DCP/NRC2473
May 14, 2009

ENCLOSURE 4

WCAP-14651 Rev 2 "Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan"

WCAP-14690 Rev 1 "Designer's Input to Procedure Development for the AP600"

(Non-Proprietary)

6 2 2 1 6 0

WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-14651
Revision 2

Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan

S. P. Kerch
E. M. Roth
S. Sancaktar
AP600 Design Certification Project

May 1997

Westinghouse Electric Corporation
Energy System Business Unit
P.O. Box 355
Pittsburgh, PA 15230-0355

3637w.wpf:1b-050697

AP600 DOCUMENT COVER SHEET

TDC: ______________ IDS: I ________ S ________

Form 58202G(5/94)

AP600 CENTRAL FILE USE ONLY:

0058.FRM

RFS#: RFS ITEM #:

AP600 DOCUMENT NO.	REVISION NO.		ASSIGNED TO
OCS-GEH-030	2	Page 1 of	

ALTERNATE DOCUMENT NUMBER: WCAP-14651, Rev. 2 WORK BREAKDOWN #: 3.3.2.4.5

DESIGN AGENT ORGANIZATION: WESTINGHOUSE ELECTRIC

TITLE: Integration of Human Reliability Analysis and Human Factors Engineering Design Implementation Plan

ATTACHMENTS:	DCP #/REV. INCORPORATED IN THIS DOCUMENT REVISION:
CALCULATION/ANALYSIS REFERENCE:	

ELECTRONIC FILENAME	ELECTRONIC FILE FORMAT	ELECTRONIC FILE DESCRIPTION
3637w.wpf	WordPerfect	

COMPLETE 1 IF WORK PERFORMED UNDER DESIGN CERTIFICATION OR COMPLETE 2 IF WORK PERFORMED UNDER FOAKE.

1 ☐ **DOE DESIGN CERTIFICATION PROGRAM** - GOVERNMENT LIMITED RIGHTS STATEMENT [See page 2]

Copyright statement: A license is reserved to the U.S. Government under contract DE-AC03-90SF18495.

☒ DOE CONTRACT DELIVERABLES (DELIVERED DATA)
Subject to specified exceptions, disclosure of this data is restricted until September 30, 1995 or Design Certification under DOE contract DE-AC03-90SF18495, whichever is later.

EPRI CONFIDENTIAL: NOTICE: 1☒ 2☐ 3☐ 4☐ 5☐ CATEGORY: A☒ B☐ C☐ D☐ E☐ F☐

2 ☐ **ARC FOAKE PROGRAM** - ARC LIMITED RIGHTS STATEMENT [See page 2]

Copyright statement: A license is reserved to the U.S. Government under contract DE-FC02-NE34267 and subcontract ARC-93-3-SC-001.

☐ ARC CONTRACT DELIVERABLES (CONTRACT DATA)
Subject to specified exceptions, disclosure of this data is restricted under ARC Subcontract ARC-93-3-SC-001.

ORIGINATOR	SIGNATURE/DATE	
S. P. Kerch	S. P. Kerch May 7, 1997	
AP600 RESPONSIBLE MANAGER	SIGNATURE*	APPROVAL DATE
D. J. Vaglia	D. J. Vaglia	May 8th, 1997

*Approval of the responsible manager signifies that document is complete, all required reviews are complete, electronic file is attached and document is released for use.

Form 58202G(5/94)

LIMITED RIGHTS STATEMENTS

DOE GOVERNMENT LIMITED RIGHTS STATEMENT

(A) These data are submitted with limited rights under government contract No. DE-AC03-90SF18495. These data may be reproduced and used by the government with the express limitation that they will not, without written permission of the contractor, be used for purposes of manufacturer nor disclosed outside the government; except that the government may disclose these data outside the government for the following purposes, if any, provided that the government makes such disclosure subject to prohibition against further use and disclosure:

(I) This "Proprietary Data" may be disclosed for evaluation purposes under the restrictions above.

(II) The "Proprietary Data" may be disclosed to the Electric Power Research Institute (EPRI), electric utility representatives and their direct consultants, excluding direct commercial competitors, and the DOE National Laboratories under the prohibitions and restrictions above.

(B) This notice shall be marked on any reproduction of these data, in whole or in part.

ARC LIMITED RIGHTS STATEMENT:

This proprietary data, furnished under Subcontract Number ARC-93-3-SC-001 with ARC may be duplicated and used by the government and ARC, subject to the limitations of Article H-17.F. of that subcontract, with the express limitations that the proprietary data may not be disclosed outside the government or ARC, or ARC's Class 1 & 3 members or EPRI or be used for purposes of manufacture without prior permission of the Subcontractor, except that further disclosure or use may be made solely for the following purposes:

This proprietary data may be disclosed to other than commercial competitors of Subcontractor for evaluation purposes of this subcontract under the restriction that the proprietary data be retained in confidence and not be further disclosed, and subject to the terms of a non-disclosure agreement between the Subcontractor and that organization, excluding DOE and its contractors.

DEFINITIONS

CONTRACT/DELIVERED DATA — Consists of documents (e.g. specifications, drawings, reports) which are generated under the DOE or ARC contracts which contain no background proprietary data.

EPRI CONFIDENTIALITY / OBLIGATION NOTICES

NOTICE 1: The data in this document is subject to no confidentiality obligations.

NOTICE 2: The data in this document is proprietary and confidential to Westinghouse Electric Corporation and/or its Contractors. It is forwarded to recipient under an obligation of Confidence and Trust for limited purposes only. Any use, disclosure to unauthorized persons, or copying of this document or parts thereof is prohibited except as agreed to in advance by the Electric Power Research Institute (EPRI) and Westinghouse Electric Corporation. Recipient of this data has a duty to inquire of EPRI and/or Westinghouse as to the uses of the information contained herein that are permitted.

NOTICE 3: The data in this document is proprietary and confidential to Westinghouse Electric Corporation and/or its Contractors. It is forwarded to recipient under an obligation of Confidence and Trust for use only in evaluation tasks specifically authorized by the Electric Power Research Institute (EPRI). Any use, disclosure to unauthorized persons, or copying this document or parts thereof is prohibited except as agreed to in advance by EPRI and Westinghouse Electric Corporation. Recipient of this data has a duty to inquire of EPRI and/or Westinghouse as to the uses of the information contained herein that are permitted. This document and any copies or excerpts thereof that may have been generated are to be returned to Westinghouse, directly or through EPRI, when requested to do so.

NOTICE 4: The data in this document is proprietary and confidential to Westinghouse Electric Corporation and/or its Contractors. It is being revealed in confidence and trust only to Employees of EPRI and to certain contractors of EPRI for limited evaluation tasks authorized by EPRI. Any use, disclosure to unauthorized persons, or copying of this document or parts thereof is prohibited. This Document and any copies or excerpts thereof that may have been generated are to be returned to Westinghouse, directly or through EPRI, when requested to do so.

NOTICE 5: The data in this document is proprietary and confidential to Westinghouse Electric Corporation and/or its Contractors. Access to this data is given in Confidence and Trust only at Westinghouse facilities for limited evaluation tasks assigned by EPRI. Any use, disclosure to unauthorized persons, or copying of this document or parts thereof is prohibited. Neither this document nor any excerpts therefrom are to be removed from Westinghouse facilities.

EPRI CONFIDENTIALITY / OBLIGATION CATEGORIES

CATEGORY "A" — (See Delivered Data) Consists of CONTRACTOR Foreground Data that is contained in an issued reported.

CATEGORY "B" — (See Delivered Data) Consists of CONTRACTOR Foreground Data that is not contained in an issued report, except for computer programs.

CATEGORY "C" — Consists of CONTRACTOR Background Data except for computer programs.

CATEGORY "D" — Consists of computer programs developed in the course of performing the Work.

CATEGORY "E" — Consists of computer programs developed prior to the Effective Date or after the Effective Date but outside the scope of the Work.

CATEGORY "F" — Consists of administrative plans and administrative reports.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ADS	Automatic Depressurization System
CDF	Core Damage Frequency
COL	Combined License
CVS	Chemical and Volume Control System
DAS	Diverse Actuation System
HFE	Human Factors Engineering
HRA	Human Reliability Analysis
HSI	Human System Interface
IRWST	In-Containment Refueling Water Storage Tank
LOCA	Loss-of-Coolant Accident
LRF	Large Release Frequency
MMI	Man-Machine Interface
M-MIS	Man-Machine Interface System
MLOCA	Medium LOCA
MOV	Motor-Operated Valve
MTIS	Maintenance, Inspection, Test and Surveillances
PMS	Protection and Safety Monitoring System
PRA	Probabilistic Risk Assessment
RAW	Risk Achievement Worth
RRW	Risk Reduction Worth
RCS	Reactor Coolant System
RNS	Normal Residual Heat Removal
SG	Steam Generator
SGTR	Steam Generator Tube Rupture
SLOCA	Small LOCA
SSC	Systems, Structures, and Components
THERP	Technique for Human Error Rate Prediction
V&V	Verification and Validation

1 INTRODUCTION

This document provides an implementation plan for the integration of Human Reliability Analysis (HRA) with Human Factors Engineering (HFE) design. It describes the interrelation among the activities conducted by the Man-Machine Design group, the Procedures Development group, and the HRA and Probabilistic Risk Assessment (PRA) group.

1.1 Scope and Objective of Implementation Plan

The objective of the *Integration of HRA with HFE Design Implementation Plan* enables:

- the HRA activity to integrate the results of the HFE design activities
- the HFE design activities to address *risk-important* tasks and human error mechanisms in order to minimize the likelihood of personnel error and to provide for error detection and recovery capability

This document does not cover HRA methodology. HRA methodology and results are described as part of the AP600 PRA Study, Reference 7.

1.2 Use of HRA/PRA Insights to Guide HFE Design

The AP600 design draws on lessons learned from existing plant experience and results of past HRAs and PRAs to reduce the potential for human error and increase safety. In response, one approach to increase plant safety in the AP600 has been to simplify the plant design and reduce the number of human actions required.

This *Integration of HRA with HFE Design Implementation Plan* describes the process by which insights from HRA/PRA are used to improve the HFE design and limit the risk to humans and the risk of errors.

Figure 1-1 provides an overview of how HRA activities are integrated within the HFE program. There are three primary points of interaction:

1. Task Analysis: Results of HRA/PRA analyses are used to identify *risk-important* tasks and performance requirements as input to HFE task analysis activities.

2. Human System Interface (HSI) Design and Procedure Development: Results of the HSI design and procedure development activities are used to confirm and/or refine HRA assumptions. Tasks that are identified in the HRA/PRA that pose serious challenges to plant safety and reliability are re-examined by task analysis, HSI design and procedure

development identifies changes to the operator task, procedures, or the control and display environment to minimize the likelihood of operator error and provide for error detection and recovery capability.

3. HFE Verification and Validation (V&V): HRA performance assumptions (e.g., actions to be performed; time within which they are completed) are validated as part of the HFE Integrated System Validation.

While training is an important contributor to human reliability, it is not explicitly addressed in this implementation plan because training program development is a Combined License (COL) applicant responsibility. Westinghouse will provide the COL applicant with the AP600 PRA Study documentation that includes the description of HRA assumptions and results relevant to training. In addition, insights relevant to the training program are provided in a report following the HFE V&V. This report includes a list of critical human actions (if any), *risk-important* human actions, the performance requirements for those actions (e.g., response time) and any insights gained during the V&V that relate to training requirements for *risk-important* human actions (see Section 13.2.1 of the AP600 SSAR).

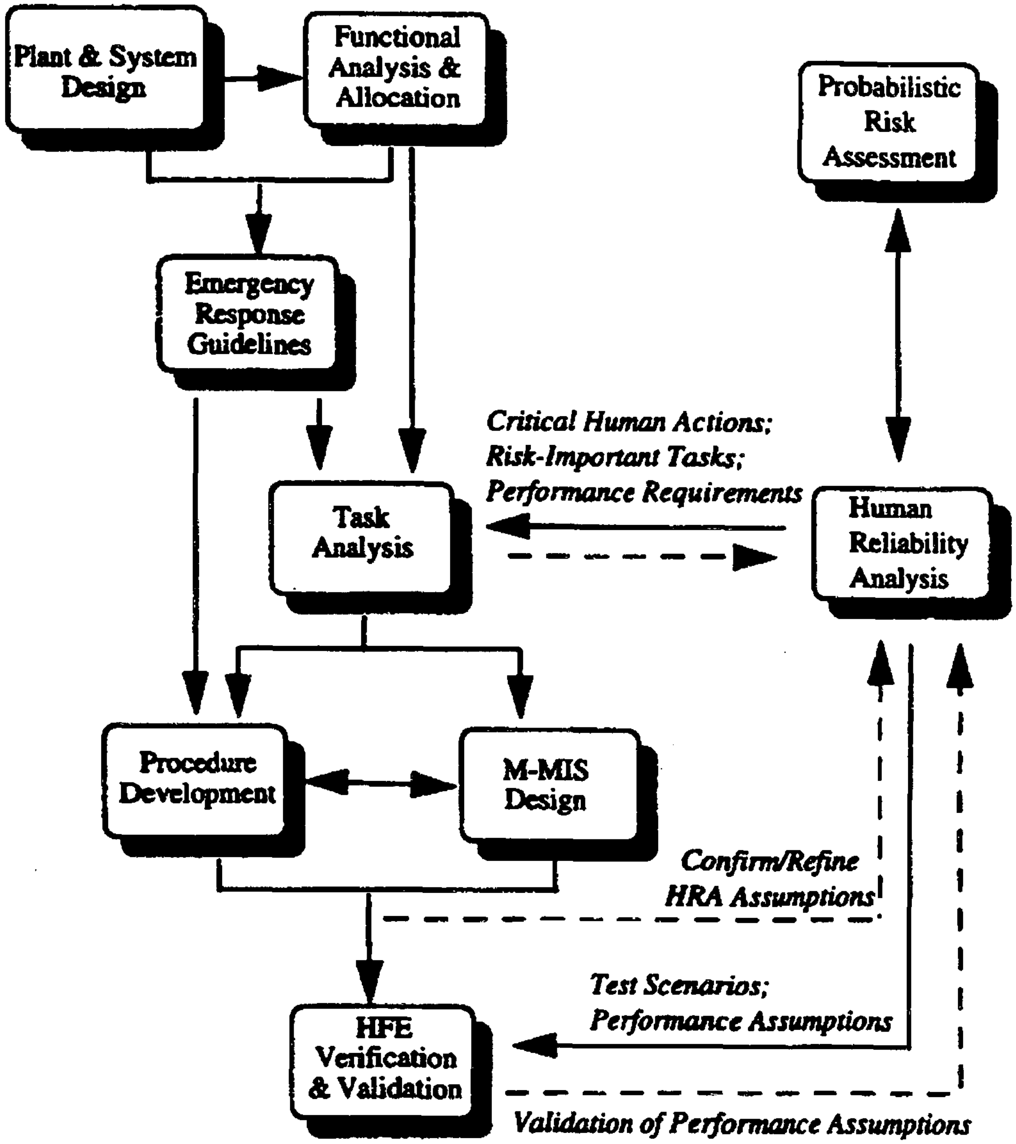

Figure 1-1 Overview of How HRA Activities are Integrated in the HFE Program

2 PRA/HRA IDENTIFICATION OF CRITICAL HUMAN ACTIONS AND RISK-IMPORTANT TASKS

In order to enable human actions and tasks (that are important to plant safety) to be explicitly addressed as part of the HFE design effort, the results of the HRA are used to identify critical human actions (if any) and *risk-important* tasks. The human actions and tasks identified are used as input to task analysis and HFE design activities.

The following subsections provide the criteria applied to identify the critical human actions and *risk-important* tasks. Appendix A provides examples that are based upon AP600 PRA studies available September 1996.

2.1 Critical Human Action

Two alternative criteria define critical human actions:

Deterministic Criteria: Any human action that is required to prevent core damage or severe release in licensing design basis accidents (Ref. 1).

or

PRA Criteria: Any human action (as identified from those baseline PRA studies with quantitative results) that, if failed, would result in total core damage frequency equal to or greater than 1E-4 ($1x10^{-4}$) or severe release frequency equal to or greater than 1E-5 ($1x10^{-5}$).

The baseline PRA studies include internal at-power events, internal shutdown events, and fire, flood, and seismic events.

2.2 *Risk-Important* Tasks

Risk-important tasks that involve human actions will be identified using two *risk-important* measures that are commonly used in PRA studies:

1. Risk-Increase Measure: This measure examines the increase in risk that would result if the probability of failing to take human action were set to 1.0. The objective of this measure is to identify human actions that, if failed to be taken, would result in a significant increase in risk. These tasks would be included in the task analyses and integrated V&V activities to ensure that they are adequately supported by the Man-Machine Interface System (M-MIS), so as to minimize the potential for error.

2. Risk-Decrease Measure: This measure examines the decrease in risk that would result if the probability of failing to take the human action were set to 0. The objective of this measure is to identify human actions, that if executed correctly, would result in a significant reduction in risk. These tasks would be included in the task analyses and integrated V&V activities to ensure that they are adequately supported by the M-MIS, so as to maximize the potential for correct performance.

PRA studies are performed for:

- Internal at-power events (core damage and severe release)
- Internal shutdown events (core damage and severe release)
- Fire, flood events (only core damage bounding assignment is being performed)
- Seismic events (seismic margins only)

In addition, a focused PRA sensitivity study is performed to provide input to regulatory treatment of nonsafety systems. In this study, no credit is taken for nonsafety-related systems in the calculation of core damage and severe release frequencies. Credit is only taken for safety-related systems. The focused PRA sensitivity study is performed for:

- Internal at-power events
- Internal shutdown events
- Fire and flooding events (core damage bounding assignment only)

The results of these PRA studies are examined to identify *risk-important* tasks.

Quantitative criteria used in identifying *risk-important* tasks, in cases where quantitative measures of risk-increase and risk-decrease are available, are described below. The qualitative criteria used to identify *risk-important* tasks are also described. The qualitative criteria are applied to each of the PRA studies listed above.

Quantitative Criteria for *Risk-Important* Tasks

A task is defined to be *risk-important* if its importance, as calculated by one of these two measures, is above a risk threshold associated with that measure.

The two measures are formally quantified as follows:

1. Risk-Increase Measure: This measure provides the importance of a human action for core damage and severe release with respect to maintaining the existing risk level. For this purpose, the core damage and severe release is requantified for each human action by setting its failure probability to 1.0. The *risk-importance* of a human action is then defined as the percentage increase in core damage and severe release frequency. For example, a

risk-importance of 100 is the same as doubling the base core damage frequency or severe release frequency (dependent upon whether the PRA study being examined is a core damage or severe release study) when the task failure probability is set equal to 1.0. The larger the percentage, the more important the human action is in maintaining the existing risk level.

The risk-increase importance threshold used for AP600 is 200 percent for internal events, at-power and shutdown, for both core damage and severe release. This is equivalent to a risk achievement worth (RAW) of 3.0. Any value below this is deemed to be too small to be considered as worthwhile to pursue.

In the case of the focused PRA sensitivity study, the risk-increase importance threshold used is 100 percent (a RAW value equivalent to 2.0).

2. Risk-Decrease Measure: This measure provides the importance of a human action for core damage and severe release with respect to reducing the existing risk level. For this purpose, the core damage and severe release is requantified by setting each operator action failure probability to zero. The importance of a human action is then defined as the percent decrease in core damage and severe release frequency. For example, a risk-decrease value of 10 percent indicates that the maximum benefit that can be obtained by improving task failure probability is 10 percent. The larger the percent decrease, the more important the human action is in potentially reducing the existing risk.

   The risk-decrease importance threshold used for AP600 is 10 percent for internal events, at-power, and shutdown, for both core damage and severe release. This is equivalent to a risk reduction worth (RRW) of about 1.1. Any value below this is deemed to be too small to be considered as worthwhile to pursue.

   In the case of the focused PRA sensitivity study, the risk-decrease importance threshold used is 5 percent (RRW of about 1.05).

The definition of *risk-important* tasks provided above utilizes well-recognized and quantifiable concepts of risk-increase and risk-decrease measures, which take into account different aspects of *risk-importance*. Defining *risk-important* tasks in terms of risk-increase and risk-decrease is consistent with the *risk-importance* measures used for other applications, such as the NRC maintenance rule. A uniform definition of *risk-importance* across different application areas allows consistency, as well as efficiency, since importance tables created for basic events may be used for different applications.

Qualitative Criteria for *Risk-Important* Tasks

In addition to quantitative measures, qualitative criteria for identifying *risk-important* tasks are applied to the PRA studies. An expert panel representative of HRA/PRA, systems engineering design, HSI design, and HFE apply the criteria and identify the associated *risk-important* tasks.

Criteria used to identify *risk-important* tasks include:

1. Operator actions that estimate the time to completion is close to the time window available for completion

2. Operator actions where the nature of the operator activities, or demands placed upon operators are complex, unique, or potentially challenging

3. Operator actions just below the threshold values for critical human actions (as defined in Section 2.1) and the threshold values for *risk-important* tasks (as defined in Section 2.2) are re-evaluated for inclusion as a *risk-important* task

4. Operator actions needed to prevent a situation where conflicting safety goals may result

5. Operator actions that are deemed to be *risk-important* by the panel members based upon history and the panel's expert opinion

Qualitative Criteria for *Risk-Important* Maintenance, Inspection, Test, and Surveillances

Qualitative criteria are used to identify *risk-important* maintenance, inspection, test, and surveillances (MTIS). *Risk-important* MTIS are identified by examining "risk-significant" Systems, Structures, and Components (SSC). The criteria used to identify "risk-significant" SSCs are provided in SSAR 16.2, "Reliability Assurance Program." A subset of these "risk-significant" SSCs and a representative set of the associated MTIS are selected by an expert panel. This panel is to be comprised of representatives with expertise from relevant groups in the design process, such as systems engineering, reliability engineering, PRA, HFE, and HSI design. Criteria used to identify *risk-important* MTIS tasks include 1, 2, 4, and 5 listed above. The set of MTIS tasks identified through the expert panel process are defined to be *risk-important* and examined in task analysis procedures, HSI design, and V&V activities.

3 TASK ANALYSES FOR CRITICAL HUMAN ACTIONS AND RISK-IMPORTANT TASKS

The HRA/PRA group specify human actions and task sequences to be used as input to the task analyses performed as part of the HFE program. This includes all critical human actions (if any) and *risk-important* human actions.

3.1 Input to Operational Sequence Task Analyses

The human actions and tasks identified by HRA activities are included in the set of tasks examined using operational sequence task analyses. The inputs to the task analyses include a specification of the task sequences performed, as well as any performance requirements, such as time windows within which an action needs to be completed. This input guides the design of the HSI and the development of the procedures so as to adequately support these *risk-important* tasks.

The HSI and procedures groups submit results of their analyses (e.g., function-based task analyses; operational sequence task analyses) and design activities (e.g., emergency response guidelines (ERGs), functional requirement documents; display descriptions) to the HRA group for review and comment.

3.2 Confirming/Refining HRA Assumptions

HRAs conducted early in the design process, necessarily make assumptions about function allocation, human actions performed, and the quality of the HSI design, procedures, and related performance-shaping factors, that are confirmed or refined as the design effort progresses.

Once man-machine function allocation becomes finalized, and initial HSI designs and procedures are completed, it becomes possible to perform more detailed sequential task analyses that more accurately reflect details of the design. At this point it becomes possible to examine the impact of advanced digital technology, and the details of the HSI design and procedures, on the operator actions to be performed, the demands they place on the operator, and the estimated duration time to complete them.

When initial HSI designs and procedures are completed, more detailed operational sequence task and workload analyses are performed to obtain more accurate estimates of workload and task completion times for the set of tasks identified by the HRA/PRA group. (These more detailed operational sequence task analyses are referred to as OSA-2 in the description of AP600 Task Analysis Activities, SSAR subsection 18.5.2.3.) The results are documented in a report, and provided to the HRA/PRA group.

The HRA/PRA group then reviews the HFE design and analysis documents for potential impact on HRA assumptions.

4 RE-EXAMINATION OF CRITICAL HUMAN ACTIONS AND RISK-IMPORTANT TASKS

If a critical human action or *risk-important* task is determined to be a potentially significant contributor to risk, based on the results of Section 3, it is re-examined by task analysis, HSI design, and procedure development. This is to identify changes to the operator task or the control and display environment, to reduce the likelihood of operator error and provide for error detection and recovery capability.

5 VALIDATION OF HRA PERFORMANCE ASSUMPTIONS

Validation of HRA operator performance assumptions is performed as part of the Integrated HFE System Validation.

The HRA/PRA group identifies scenarios that involve critical or *risk-important* human actions that are included as part of the set of scenarios used in the Integrated HFE System Validation.

The HRA/PRA group identifies specific performance assumptions to be confirmed as part of the validation exercises. Examples of these assumptions are: that particular actions to be performed are satisfactorily completed, and completed within the time-window specified in the PRA.

The scenarios indicated by the HRA/PRA group are included as part of the Integrated HFE System Validation, and performance measures are collected to support confirmation of the HRA performance assumptions. The results of the analyses are provided to the HRA/PRA group.

No attempt is made to validate the quantitative HRA probabilities.

After reviewing the results of the Integrated HFE System Validation, the HRA/PRA group determines whether any changes need to be made to the HRA modeling assumptions and whether any changes are required to the HRA quantification. If necessary, the HRA is modified, and the impact on the PRA is assessed.

As part of the process determining whether HRA requantification is necessary, the HRA/PRA group assesses whether the technique for human error rate prediction (THERP) error frequency database currently employed to generate error probability estimates continues to be the most appropriate source for HRA quantification, or whether new error quantification databases, that more closely match the AP600 modeling assumptions and are accepted by the NRC, have become available.

A report is generated documenting the results of the exercises intended to validate the HRA performance assumptions, and the impact on HRA/PRA quantification, if any. This report is submitted to the NRC for review and constitutes the analysis results report for Element 6 of the Human Factors Engineering Program Review Model (NUREG-0711).

6 REFERENCES

1. AP600 Standard Safety Analysis Report, Volume 8, Chapter 15 Accident Analysis

2. AP600 PRA Study: Core Damage Frequency Quantification, February 1996

3. AP600 PRA Study: Focused PRA for RTNSS Analysis, September 1996

4. AP600 PRA Study: Severe Release Frequency Quantification, September 1996

5. AP600 PRA Study: Low Power and Shutdown Assessment, June 1995

6. AP600 PRA Study: Focused PRA for RTNSS Analysis, June 1995

7. AP600 PRA Study: Human Reliability Analysis, June 1996

APPENDIX A

EXAMPLES OF CRITICAL HUMAN ACTIONS AND RISK-IMPORTANT TASKS

APPENDIX A

EXAMPLES OF CRITICAL HUMAN ACTIONS AND RISK-IMPORTANT TASKS

This Appendix provides examples of critical human actions and *risk-important* tasks, as identified from the AP600 PRA Study results, available as of September 1996. These examples are a result of applying only the quantitative criteria described in Sections 2.1 and 2.2 of this document. Since the qualitative criteria have not been applied, these examples represent only a subset list.

These examples are provisional and may change as PRA studies are updated and the qualitative assessments are performed. The examples are provided as illustration of the methodology for identifying critical human actions and *risk-important* tasks.

A.1 Critical Human Actions

Based on the results of the AP600 PRA Study, as of September 1996, there are no critical human actions (as defined by the criteria of Section 2.1) for the AP600 plant.

A.2 Risk-Important Human Tasks

In this section, examples of *risk-important* tasks obtained by quantitative risk measures for internal events during power operation and during shutdown are provided.

A.2.1 Internal Events During Power Operation

For internal events during power operation, quantitative ranking of operator actions modeled in the PRA are available for the base case and the focused PRA, both for plant core damage frequency (CDF) and the plant large release frequency (LRF). References 2, 3, and 4 provide this information. Using the quantitative criteria of Section 2.2, the *risk-important* tasks are identified and are listed in Table A-1. The table also shows the source (e.g., base or focused PRA; core damage or large release; risk increase or risk decrease).

In Table A-1, the quantitative risk measures for each selected action are given in terms of their RAW and/or RRW values. The cutoffs used for these values, as described in Section 2.2 of the report are repeated here for the convenience of the reader:

Table A-1	Risk-Important Tasks for Internal Events During Power Operation									
			Base PRA				Focused PRA			
			CDF		LRF		CDF		LRF	
	Basic Event	Description	RAW	RRW	RAW	RRW	RAW	RRW	RAW	RRW
1	ADN-MAN01	Operator fails to manually actuate ADS	4.6	-	6.8	-	3.5	-	2.8	-
2	ATW-MAN03	Operator fails to manually trip reactor via PMS	-	1.05	4.5	1.24	6.7	1.45	5.7	1.34
3	ATW-MAN04C	Operator fails to manually trip reactor via DAS	-	-	-	1.23	-	-	-	-
4	ATW-MAN05	Operator fails to manually trip reactor via PMS	-	-	8.5	-	-	-	-	-
5	CIB-MAN00	Operator fails to diagnose SGTR event	5.5	-	6.5	-	-	-	2.9	-
6	CIB-MAN01	Operator fails to close MSIV for failed SG	-	-	4.4	-	-	-	2.9	-
7	LPM-MAN01	Operator fails to recognize need for RCS depressurization (SLOCA/transient)	-	-	5.6	-	3.5	-	2.6	-
8	LPM-MAN02	Operator fails to recognize need for RCS depressurization (MLOCA)	3.6	-	-	-	-	-	-	-
9	REC-MANDAS REC-MANDASC	Operator fails to actuate a system using DAS only	-	-	-	1.18	-	-	-	-
10	REN-MAN03	Operator fails to open IRWST valves to flood reactor cavity	-	-	5.4	-	-	-	-	-
11	REN-MAN04	Operator fails to actuate containment sump recirc. after level signal fails	5.0	-	-	-	-	-	-	-
12	RTN-MAN01	Operator fails to perform controlled shutdown (OTH-SDMAN)	3.7	-	-	-	-	-	-	-

- Base PRA: RAW ≥ 3
  RRW ≥ 1.1

- Focused PRA: RAW ≥ 2
  RRW ≥ 1.05

From Table A-1, it is observed that 12 human actions/tasks are identified as *risk-important* for internal events during power operation.

A.2.2 Internal Events During Shutdown

For internal events during shutdown, quantitative risk measures for only CDF are available. Applying the quantitative criteria of Section 2.2 to the CDF results of the base case and the focused PRA, the *risk-important* tasks are identified below. The *risk-important* tasks for LRF for shutdown events can be later identified using qualitative criteria.

Base PRA

When the *risk-important* measures and threshold values are applied to the output of the AP600 CDF for shutdown events (Ref. 5) a total of three *risk-important* tasks result from the application of risk-increase and risk-decrease measures. These are:

- Operator fails to recognize a need for Reactor Coolant System (RCS) depressurization (LPM-MAN-05)

- Operator fails to open two in-containment refueling water storage tanks (IRWSTs) motor-operated valves (MOVs) (IWN-MAN-00)

- Operator fails to recognize the need to open normal residual heat removal (RNS) MOV-V023 (RHN-MAN-05)

Initiating events are also examined to determine whether there are any cases where operator actions substantially contribute to the frequency of the initiating event. Three initiating events were identified that met the criteria for risk-increase and/or risk-decrease and where assumptions of a human error substantially contributed to the frequency of the initiating event. These initiating events are:

- RCS overdrain during drainage to midloop condition initiating event occurs

- Loss-of-coolant accident (LOCA) due to inadvertent opening of RNS-V024 initiating event occurs — hot/cold shutdown

- LOCA due to inadvertent opening of RNS-V024 initiating event occurs — RCS drained

There are three operator actions identified that substantially contribute to these initiating events and are therefore considered *risk-important* tasks:

- Failure to align the RNS to provide a diversion path to the IRWST during cold shutdown, and terminate the event by reclosing the valve
- Failure to observe failure of the hot-leg-level instruments and failure to close the air-operated valves chemical and volume control system (CVS)-V045 and V047 to preclude initial overdraining of the RCS, during draining of the system to mid-loop
- Failure to detect failure of automatic closure of air-operated valves CVS-V045 and V047, and failure to manually close the valves, when low hot-leg-level is reached during draining of the system to midloop

Focused PRA

When the results of the focused PRA sensitivity study for CDF are examined (Ref. 6), using a risk-increase threshold of 100 percent and a risk-decrease threshold of 5 percent, no new *risk-important* tasks are identified for shutdown events. A total of one *risk-important* task results from the application of risk-increase and risk-decrease measures to the focused PRA sensitivity study for shutdown events. This is:

- Operator fails to open two IRWST MOVs (IWN-MAN-00)

Note this operator action was already identified to be *risk-important* based on the base shutdown PRA.

APPROVAL FOR CLASSIFICATION/RELEASE OF PROPRIETARY INFORMATION

REPORT NUMBER: **WCAP - 14651**
Revision 2

W PROPRIETARY CLASS: **3**

THIS REPORT HAS BEEN ORIGINATED/REQUESTED BY: **Robin Nydes, X-4125**

FOR RELEASE TO: **NRC**

FOR THE FOLLOWING REASON(S): **NRC Review of the AP600**

PREVIOUS RELEASE: **None**

REPORT TITLE: **Integration of Human Reliability Analysis with Human Factors Engineering Design Implementation Plan**

REPORT FUNDED BY:

DATE OF ISSUE: **May 1997**

DATE STARTED ROUTING: **05/15/97**

SIGNATURE		CHECK BOX RELEASE	DO NOT RELEASE*	DATE
** R. M. Vijuk	AP600 DESIGN CERTIFICATION[1] MANAGER	[✓]	[ ]	5/16/97
J. Seenu Srinivasan	PATENT REPRESENTATIVE[3,4] NUCLEAR PROJECTS DIV.	[✓]	[ ]	5/16/97
H. A. Sepp	NUCLEAR SAFETY & REGULATORY ACTIVITIES[5]	[ ]	[ ]	5/16/97
L. M. Engwer	TECHNICAL LIBRARY[2]	[✓]	[ ]	5/16/97

*IF APPROVAL IS NOT GIVEN, STATE REASON(S) BELOW. DO NOT CONTINUE ROUTING!
RETURN TO: EC TECHNICAL LIBRARY - EC-E-209.

1 Approval indicates (in part) proper class is affixed; that the report has been reviewed for patentable material and proper action with the LD, IPS has been taken (if necessary), and the report is considered releasable to the customer.

2 Approval indicates (in part) your verification that a proper copyright notice has been affixed; and that the proper proprietary information statement (if Class 2 or Class 1) is also present.

3 If report is W Proprietary Class 2, then signature is not required as per NS-RAW-87-014.

4 IF NDR/POP Report, then signatures are not required as per CE-86-054 and NS-RAW-86-018.

5 IF NRC or DOE or EPRI or WOG Regulatory bodies during nuclear power plant licensing and hearings.

NOTE: For "Generic Report," i.e., those reports substantially the same as previously classified/released reports Author/Originator Next Level Manager line may be executed by the Immediate Manager (i.e., First Level) following classification/release.

FORM36C.DOT