the PRA were considered to determine the risk-significant HAs and the importance measures, HRA sensitivity analyses, and threshold criteria used to compile the list of risk-significant HAs.
- A description of how HAs influence operator tasks related to monitoring passive and automated systems.
- A description of how the PRA and HRA results along with the risk-significant HAs are addressed in other aspects of the HFE program with a goal of minimizing the likelihood for operator error and the ability to detect and recover from errors.
- A description of how HRA assumptions are validated during the design process.

- A description of the integration of HRA into the HFE program.

The HFE design gives special attention to those plant scenarios, risk-important HAs, and HSIs that have been identified by PRA and HRA as being important to plant safety and reliability.

The HRA evaluates and identifies specific HAs based on the impact of potential errors on plant safety. This evaluation is iterative. It begins early in the design process and continues throughout all phases of the design. The initial HRA is defined by a set of scenarios and accident sequences that contribute to core damage frequency or large release frequency. The HRA also considers operating experience, staffing and training, and other engineering assumptions that affect plant operation and human performance. From these inputs, human error probabilities (HEP) are calculated. HEPs are influenced by performance shaping factors (PSF), which are used to adjust the base HEPs to account for conditions such as the complexity of the accident and the stress upon the operators (refer to Chapter 19).

As the EPR design develops, the HRA model is refined to incorporate other HFE elements that will affect human performance. These elements influence the HEP estimates through the PSF values and the PRA evaluates the impact of these errors on accident scenarios. The HRA supports the HFE by providing the HSI design team with feedback that assists in minimizing personnel errors, and improving operator recovery from human errors and plant system failures.

All risk-significant HAs and their associated tasks and scenarios are specifically addressed during function allocation analyses, task analyses, and HSI design. The risk-significant HAs will be addressed as prime sources for specific assessment in the Integrated System Validation (ISV) through the Operational Conditions Sampling (OCS) process. This process helps verify that these tasks are well supported by the design and are within acceptable human performance capabilities (e.g., within time and workload requirements).

As described in Section 18.10, HRA assumptions such as decision making and diagnosis strategies for dominant sequences are validated by walkthrough analyses with operationally experienced personnel using a plant-specific control room mockup or simulator. Reviews are then incorporated into subsequent iterations of HRA and PRA. Risk-significant humans actions are addressed during integrated system validations.

18.6.3 Results

An output report identifies the list of risk-important HAs and summarizes how those HAs and the associated tasks and scenarios were addressed during the various parts of the HFE design process. The output report addresses the results of the HRA assumption validation.

18.6.4 References

1. [*U.S. EPR Implementation Plan for the Integration of Human Reliability Analysis (HRA) with the Human Factors Engineering (HFE) Program, AREVA NP Inc., 2012.*]*

1. NUREG-0711, "Human Factors Engineering Program Review Model," Revision 2, U.S, Nuclear Regulatory Commission, February 2004.