Treatment of Important Human Actions Implementation Plan

Technical Report

Non-Proprietary

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ABSTRACT

This document provides the Implementation Plan (IP) for the advanced power reactor 1400 (APR1400) treatment of important human actions (TIHAs).

The objective of the including important human actions (IHAs) in the design of the APR1400 human-system interface (HSI) is to: 1) identify the risk-important human actions (RIHAs) through integration with the plant specific probabilistic risk assessment (PRA), Chapter 19 of the DCD and 2) include IHAs from the deterministic analyzes in Chapter 7, Instrumentation and Controls, and Chapter 15. The methodology described in this document provides information for identifying IHAs, and information for integration activity between IHAs and human factors engineering (HFE) program, which are function allocation (FA), task analysis (TA), HSI design, procedure development, training program development and the verification and validation program.

In addition, this document provides the information for DCD, Chapter 18 Human Factors Engineering.

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List of Acronyms

ASME	American Society of Mechanical Engineer
APR	advanced power reactor
CDF	core damage frequency
DAS	diverse actuation system
DCD	design control document
D3	diversity and defense-in-depth
DIHA	deterministically-important human action
F-V	Fussell-Vesely
FA	function allocation
FRA	functional requirements analysis
HA	human action
HED	human engineering discrepancy
HF	human factors
HFE	human factors engineering
HFEPP	human factors engineering program plan
HF V&V	human factors verification and validation
HSI	human-system interface
IP	implementation plan
ISV	integrated system validation
KHNP	
LBLOCA	large break loss of coolant accident
LCS	local control stations
MCR	main control room
OER	operating experience review
PRA	probabilistic risk assessment
PSF	performance shaping factor
RAP	reliability assurance program
RAW	risk achievement worth
RIHA	risk-important human action
SGTR	steam generator tube rupture
SME	subject matters expert
TA	task analysis
TIHA	treatment of important human actions
V&V	verification and validation

1.0 Overview

1.1 Purpose

The treatment of important human actions (TIHAs) is performed to:

- identify risk-important human actions (RIHAs) from design control document (DCD) Chapter 19
- identify deterministically important human actions (DIHAs) analysis from DCD Chapters 7 and 15
- assure the integration of important human actions (IHAs) into the human factors engineering (HFE) program

1.2 Scope

1.2.1 Risk-important Human Actions

RIHAs are IHAs developed from Level 1 and Level 2 probabilistic risk assessment (PRA) for both internal and external events.

The RIHA includes the diagnosis and execution tasks performed in the main control room (MCR). The other RIHAs are the diagnosis tasks performed in the MCR and execution tasks performed at applicable local control stations (LCS).

The scope of the RIHA integration and evaluation includes incorporating into the HFE design effort all IHAs.

The iterative nature of the interaction of HFE design and the RIHA continues increasing level of details with the design progresses, resulting in IHAs being removed and new ones added to the list.

1.2.2 Deterministically-Important Human Actions

The manual operator actions credited in the transient and accident analysis documented in Chapter 15 of the DCD and the Diversity and Defense-in-depth (D3) coping analysis documented in Chapter 7 of the DCD are included in the TIHAs.

1.3 Definitions and Acronym

The terms below are defined to provide definitions for specific terms used in this report and to support interactions between the treatment of IHAs and the other elements of the HFE design.

Accident sequence: a representation, in terms of an initiating event followed by a combination of system, function and operator errors or successes, of an accident that can lead to undesired consequences, with a specified end state (e.g., core damage or large early release). An accident sequence may contain many unique variations of events (minimal cut sets) that are similar (ASME-RA-S-2002).

Consequences: the results of (i.e., events that follow and depend upon) a specified event. Contingency plans: pre-thought out plans for mitigating undesired events that occur during plant operations.

Core damage frequency (CDF): expected number of core damage events per unit of time.

Core damage: uncover and heat-up of the reactor core to the point at which prolong oxidation and severe fuel damage involving a large fraction of the core is anticipated.

Cut-set: the route through a logic tree represented as a collection of basic events whose occurrence guarantees that a top event in a fault tree or sequence end state in an event tree occurs. The cutset is minimal if the non-occurrence of one basic event in the collection prevents the top event or sequence from occurring.

Diagnosis: examination and evaluation of data from the HSI to determine either the condition of the system structures and components or the cause of the condition (ASME-RA-S-2002).

Function allocation (FA): The process of assigning responsibility for accomplishing functions to personnel or automation, or to a combination of them.

Human action (HA): a manual response to a cue involving one person to achieve one task or objective. Potentially risk-IHAs affect equipment or physical systems. Single human actions can be represented as an event in a fault tree or branch point in an event tree.

Human error: can be defined as a mismatch between a performance demand and the human capability to satisfy that demand.

Human-system interface: in general the HSI encompasses all instrumentation and control systems provided as part of the APR1400 for use in performing the monitoring, control, alarming, and protection functions associated with all modes of plant normal operation as well as off-normal, emergency, and accident conditions. Specifically, the HSI is the organization of inputs and outputs used by personnel at a location to interact with the plant, including the using of alarms, displays, controls, and job performance aids. Generically, this includes interfaces that support actions for monitoring, controlling, maintaining protection functions, responding to events, and performing maintenance, calibration, inspection and testing activities.

Important human actions (IHAs) - IHAs consist of those actions that meet either risk or deterministic criteria.

- Risk-important human actions - Actions defined by risk criteria that plant personnel use to assure the plant’s safety. There are absolute and relative criteria for defining risk important actions. For absolute ones, a risk-important action is any action whose successful performance is needed to reasonably assure that predefined risk criteria are met. For relative criteria, the risk-important actions are defined as those with the greatest risk compared to all human actions. The identification can be made quantitatively from risk analyses, and qualitatively from various criteria, such as concerns about task performance based on considering performance-shaping factors.
- Deterministically identified IHAs - Deterministic engineering analyses typically are completed as part of the suite of analyses in the DCD in Chapters 7, Instrumentation & Controls diversity and defense-in-depth (D3) analysis, and Chapter 15, Transient and Accident Analyses for credited manual actions.

Local control station (LCS): an operator interface related to nuclear power plant process control that is not located in the main control room. This includes multifunction panels, as well as single-function LCSs such as controls (e.g., valves, switches, and breakers) that are operated and displays (e.g., meters) that are consulted during normal, abnormal, or emergency operations.

Main control room (MCR): room that provides the location from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions, including loss-of-coolant accidents.

Operating experience review (OER): a systematic review, analysis and evaluation of lessons learned from operating experience that can apply to the development of the man machine interface design.

Performance shaping factor (PSF): a factor that influences human error probabilities as considered in a PRA's human reliability analysis and includes such items as level of training, quality/availability of procedural guidance, time available to perform an action, etc. (ASMERA-S-2002).

Recovery: a general term describing restoration and repair acts required to change the initial or current state of a system or component into a position or condition needed to accomplish a desired function for a given plant state (ASME-RA-S-2002).

Risk: probability and consequences of an event.

System: an integrated collection of plant components and control elements that operate alone or with other plant systems to perform a function (NUREG-1764).

Task: a collection of activities with a common purpose, often occurring in temporal proximity, with an identifiable start and end point for which human actions are performed using displays and controls.

Task analysis (TA): a method of description for what plant personnel must do to achieve and support plant equipment.

Time available: the time period from the presentation of a cue for human action or equipment response to the time of adverse consequences if no action is taken (ASME-RA-S-2002).

2.0 Applicable Documents

1. NUREG-1764, “Guidance for the Review of Changes to Human Actions,” 2004.
2. IEEE Std. 497-2002, “IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations,” 2002.
3. RG 1.97, Revision 4, “Criteria For Accident Monitoring Instrumentation For Nuclear Power Plants,” June 2006.
4. NUREG-0711, Revision 3, “Human Factors Engineering Program Review Model,” U.S. Nuclear Regulatory Commission, November 2012.
5. KHNP, APR1400-E-J-NR-12001-P, “Functional Requirements Analysis and Function Allocation Implementation Plan,” September 2013.
6. KHNP, APR1400-E-J-NR-12007-P, “Task Analysis Implementation Plan,” September 2013.
7. KHNP, APR1400-E-J-NR-12008-P, “Human-System Interface design Implementation Plan,” September 2013.

3.0 Methods

3.1 Risk-Important Human Action Analysis

3.1.1 Basis and Requirements

The RIHA is evaluated the potential for, and mechanisms of human error that might affect plant safety. Thus, it is an essential feature in assuring the HFE program goal of generating a design to minimize personnel errors, support their detection, and ensure recovery capability.

The first version of the RIHA (depending on the amount of design information available) are used iteratively to identify the IHAs, so that they can be considered in the early HFE design elements.

The RIHA should be updated iteratively as the design progresses (including the final TIHA) to ensure the actual IHAs are captured and considered. At the very least, the initial RIHA, and the set of IHAs, should be finalized when the design of the plant and HSI are complete.

3.1.2 Identification of Risk-important Human Actions

The RIHAs are identified through the importance analysis of PRA.

The method and selection criteria applied in determining RIHAs uses two industry accepted sensitivity methods: TS

The values of RAW and F-V for human errors are estimated by importance analysis using minimal cut-sets of the Level 1 internal events PRA.
The level 2 and external events RIHA are performed by expert judgment or methods described for the level 1 internal RIHA

3.1.3 Application

Identified RIHAs and its related information are provided to HFE program elements for HFE design. The related information includes description of each RIHA and related accident sequence and PSFs.

3.2 Deterministically-Important Human Actions Analyses

The HFE design team reviews Chapters 7 and 15 of the DCD and creates a list of credited manual actions and IHAs addressed by the D3 analysis. DIHA list is combined with the RIHA list used as a checklist for the FRA/FA, TA, HSI design, procedures development, training program development and V&V elements of the HFE program.

3.2.1 Basis and Requirements

The treatment of IHAs will identify DIHA from following licensing analyses:

- Operator actions credit in the DCD Chapter 15 accident and transient analyses
- Operator actions credited in the D3 coping analyses as specified Section 1 and 2 of Interim Staff Guidance DI&C-ISG-02, D3 issues.

3.2.2 Identification of Deterministically-Important Human Actions Analysis

There are no clear criteria for distinguishing DIHA from other actions. However, the most conservative approach is to identify all credited manual action that is described in the transient and accident analysis and D3 coping analysis as a DIHA.

The resulting list of IHAs is then reviewed and incorporated into the HFE program element by expert judgment.

If this review does not adversely impact the element or results from that element on the HSI design, no change in the design is required.

For example, for all design basis accidents (i.e., transient and accident analysis events), the DIHAs are taken from HSI within the MCR. For beyond design basis accidents (i.e., D3 coping analysis events) the all DIHAs are required within the first 30 minutes of an accident to be taken from HSI within the MCR. DIHA after 30 minutes can be taken from local controls.

3.2.3 Application

For any transient and accident analysis and D3 coping analysis identify (1) HAs directly credited to mitigate the action and achieve plant stabilization, and (2) HAs needed to maintain a stable plant condition for the long term are identified.

Two examples from the transient and accident analysis:

TS

For the transient and accident analysis, consistency is maintained between the methodology used for selecting DIHAs and the methodology used for selecting Type A variables in compliance to IEEE Std. 497-2002 (Reference 2) which is endorsed by RG 1.97, Revision 4 (Reference 3).

The credited manual actions in the transient and accident analysis that lead to the identification of Type A variables are DIHAs.

A similar methodology is applied to the credited manual actions from the D3 coping analysis. Actions that are credited for accident mitigation and plant stabilization are DIHAs; other actions to maintain plant stabilization for the long term are not.

TS

IHAs are identified by systems safety engineering subject matter experts (SME) with qualifications as defined in NUREG-0711 Appendix A. For each accident the SME documents the credited manual actions identified in the text of the analysis, along with the SME assessment.

4.0 Implementation

4.1 List of IHAs applied by HFE Elements

The HFE implementation process identifies the roll of TIHA in the HFE design process and complies with logical flow described in Figure 7-1 from NUREG-0711 (Reference 4).

The TIHA plays a vital role in the overall design of the HSI by identifying expected human response times, automation needs and IHAs that must be considered in the design. It is also used to evaluate HSI design changes based on identification of controlling mechanisms to minimize the impact of the TIHAs and on design changes that come from the other elements of the overall HFE program.

The TIHA results interface with other elements of HFE program and systematically integrated into relevant parts of the overall plant design.

The TIHA taken input from and feeds information to the OER, FA, TA, HSI design, and HF V&V elements of the HFE program. In addition, it forms one of the bases for the procedures development and training program development so that these elements support to minimize human errors and their consequences. The TIHAs finally identifies and evaluates the IHAs that will be included in the HF V&V.

IHAs with other HFE element interactions include the followings:

- Function Allocation
  IHA impacts on FA by identifying deterministic and RIHAs that are assessed in the FA for consideration for further assignment of automation. The use of IHA in the FA is described in the Functional Requirements Analysis and Function Allocation Implementation Plan (Reference 5)

- Task Analysis
  IHAs identified by the probabilistic and deterministic analyses are provided to TA. TA provides detailed task requirements for IHA to treatment of IHA. The use of IHA in the TA is described in the Task Analysis Implementation Plan (Reference 6).

- Human-System Interface Design
  The HSI design is considered as an input to the TIHA and is evaluated adequately by the IHA. IHAs and their related information are fed back to the HSI design for prompt possible redesign. The use of HSI design in the IHA is described in the Human-System Interface Implementation Plan (Reference 7).

- Procedure Development
  Procedure development considers IHAs as an input.

- Training Program Development
  Training program development considers IHAs as an input.

The human performance assumptions, based on the HFE design influence on the TIHA, are verified as a part of HF V&V through independent expert review or walk-through using operating procedures. The IHA will be included in scenarios for the HF V&V to assure that the final HSI design limits impact on the plant safety.

4.2 Evaluation of IHAs to HFE elements

IHAs results from TIHA are reviewed by every organization in HFE design team. The result includes the HFE organizations responsible for the FA, TA, HSI design, procedure development, training program development, and HF V&V.

HFE design team is responsible for assuring these results considered in terms of reviewing their respective design analysis or testing programs such that HSI design minimizes the likelihood of human errors and provides opportunity for error detection and recovery.

5.0 Results

Results of the TIHAs are documented in the Results Summary Report.

The report will describe how IHAs were identified and integrated with HFE program in compliance with this Implementation Plan, including the list of IHAs.