Docket File

DOCKET NUMBER: 50-605

PROJECT: ADVANCED BOILING WATER REACTOR STANDARD DESIGN REVIEW

DATE: 26 MARCH 1992

NOTE TO: DOCKET FILE

FROM: VICTOR M. McCREE

SUBJECT: 1 - STATUS OF ABWR PRA TASKS
2 - DRAFT INTERIM HUMAN FACTORS REVIEW CRITERIA FOR THE DESIGN PROCESS OF AN ADVANCED NUCLEAR POWER PLANT

DOCUMENT DATE: 1 - 17 MARCH 1992
2 - 26 MARCH 1992

Enclosed are documents related to the NRC's ABWR design review. Please place them on the docket and in the NRC Public Document Room. To the best of my knowledge they do not contain GE proprietary information.

Enclosures:
1 - TELEFAX from GE describing the status of PRA issues.

2 - DRAFT document provided by the NRC to GE describing human factors review criteria to be used in the design process for advanced reactor designs.

cc:
PDST Reading File
PM File
CPoslusny
RNease
VMcCree

QF03
1/1

GE Nuclear Energy

ABWR

Date 17 MAR 92

To VICTOR McCREE NRC 11H3
GLEN KELLY

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This page plus 14 page(s)

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Subject ABWR PUNCH LIST - PRA

Message OUR PUNCH LIST FOLLOWS
STILL SOME BLANKS BUT
ALL THE ITEMS ARE
ON THE LIST I THINK

MAYBE WE CAN RESOLVE A FEW
MORE IN OUR 19 MARCH PHONE
CALL (4 PM EASTERN / 1 PM PACIFIC)

ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Rcvw	Next Actor	Date	Action	Comments
Fault Tree Update										
O-1		RPS Reliability	Kelly Raftery	v	s		GE	4/15	Provide RPS fault tree to NRC	
n		Update other fault trees	Kelly Raftery	v	s		GE		Provide balance of fault trees to NRC	Some additional functions to be automated
Initiating Events										
S-2		Defend IORV frequency	Kelly Raftery				GE			Staff requires use 0.1 event/year. GE accepts - Item Resolved
C-1		IORV success criteria	Kelly Raftery						Clarify SSAR text, submit to NRC	
S-1	n	Defend one trip per year	Kelly Duncan	v	n	v	n		none	NRC now agrees 1 trip/year as reasonable - Item Resolved

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
O-2		Evaluate support system failure on plant trips	Kelly Raftery	v	s	s	NRC	?	Review draft material	GE has provided (Jan. 27) draft material (HVAC failure) and list of other support system to be addressed. GE agreed to staff request to add loss of single AC or single DC bus
O-3		Analyze interfacing LOCA	Kelly Visweswaren	n			GE		Document piping upgrade. Track Separately	
O-4		Outside containment LOCA	Kelly Frederick	s			NRC	?	Review SSAR	GE request NRC review SSAR 19E.2.3.3. Issue is addressed
I-1		Confirm site loss of AC, other site specific parameters	Kelly Raftery	s	v		GE		Guidance to utility	

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
Success Criteria										
C-2		ATWS Success Criteria to prevent core damage	Kelly Buchholz	c	v	v	GE	3/27	Document agreement	Agreed SSAR treatment is adequate at San Jose 1/92 meeting, but not documented
n		ATWS RHR Success Criteria	Kelly Buchholz	c	v	v	GE	3/27	Document agreement	Agreed SSAR treatment is adequate at San Jose 1/92 meeting, but not documented
Failure Data										
C-3		Justify common cause failure data	Kelly Raftery							
0-5		Justify train-level common cause approach is adequate	Kelly Raftery				GE	3/24	Discuss which components to include with NRC	NRC suggested requantify PRA without addressing CCF, then requantify CCF as sensitivity study as part of input to RAP (Item I-15)

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ABWR Tasks to wrap up PRA

DSER item	SSAP Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Rev iew	Next Actor	Date	Action	Comments
C-4		Justify test/maintenance data analysis	Kelly Raftery							
O-6		Justify RHR, HPCF pump failure probability	Kelly Raftery				GE	4/15	Provide justification	
O-21A		List systems not part of certified design, significant assumptions, assumed reliability	Palla Duncan							
Level 1 PRA and Subsequent Related Studies										
S-11		Fire water credit correction	Kelly Visweswaren				n	n	GE approach conservative - no action needed - Item Resolved	
n		Requantify level 1 PRA results (base case)	Kelly Raftery				GE	4/7	Tabular results to NRC	
							GE	6/30	SSAR text draft to NRC	
O-18A		Level 1 uncertainty analysis	Kelly Raftery		v		GE	5/15	Submit uncertainty analysis	Results stop at CDF, will not be propagated through analysis

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
O-11		Initiating Event uncertainty	Kelly	—	—	—	—	—		Address as part of item O-18A
I-15		PRA input to Reliability Assurance	Kelly Raftery	v			GE		Define input	General agreement reached on how to proceed
n		PRA input to ITAAC	n Duncan							
0-22		PRA as a design tool	Kelly Duncan	v	s		GE	4/15	Provide 90% complete draft	
0-20		Shutdown risk. Four subtasks:	Kelly? Visweswaren	c	s		GE	3/24	Further discussion	
		1. ABWR design features					GE	4/30		
		2. Review of past shutdown events					GE	4/30		
		3. Decay heat removal reliability					GE	6/30		
		4. Other tasks					GE	6/30		

Other Analyses

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Revie*	Next Actor	Date	Action	Comments
O-12		Fire PRA	Kelly Raftery	c	c	s	NRC	?	Provide results of review to GE	No major items expected
I-9		Internal Flood	Kelly Visweswaren	s	s		GE	3/24	Outline approach	

Human Factors in PRA

C-5 O-7 O-8 O-9 O-10 I-2 I-3 I-4 I-5 I-6 I-7	These items are addressed by the following job subtasks:	Plan (Subtasks A,B, C) based on NRC/GE phone call 3 March 92

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
		A) Provide description of general methods used to determine all failure probabilities	Beckner Frederick	v			GE			
		B) Conduct sensitivity study	Kelly Raftery	v			GE	6/1	Sensitivity study results	
		C) Develop descriptions for most important actions for input to control room design	Kelly Duncan	v			GE			
Containment Event Trees										
S-4		Staff estimates extra credit for vent in Class II sequences	Kelly Buchholz				GE			
O-13		Treatment of drywell -wetwell bypass in CETs. This item is addressed by two sub tasks:								

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Rcvi ew	Next Actor	Date	Action	Comments
		A) Design sensitivity studies	Kudrick Saxena							Tracked separately by Kudrick/Saxena
		B) Determine if CETs need to change	Palla/ Kudrick Buchholz							See O-18, Backend Uncertainty Analysis
O-17B		Modify CET for severe accident phen.	Palla Buchholz							See item O-17A under Backend Analysis

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
Backend Analyses										
C-6		Flashing during venting	Palla Buchholz	c	s		GE	3/27	Document analysis	Analysis has been completed but not documented
O-14		Justify aspects of OPPD (Rupture Disk Setpoint)	Palla Buchholz	c	s		GE		Provide documentation indicating results of sensitivity and uncertainty analyses in regard to the OPPD and giving the basis for the setpoint.	GE agreed to raise rupture disk setpoint
O-15		Net risk of passive flooder system	Palla Buchholz	c			GE	4/30	Provide documentation indicating results of sensitivity and uncertainty analyses in regard to the passive flooder.	
O-16		CCI- coolability	—	—	—	—	—	—	—	—

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Rcv iew	Next Actor	Date	Action	Comments
		- Containment integrity	Palla Buchholz	c	s		GE	3/27	Take credit for assumed factor of safety in calculation	GE has shown staff early results of bounding analysis - work not complete but results appear to support no containment failure
		- Source terms	Palla Buchholz	c	—	—	—	—	—	See uncertainty analysis
O-17A		Modify CETs for DCH, FCI, etc.	Palla Buchholz	v	—	—	—	—	—	DCH and FCI are included as early containment failure modes in the current event trees. CCI and Pool bypass will be added if the uncertainty analysis warrants it.
O-18		Uncertainty analysis	—	—	—	—	—	—	—	—
		- Survey literature	Palla Buchholz	c	v	v	GE	3/27	Document results	Discussed at 1/22 meeting in Bethesda

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
		- Screen events for applicability to ABWR	Palla Buchholz	c	v	v	GE	3/27	Document results	Discussed at 1/22 meeting in Bethesda
		- Perform sensitivity studies	Palla Buchholz	v	s		GE	3/27	Complete sensitivity studies and document.	List of sensitivity studies discussed at 1/22 meeting in Bethesda. About 50% of studies complete.
		- Detailed DCH Uncertainty analysis	Palla Buchholz	c	v	v	GE	3/30	Incorporate NRC comments. Document study and results.	Essentially done. Discussed at 1/22 meeting in Bethesda and in 2/26 telecon. NRC had only minor comments.
		- Detailed CCI/Coolability Uncertainty analysis	Palla Buchholz	v	s	s	GE	4/30	Complete study - incorporating NRC comments	Discussed at 1/22 meeting in Bethesda and in 2/26 telecon

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Review	Next Actor	Date	Action	Comments
S-9		Rupture disk operation before 24 hours not cont failure	Palla Buchholz							
S-12		ATWS treatment by NRC	Palla Buchholz							
n	Chapter 22	Severe Accident Closure	Kudrick Buchholz	c	c		NRC	?	Write section. Inform GE if more info needed	
n		Accident management	Palla Buchholz	s	c		NRC		Provide response to GE submittal	
Seismic Analysis Beyond Design Base										
S-5		Fuel assembly capacity	Kelly Liu				GE		Update SSAR	NRC, GE have agreed to 1.2g Item resolved
S-6		Flat-bottom tank capacity	Kelly Liu				GE			GE will probably reduce value

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ABWR Tasks to wrap up PRA

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S-7		Diesel generator capacity	Kelly Liu	v			GE			GE will probably reduce value
S-8		Electrical equipment capacity	Kelly Liu	v			GE			GE will probably reduce value
I-14		Confirm electrical equipment capacities in site specific PRA	Kelly Duncan	v			GE		Margins analysis	Site specific PRA not required. Capacities used in margins analysis will be interface requirements.
O-21B		Seismic capacities for systems not in certified design	Palla Duncan				GE		After margins assessment	
S-10	n	Staff will use LLNL hazard curve	Kelly Duncan	—	—	—	n		n	Seismic PRA not required. Item resolved
?	n	How to treat seismic hazard uncertainties	Kelly Duncan	—	—	—	n		n	Not required. Item resolved
I-10		Confirm assumed seismic capacities and incorporate in design specs	Kelly Duncan	v			GE			Probably cover by PRA input to ITAAC

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ABWR Tasks to wrap up PRA

DSER item	SSAR Section	Title - Subtask	NRC Contact GE Contact	Plan	Anal	Rev iew	Next Actor	Date	Action	Comments
I-11		Modify seismic PRA to account for soil failures	Kelly Duncan	—	—	—	n		n	Seismic PRA not required. Item Resolved
I-12		Plant walkdown by applicant	Kelly Duncan	—	—	—	n		n	Ge agrees to plant walkdown. Item resolved
I-13		Site specific seismic PRA by applicant	Kelly Duncan	—	—	—	n		n	Seismic PRA not required Item Resolved
O-19		Address potential for penetration, isolation valve failure during seismic event	Palla Knecht	v			NRC	?	Evaluate proposal	Proposed approach provided to NRC Dec. 91, Jan. 92
S-3		Correct the treatment of firewater in Seismic Class II CET	Kelly Vishu	v						GE will correct
Other External Hazards										
I-8		Site specific design verification: external floods, transportation hazards	Kelly Duncan							

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26 MAR 92

* DRAFT *

Interim Human Factors Review Criteria for the Design Process of an Advanced Nuclear Power Reactor

Table of Contents

1. INTRODUCTION

The staff of the Nuclear Regulatory Commissions (NRC) Human Factors Assessment Branch (LHFB) is reviewing the human factors elements of the General Electric (GE) Advanced Boiling Water Reactor (ABWR) Standard Safety Analysis Report (SSAR). Based upon the review of this material, the staff will prepare input for the NRC final safety evaluation report (FSER). Brookhaven National Laboratory (BNL) assisted the staff by producing a Technical Evaluation Report (TER) which was used in the preparation of the draft safety evaluation report (DSER) which was completed on July 2, 1991. Many outstanding issues were identified in the DSER. Each of these outstanding issues will be addressed prior to completion of the FSER.

One issue to emerge from the initial review is that detailed human-system interface (HSI) design information will not be available for staff review prior to design certification. To address this issue, the NRC is considering issuing a design certification based partially on the approval of a written design implementation process plan. GE has submitted a Design and Implementation Process Plan (D&IPP) describing the major design and implementation process activities for the ABWR human factors engineering (HFE) effort. The D&IPP is characterized in GE's Figure 18E.1-1 and Table 18E.1-1 of the SSAR submitted to the staff in October 1991. The first part of the plan presents the plant and system design definition stage which will be completed prior to design certification, and the second part outlines the minimum activities that must be conducted by a referencing applicant. The D&IPP will contain (1) descriptions of all required activities in the design, development and implementation of the ABWR human-system interfaces, (2) identification of predetermined NRC conformance review points, and (3) design acceptance criteria (DAC) and Inspection, Test, Analysis and Acceptance Criteria (ITAAC) for the conformance reviews.

To review the GE's ABWR D&IPP, it is necessary to (1) assess whether all the appropriate human factors engineering elements are included in the plan, (2) identify which HFE elements require NRC review, and (3) evaluate the proposed DAC/ITAAC to be utilized by the NRC to verify each of the review elements. Where GE's D&IPP is found by the staff to be lacking, appropriate elements and DAC/ITAAC must be developed.

The objective of the effort described in this report was to develop a technical basis for the review of the D&IPP. Since a design process review has not been conducted previously by the NRC as part of reactor licensing and is not addressed in the presently available guidance, i.e., NUREG-0800, a firm technical basis for such a review is lacking. Thus, it is important to identify what elements of such a plan are required to assure that safety goals are achieved and to identify the review criteria by which each element can be assessed. This element identification should be accomplished independently from that provided by GE in order to assure that GE's plan reflects currently acceptable human factors engineering practices and that it is a thorough, complete, and workable plan. While it is likely that such guidance will be developed under the proposed update to the Standard Review Plan, that the guidance will not be available in a time frame consistent with the GE review.

The specific objectives of this effort were:

1. To develop a model of the HFE design process which can serve as a technical basis for the review of the D&IPP proposed for certification by GE. The model should be: (1) based upon currently accepted practices, (2) well-defined, and (3) validated through experience with the development of complex, high-reliability systems.

2. To identify necessary HFE elements in a system development, design, and evaluation process that are requisites to successful integration of the human component in complex systems.

3. To identify which of the HFE elements are the key and require review to monitor the process.

4. To specify the design acceptance criteria by which key HFE elements can be evaluated.

2. METHODOLOGY

A technical review of current HFE guidance and practices was conducted to identify important human factors program plan elements relevant to a design process review. Sources reviewed included a wide range of nuclear industry and non-nuclear industry documents, including those currently under development as part of the DoD MANPRINT program. From this review a generic system development, design, and evaluation process was defined. Once specified, key HFE elements were identified and criteria by which they are assessed (based upon a review of current literature and accepted practices in the field of human factors engineering) were developed.

A Generic HFE Program Model was developed based largely on applied general systems theory and the Department of Defense (DoD) system development process which is rooted in systems theory. Applied general systems theory provides a broad approach to system design and development, based on a series of clearly defined developmental steps, each with clearly defined and attainable goals, and with specific management processes to attain them. Kockler et. al. define system engineering as ". . . the management function which controls the total system development effort for the purpose of achieving an optimum balance of all system elements. It is a process which transforms an operational need into a description of system parameters and integrates those parameters to optimize the overall system effectiveness. (Kockler, F., Withers, T., Podiack, J., & Gierman, M., 1990).

Utilization of the DoD system development as an input to the development of the Generic HFE Program Model was based on several factors. Department of Defense (DoD) policy identifies the human as an element of the total system (DoD, 1990a). A system approach implies that all system components (hardware, software, personnel, support, procedures, and training) are given adequate consideration in the developmental process. A basic assumption is that the personnel element receives serious consideration from the very beginning of the design process. In addition, the military has applied HFE for the longest period of time (as opposed to industrial, commercial or other users), thus the process is highly evolved and formalized and represents the most highly developed model available. Finally, since military system development and acquisition is tightly regulated by federal, DoD, and military branch laws, regulations, requirements, and standards, the model provides the most finely grained, specifically defined process available.

Within the DoD system, the development of a complex system begins with the mission or purpose of the system, and the capability requirements needed to satisfy mission objectives. Systems engineering is essential in the earliest planning period to develop the system concept and to define the system requirements. During the detailed design of the system, systems engineering assures:

- balanced influence of all required design specialties;
- resolution of interface problems;
- the effective conduct of trade-off analyses;
- the effective conduct of design reviews;
- the verification of system performance.

Systems engineering ensures the effective integration of HFE considerations into the design by providing a structured approach to system development and a management structure which details the nature of that inclusion into the overall process. The systems approach is iterative, integrative, interdisciplinary and requirements driven.

The systems engineering approach was expanded to develop a Generic HFE Program Model to be used for advanced through the inclusion of NRC regulatory requirements and acceptance criteria specific to the ABWR certification process.

3. RESULTS

3.1 HFE Program Requirements

A Generic HFE Program Model has been developed to serve as the basis for review of the GE ABWR HFE program. The generic model contains 10 elements which include:

- Element A - Human Factors Engineering Program Management
- Element B - Predecessor System Review
- Element C - HFE Issues Tracking
- Element D - Human Reliability Analysis
- Element E - System Functional Requirements Analysis
- Element F - Allocation of Function
- Element G - Task Analysis
- Element H - Human-System Interface Design
- Element I - Plant and Emergency Operating Procedure Development
- Element J - Human Factors Verification and Validation.

The elements and their interrelationships are illustrated in Figure 1. Also illustrated are the minimal set of items submitted to the NRC for review of the COL's HFE efforts. All NRC review items are identified as falling into one of the five review stages:

- HF Management Planning Review
- Implementation Plan Review
- Analysis Results Review
- HSI Results Review
- Human Factors Verification & Validation.

The materials reviewed at each stage are shown in Figure 2.

The specification for the NRC review materials and the acceptance criteria to be used for their evaluation are identified in the draft ITAAC/DAC which follow.

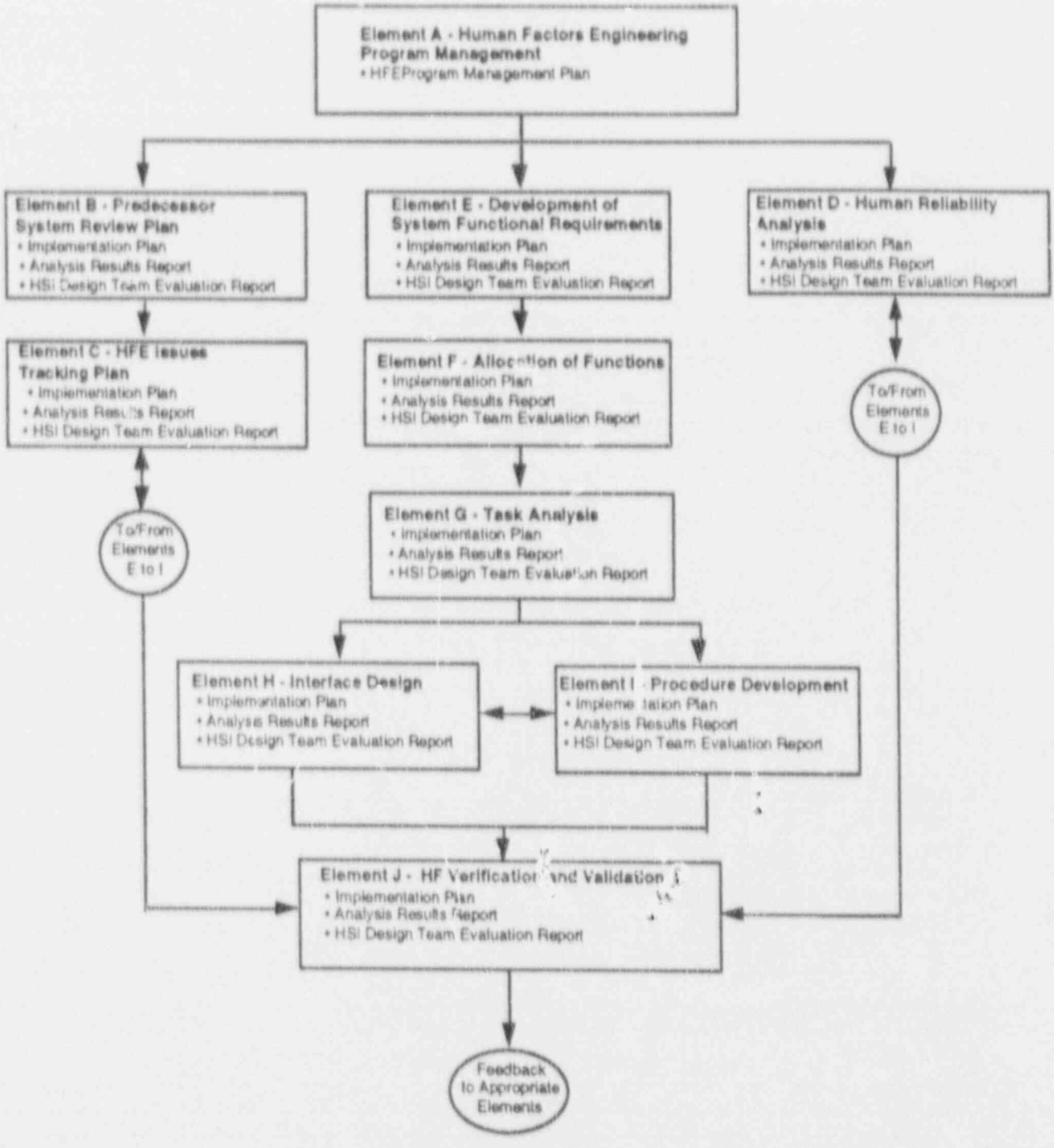

Figure 1. HFE Elements in NPP Design & Tier 1 DAC/ITAAC Structure

(Draft 3/12/92)

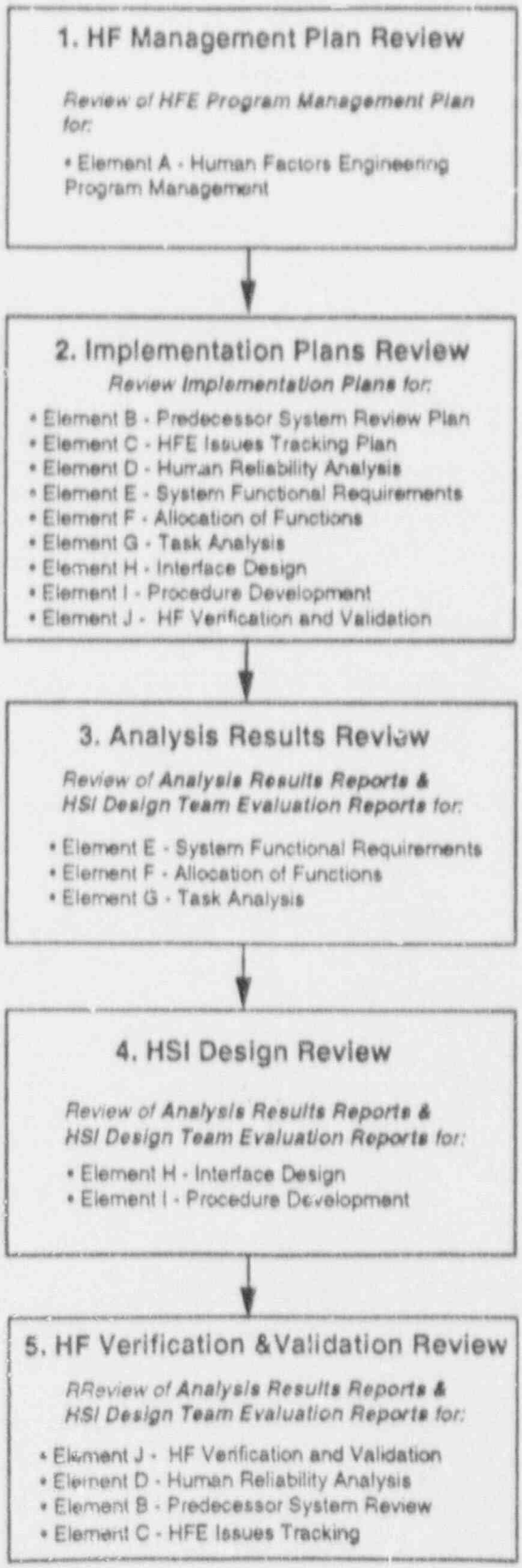

Figure 2. Human Factors Review Stages

(3/12/92)

3.2 Draft ITAAC/DAC Structure

A brief description of the generic structure of the draft ITAAC/DAC are briefly is provided in this section. The draft ITAAC/DAC are contained in Appendix A. For the present drafts, one ITAAC/DAC has been prepared for each element and no distinction has been made between Tiers 1 and 2. Each draft ITAAC/DAC is divided into three sections: Design Commitment, Inspection/Test/Analysis, and Design Acceptance Criteria.

Design Commitment
A concise and general statement as to the HFE objective of the Element is provided in this section.

Inspection/Test/Analysis
A specification of the inspections, tests, analysis, or other actions (i.e., some action that is required but which is not a specific inspection, test, or analysis, such as development of a program plan) taken by the COL to achieve the objective. Generally these are divided into three activities: planning, "analysis", and review. This section also defines those minimal set of materials to be provided to the NRC for review of the element

Design Acceptance Criteria
This section is typically divided into four sections: General Criteria, Implementation Plan, Analysis Report, and HFE Design Team Review Report. The General Criteria represent the major statement of design acceptance criteria. These are the criteria the ITAAC are required to meet and which should govern the Implementation Plan, Analysis Report, and HFE Design Team Review Report development. The general criteria are derived from three sources:

1. *Regulatory Requirements* - these are the HFE related requirements stated in 10CFR. Since regulatory requirements generally apply to more than one HFE Program element, they are contained in a table (Table Y, at the end of the document) and are referenced as the first general criteria in each section. It must be emphasized that this represents a "coarse screening" of incorporation of regulatory requirements into ITAAC/DAC and further refinement is needed.

2. *Accepted HFE Practices* - these are the criteria derived from the HFE model development and HFE literature and current practices review. Important points are listed in the acceptance criteria and applicable documents are referenced in a table (Table X). This table is not contained in the attached package and is currently under development.

3. *ABWR Specific Criteria* - Up to this point, the model and criteria are generic and can be applied to any advanced reactor. In addition to the generic criteria, the certification process provides commitments that are specific to the design. In this case, these include the list of key HSI elements and the results of the inventory development. Where appropriate, these criteria are listed in the draft ITAAC/DAC and are put in italics for easy identification.

4. Bibliography

The following is a partial list of documents were used in the development of the Generic HFE model and the draft DAC contained in Appendix A. (The full list is being complied)

Bailey, R.W. (1982). *Human performance engineering: A guide for system designers.* Englewood Cliffs, NJ: Prentice-Hall, Inc.

Booher, H.R. (Ed.) (1990). *MANPRINT: An approach to systems integration.* New York: Van Nostrand Reinhold.

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Appendix A

Draft ITAAC/DAC

DESIGN COMMITMENT:

Human-system interfaces (HSI) shall be provided for the operation, maintenance, test, and inspection of the ABWR that reflect "state-of-the-art human factors principles" (10 CFR 50.34(f)(2)(iii)) as required by 10 CFR 52.47(a)(1)(ii). All aspects of HSI shall be developed, designed, and evaluated based upon a structured top-down system analysis using accepted human factors engineering (HFE) principles based upon current HFE practices. HSI is used here in the very broad sense and shall include all operations, maintenance, test, and inspection interfaces, procedures, and training materials.

INSPECTION/TEST/ANALYSIS:

To assure the integration of HFE into system development, a HSI Design Team and a HFE Program Plan shall be established to assure the proper development, execution, oversight, and documentation of the human factors engineering program. The plan shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The primary goal of the HFE program shall be to developing an HSI which makes possible safe, efficient, and reliable operator performance and which satisfy all regulatory requirements as stated in 10 CFR as identified in Table Y. The general objectives of this program shall be stated in "operator-centered" terms which, as the HFE program develops, shall be objectively defined and shall serve as criteria for test and evaluation activities. Examples of such general "operator-centered" HFE design goals include:

   - The operating team can accomplish all assigned tasks within system defined time and performance criteria.
   - The system and allocation of functions will provide acceptable workload levels to assure vigilance and to assure no operator overload.
   - The system will support a high degree of operating crew "situation awareness."
   - Signal detection and event recognition requirements will be kept within the operators' information processing limits and will minimize the need for operators to mentally transform data in order to be usable.
   - The system will minimize operator memory load.
   - The operator interfaces will minimize operator error.
   - The system will be error tolerant and will provide for error detection and recovery capability.

2. An HFE Design Team shall be established.

3. The HFE Design Team shall be governed by an HFE team and management plan which defines procedures to:

• Define the scope of the Team's authority within the broader scope of the organization responsible for plant construction. Included within this scope shall be the authority to suspend from delivery, installation, or operation any equipment which is determined by the Team to be deficient in regard to established human factors design practices and evaluation criteria.

Define the process through which the Team will execute its responsibilities,

• Define the processes through which findings of the Team are resolved and how equipment design changes that may be necessary for resolution are incorporated into the actual equipment ultimately used in the plant.

• Establish the process through which the Team activities will be assigned to individual team members, the responsibilities of each team member and the procedures that will govern the internal management of the team.

4. The HFE team and management plan shall be developed to be fully compliant to the Design Implementation Process as defined by the SSAR and FSER.

HFE Design Team

1. An HFE Design Team shall have the responsibility, authority and placement within the organization to ensure that the design commitment is achieved.

2. The team shall be responsible for (1) the development of all HFE plans and procedures; (2) the oversight and review of all HFE design, development, test, and evaluation activities; (3) the initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities; (4) verification of implementation of team recommendations, (5) assurance that all HFE activities comply to the HFE plans and procedures, and (7) scheduling of activities and milestones.

x. The scope of the Team's responsibility shall include:

- Control and instrumentation equipment
- all operations, maintenance, test, and inspection interfaces and facilities both within and outside the control room,
- procedures
- training development.

3. The Team shall have the authority and organizational freedom to ensure that all its areas of responsibility are accomplished and to identify problems in the implementation of the HSI design. The team shall have the authority to determine where its input is required, access work areas, design documentation. The Team shall have the authority to assure that further processing, delivery, installation or use of HFE/HSI products is controlled until proper disposition of a non-conformance, deficiency or unsatisfactory condition has been achieved.

4. The HFE Team shall be placed at the level in the COL organization required to execute its responsibilities and authorities. The team shall report to a level of management such that required authority and organizational freedom are provided, including sufficient independence

from cost and schedule considerations.

5. The HFE Team shall work on an interactive and timely basis with the NSSS and BOP designers and contractors engaged in HFE design-related activities.

6. The HFE design team shall include the following expertise:
(Insert specific GE's Table 18.E.2.1-Part II to elaborate on below)
- Technical Project Management
- Systems Engineering
- Nuclear Engineering
- Control and Instrumentation Engineering
- Architect Engineering
- Human Factors
- Plant Operations
- Computer Systems Engineering
- Plant Procedure Development
- Personnel Training
- Safety Engineering
- Reliability/Availability/Maintainability/Inspectability (PAMI) Engineering

HFE Program and Management Plan

1. The Plan shall be developed to describe how the human factors program shall be accomplished. The plan shall describe the HFE Team's organization and composition and which lays out the effort to be undertaken and provides a technical approach, schedule, and management control structure and technical interfaces to achieve the HFE program objectives. The plan is the single document which describes the designer's entire HFE program, identifies its elements, and explains how the elements will be managed. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element A in Table X.

2. The HFE Program Management Plan shall address the following:
1. Purpose and organization of the plan
2. Literature and current practices review
   - Describe the technical basis for the plan.
3. Overall HFE program goals and objectives
4. The relationship between the HFE program and the overall plant design program (organization and schedule).
5. HFE Team
   - Organization within the HFE program
     - Identify and describe the primary HFE organization or function within the organization of the total program, including charts to show organizational and functional relationships, reporting relationships, and lines of communication
   - Functions and internal structure of the HFE Organization
     - Describe the responsibility, authority and accountability of the HFE organization
     - Identify the organizational unit responsible for each HFE task
     - Describe the process through which management decisions will be made regarding HFE

- Describe the process through which design decisions will be made regarding HFE
- Describe all tools and techniques (e.g., review forms, documentation) to be utilized by the Team to ensure they fulfill their responsibilities

• Staffing
- Describe the staffing of the HFE Team
- Provide job descriptions of personnel of the HFE Team
- Indicate the assignment of key personnel and provide their qualifications with regard to the areas of expertise indicated above

6. HFE requirements
• Identify and describe the HFE requirements imposed on the design process
• List the standards and specifications which are sources of HFE requirements

7. HFE program
Identify and describe HFE participation in the development of implementation plans, analyses, and evaluation/verification of:
• Predecessor System Review
• HFE Issues Tracking
Human Reliability Analysis
• System Functional Requirements Development
• Allocation of Function
• Task Analysis
• Interface Design
• Plant and Emergency Operating Procedure Development
• HF Verification and Validation

8. HFE program milestones
• Identify HFE milestones, so that evaluations of the effectiveness of the HFE effort can be made at critical check points and show the relationship to the plant design schedule
• Provide a program schedule of HFE tasks showing:
- compliance to the process implementation plan
- start and completion dates
- reports
- reviews
• Identify integrated design activities applicable to the HFE program but specified in other areas

9. HFE Documentation
• Identify and briefly describe each required HFE documented item
• Identify additional HFE data and describe procedures for accessibility and retention.
• Identify and briefly describe all HFE reports and data to be submitted for NRC review.
• Describe the supporting documentation and its audit trail maintained for NRC audits

10. HFE In subcontractor efforts
• Provide a copy of the HFE requirements proposed for inclusion in each subcontract
• Describe the manner in which the designer proposes to monitor the subcontractor's compliance with HFE requirements

DESIGN COMMITMENT:
Problems and issues encountered in similar systems of previous designs shall be identified and analyzed so that special attention may be given to those problems and issues in the development of the current system in order to avoid their repetition, or in the case of positive features to ensure their retention.

INSPECTION/TEST/ANALYSIS:
- A Predecessor System Review Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

- An analysis of predecessor systems shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

- The Predecessor System Review Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:
General Criteria
1. The analysis shall meet all 10CFR regulatory requirements as specified under Element B in Table Y.

2. Problems and issues encountered in similar systems of previous designs shall be identified and analyzed:
   - Human performance issues, problems and sources of human error shall be identified .
   - Design elements which support and enhance human performance shall be identified.

3. The review shall include both a review of literature pertaining the human factors issues related to similar systems and operator interviews.

4. The following sources both industry wide and plant or subsystem relevant should be investigated at a minimum:
   - Government and Industry Studies of Similar Systems
   - Licensee Event Reports
   - Outage Analysis Reports
   - Final Safety Analysis Reports and Safety Evaluation Reports
   - Human Engineering Deficiencies identified in DCRDRs
   - Modifications of the Technical Specifications for Operation
   - Internal Memoranda/Reports as Available

5. The following topics should be included in interviews as a minimum:
   - Screen Design Issues
   - Data Presentation Formats
   - Data Entry Requirements
   - Situational Awareness
   - Communications
   - Procedures
   - Staffing and Job Design
   - Training

Implementation Plan

1. The plan shall describe the designer's approach to Predecessor System Review. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element B in Table X.

2. At a minimum, the plan shall address the following:
   - Literature and current practices review
   - Describe the technical basis for the plan
   - Documentation review and analysis
   - User survey methodology (for conducting interviews) and analysis plans
   - Method of documenting lessons learned
   - Integration of lessons learned into the design process

Analysis Results Report

At a minimum, the report shall address the following:
   - Objectives
   - Description of the Methods
   - Identification of any deviations from the implementation plan
   - Results and Discussion
   - Conclusions
   - Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:
   - The review methodology and procedures
   - Compliance with Implementation Plan Procedures
   - Review findings

DESIGN COMMITMENT:
A method or procedure shall be developed to document and track HFE related problems and concerns. To assure that the system is conducted according to accepted HFE principles, a HFE Issues Tracking Plan shall be developed. The plan shall be based upon accepted HFE practices at the time of its development.

INSPECTION/TEST/ANALYSIS:
• An HFE Issues Tracking Implementation Plan shall be developed to assure that the tracking system is established according to accepted HFE principles.

• An HFE Issues Tracking system shall be maintained in accordance with the plan and the findings will be documented in an Analysis Results Report.

• The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

• The HFE Issues Tracking Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:
General Criteria
1. The analysis shall meet all 10CFR regulatory requirements as specified under Element C in Table Y.

2. The tracking system shall address human factors issues that are (1) generally known to the industry (such as TMI related HF issues and other NRC, industry and generic human factors issues), (2) identified in the Predecessor system review, and (3) those identified throughout the life cycle of the ABWR system design, development and evaluation.

3. The method shall document and track human factors engineering issues and concerns, from identification until elimination or reduction to a level acceptable to the review team.

4. Each issue/concern that meets or exceeds the threshold effects established by the review team shall be entered on the log when first identified, and each action taken to eliminate or reduce the issue/concern should be thoroughly documented. The final resolution of the issue/concern, as accepted by the review team, shall be documented in detail, along with information regarding review team acceptance (eg., person accepting, date, etc.)

5. The tracking procedures shall carefully spell out individual responsibilities when an issue/concern is identified, identify who should log it, who is responsible for tracking the resolution efforts, who is responsible for acceptance of a resolution, and who should enter closeout data.

Implementation Plan

1. The plan shall describe the designer's approach to HFE Issues Tracking. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element C in Table X.

2. The HFE Issues Tracking plan shall address:

- Literature and current practices review
- Responsibilities
  - Responsibilities on Issue Identification
  - Responsibilities for Issue Logging
  - Responsibilities for Issue Resolution
  - Responsibilities for Issue Closeout
- Procedures
  - ISSUE IDENTIFICATION
    - Description
    - Effects
    - Criticality and Likelihood
  - Issue resolution
    - Proposed Solutions
    - Implemented Solution
    - Residual Effects
    - Resultant Criticality and Likelihood
- Documentation
- Audit of the issue identification and tracking system

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:

Careful attention shall be given to the identification of those human interactions with the plant systems which are important to plant risk and reliability. A human reliability analysis shall be conducted in support of both HFE/HSI design activities and probabilistic risk assessment activities. The conduct of the analysis and the feedback of the results and findings shall be fully integrated between HFE and PRA teams.

INSPECTION/TEST/ANALYSIS:

- An HRA Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

- An analysis of human reliability shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

- The HRA Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element D in Table Y.

2. A thorough documentation system shall be established, including procedures to document the HRA including a description of the analyses, an audit trail for each analysis performed and each human error probability (HEP) derived, supporting rationale, and source materials.

3. Specification shall be made of the materials (such as procedural guidance and control room panel design information) to be utilized by the HRA team in order to provide a reasonably accurate understanding of human involvement in the ABWR.

4. Specification shall be made of the human-system analyses utilized by the HRA team (such as screening analyses, detailed task analyses which would provide an understanding of the task requirements and demands on the operating staff, their interfaces with plant equipment, and the time constraints within which critical tasks must be accomplished).

5. The HRA shall address a broad diversity of human interactions with the plant systems and components.

6. Human action shall be adequately modelled within the event and fault trees.

7. Quantification methods and the human error data sources used to estimate human error probabilities (HEP) shall be selected based upon their appropriateness to the types of actions being quantified. Where data from earlier PRAs is to be used in the HRA, the rationale to justify

these generalizations, and if/why/how the values will be modified for use in the HRA shall be made.

8. Performance shaping factors shall be specifically identified and used in HEP quantification.

9. The influences of the advanced technology aspects of the human task allocation and HSI shall be accounted for in the analysis. In addition, specification shall be made of how the modelling will reflect changes in the operator's tasks and role in the system resulting from the increases in system automation.

10. Critical human actions shall be quantified by the HFE review team (or their designee) independently from the primary HFE team to serve as a verification of their values.

11. Sensitivity and uncertainty analyses shall be performed on the HEP values.

12. The HRA effort shall be thoroughly integrated with the development of the PRA. The insights gained from the analyses will be factored into system/operational design.

Implementation Plan

1. The plan shall describe the designer's approach to HRA. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element D in Table X.

2. The HRA Implementation Plan shall address:

- Literature and current practices review
- Documentation Procedures
- Material Available to Support the HRA Team
- Use of Human-System Analyses (completed as part of HFE design)
- Types of Human Task Actions Analyzed
- Adequacy of the Human Action Modelling
- Quantification Methods Used to Estimate HEPS
- Evaluation of Performance Shaping Factors
- Treatment of Advanced Technology
- Utilization of Human Error Data Sources
- Basis for Generalization from Earlier PRAs
- Approach to Sensitivity Modelling
- Utilization of Insights Gained from the Analyses and assurance of bidirectional feedback between the PRA and HFE organizations.

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:

System requirements shall be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. System function analysis shall: (1) determine the objective, performance requirements, and constraints of the design; and (2) establish the functions which must be accomplished to meet the objectives and required performance.

INSPECTION/TEST/ANALYSIS:

- A System Functional Requirements Analysis Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

- An analysis of System Functional Requirements shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

- The System Functional Requirements Analysis Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element E in Table Y.

2. System requirements shall determine system functions, and the function itself shall determine what performance is necessary to carry out that function.

3 The system function requirements shall utilize the results of the precertification analyses as contained in the SSAR, GE design files, and in the system analyses utilized to derive the Inventory.

4. Critical functions shall be defined (i.e., those functions required to achieve major system performance requirements; or those functions which, if failed, could degrade system or equipment performance or pose a safety hazard to plant personnel or to the general public),

5. Those functions identified as safety functions shall be identified and their functional relationship with non-safety systems shall be identified.

6. Functions shall be defined as the most general, yet differentiable means whereby the system requirements are met, discharged, or satisfied. Functions shall be arranged in a logical sequence so that any specified operational usage of the system can be traced in an end-to-end path.

7. Functions shall be described initially in graphic form, since graphic representation generally is more effective is presenting loosely defined material in an easily understood manner. Function diagramming is typically done at several levels, starting at a "top level"

where a very gross picture of major functions is described, and continuing to decompose major functions to several lower levels until a specific critical end-item requirement will emerge, e.g., a piece of equipment, software, or an operator.

8. Detailed narrative descriptions shall be developed for each of the identified functions and for the overall system configuration design itself. Each function shall be identified and described in terms of inputs (observable parameters which will indicate system status), functional processing (control process and performance measures required to achieve the function), outputs, feedback (how to determine correct discharge of function), and interface requirements from the top down so that subfunctions are recognized as part of larger functional areas. In addition, the alternatives available if correct functioning is lost shall be specified along with and how alternatives can be chosen.

9. Functional operations or activities shall minimally include:
- detecting signals
- measuring information
- comparing one measurement with another
- processing information
- acting upon decisions to produce a desired condition or result on the system or environment (e.g., system and component operation, actuation, and trips)

10. The function analysis shall continue over the life cycle of design development.

11. Verification
- All the functions necessary for the achievement of operational and safety goals are identified.
- All requirements of each function are identified.

Implementation Plan

1. The plan shall describe the designer's approach to System Functional Requirements Analysis. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element D in Table X.

2. The System Functional Requirements Analysis Implementation Plan shall address:
- Literature and current practices review
  - Describe the technical basis for the plan.
- List required system level functions
  - Based on System Performance Requirements
- Graphic function descriptions
  - e.g., Functional Flow Block Diagrams and Time Line Diagrams
- Detailed function narrative descriptions

Describe:
- Observable Parameters Which Will Indicate System Status
- Control Process and Performance Measures Required to Achieve the Function
- How to Determine Correct Discharge of Function
- What Alternatives are Available if Correct Functioning is Lost and How Alternatives Can Be Chosen

- Analysis
  - Define an integration of subfunctions that are closely related so that they can be treated as a unit
    - Divide identified subfunctions into two groups
      - Common achievement is an essential condition for the accomplishment of a higher level function
      - Alternative supporting functions to a higher level function or whose accomplishment is not necessarily a requisite for higher level function
    - Identify for each integrated subfunction:
      - Logical requirements for accomplishment (Why accomplishment is required)
      - Control actions necessary for accomplishment
      - Parameters necessary for control action
      - Criteria for evaluating the result of control actions
      - Parameters necessary for the evaluation
      - Evaluation criteria
      - Criteria for choosing alternatives
    - Identify characteristic measurement and define for each measurement important factors such as Load, Accuracy, Time factors, Complexity of action logic, Types and complexities of decision making, Impacts resulting from the loss of function and associated time factors
- Verification
  - Describe the approach to system function verification

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:

The HFE organization shall insure that allocation takes advantage of human strengths and avoids allocating functions which would be impacted by human limitations. To assure that the allocation of function is conducted according to accepted HFE principles, a structured and well-documented methodology of allocating functions to personnel, system elements, and personnel-system combinations shall be developed and detailed in a HFE Issues Tracking Plan. The plan shall be based upon accepted HFE practices at the time of its development.

INSPECTION/TEST/ANALYSIS:

- An Allocation of Function Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

- An analysis of Allocation of Function shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

- The Allocation of Function Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element F in Table Y.

2. All aspects of system and functions definition must be analyzed in terms of resulting human performance requirements based on the expected user population.

3. The allocation of functions to personnel, system elements, and personnel-system combinations shall be made reflect (1) sensitivity, precision, time, and safety requirements, (2) required reliability of system performance, and (3) the number and level of skills of personnel required to operate and maintain the system.

4. The allocation criteria, rational, analyses, and procedures shall be thoroughly documented.

5. As alternative allocation concepts are developed, analyses and trade studies shall be conducted to determine optimum configurations of personnel- and system- performed functions. Analyses should confirm that the personnel elements can properly perform tasks allocated to them and assure appropriate operator situation awareness, workload, and vigilance. Proposed function assignment shall take the maximum advantage of the capabilities of human and machine without imposing unfavorable requirements on either.

6. Functions shall be re-allocated in an iterative manner, in response to developing design specifics and the outcomes of on-going analyses and trade studies.

7. Function assignment shall be evaluated.

Implementation Plan

1. The plan shall describe the designer's approach to Allocation of Function. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element F in Table X.

2. The Allocation of Function Implementation Plan shall address:

- Literature and current practices review
- Establishment of a structured basis for function allocation
- Alternative systems analyses
  - Specification of criteria for selection
- Trade studies
  - Define objectives and requirements
  - Identify alternatives
  - Formulate selection criteria
  - Weight criteria
  - Prepare utility functions
  - Evaluate alternatives
  - Perform Sensitivity Check
  - Select Preferred Alternatives
- Iterative allocation
  - The basis of iterative allocation shall be defined.
- Evaluation of function assignment
  - The plan shall describe the tests and analyses that will be performed to evaluate the function allocation

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:

Task analysis shall provide the systematic study of the behavioral requirements of the tasks the personnel subsystem is required to perform in order to achieve the functions allocated to them. The task analysis shall:

- provide one of the bases for making design decisions; e.g., determining before hardware fabrication, to the extent practicable, whether system performance requirements can be met by combinations of anticipated equipment, software, and personnel,
- assure that human performance requirements do not exceed human capabilities,
- be used as basic information for developing procedures,
- be used as basic information for developing manning, skill, training, and communication requirements of the system, and
- form the basis for specifying the requirements for the displays, data processing and controls needed to carry out tasks.

INSPECTION/TEST/ANALYSIS:

- A Task Analysis Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

- An analysis of tasks shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

- The Task Analysis Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element G in Table Y.

2. The scope of the task analysis shall include all operations, maintenance, test and inspection tasks. The analyses shall be directed to the full range of plant operating modes, including start-up, normal operations, abnormal operations, transient conditions, low power and shutdown conditions. The analyses shall include tasks performed in the control room as well as outside of the control room.

3. A task shall be a group of activities that have a common purpose, often occur in temporal proximity, and which utilize the same displays and controls.

4. . The analysis shall link the identified and described tasks in operational sequence diagrams. A review of the descriptions and operational sequence diagrams shall reveal which tasks can be considered "critical" in terms of importance for function achievement, potential for human

error, impact of task failure, etc. Where critical functions are automated, the analyses shall consider all human tasks including monitoring of an automated safety system and back-up actions if it fails.

5. Task analysis shall begin on a gross level and involve the development of detailed narrative descriptions of what personnel must do. Task analyses shall be defined the nature of the input, process, and output required by and of personnel. Detailed task descriptions shall address (as appropriate):

- Information Requirements
  - -Information required, including cues for task initiation
  - -Information available
- Decision-Making Requirements
  - -Description of the decisions to be made (relative, absolute, probabilistic)
  - - Evaluations to be performed
  - -Decisions that are probable based on the evaluation (opportunities for cognitive errors, such as capture error, will be identified and carefully analyzed)
- Response Requirements
  - -Action to be taken
  - - Overlap of task requirements (serial vs. parallel task elements)
  - -Frequency
  - -Speed/Time line requirements
  - -Tolerance/accuracy
  - -Operational limits of personnel performance
  - -Operational limits of machine and software
  - -Body movements required by action taken
- Feedback Requirements
  - -Feedback required to indicate adequacy of actions taken
- Workload
  - - Cognitive
  - - Physical
  - - Estimation of difficulty level
- Task Support Requirements
  - - Special/protective clothing
  - - Job aids or reference materials required
  - -Tools and equipment required
  - - Computer processing support aids
- Workplace Factors
  - -Workspace envelope required by action taken
  - -Workspace conditions
  - -Location and condition of the work
  - -Environment/habitability
- Staffing and Communication Requirements
  - -number of personnel, their technical specialty, and specific skills
  - - Communications required, including type
  - -Personnel interaction when more than one person is involved
- Hazard Identification
  - -Identification of Hazards involved

6. The task analysis shall be iterative and become progressively more detailed over the design cycle. The task analysis shall be detailed enough to identify information and control

requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls for human task accomplishment.

7. The task analysis shall be used to specify the procedures for operations (normal, abnormal, and emergency), test, maintenance and inspection.

8. The task analysis results shall provide input to the personnel training programs.

9. The task analysis shall utilize the results of the precertification analyses as contained in the SSAR, GE design files, and in the system analyses utilized to derive the Inventory.

Implementation Plan

1. The plan shall describe the designer's approach to task analysis. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element G in Table X.

2. The Task Analysis Implementation Plan shall address:

- Literature and current practices review
- General methods and data sources
- Gross task analysis
  - Convert Functions to Tasks
  - Develop Narrative Task Descriptions
    - General statement of task functions
    - Detailed task descriptions
    - Breakdown of tasks to individual activities
  - Develop Operational Sequence Diagrams
- Critical task analysis
  - identification of Critical Tasks
  - Detailed Task Descriptions
- Information and control requirements
- Initial alarm, display, processing, and control requirements analysis
  - Develop a task-based I&C inventory
- Application of task analysis results to procedure development
- Application of task analysis results to training development
- Evaluation of task analysis
  - The plan shall describe the methods that will be used to evaluate the results of the task analysis.

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:
Human engineering principles and criteria shall be applied along with all other design requirements to identify, select, and design the particular equipment to be operated/maintained/controlled by plant personnel.

INSPECTION/TEST/ANALYSIS:
• A Human-System Interface Design Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

• An analysis of Human-System Interface Design shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

• The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

• The Human-System Interface Design Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:
General Criteria
1. The analysis shall meet all 10CFR regulatory requirements as specified under Element H in Table Y.

2. The design configuration shall satisfy the functional and technical design requirements and insure that the HSI will meet the appropriate HFE guidance and criteria.

3. The HFE effort shall be applied to HSI both inside and outside of the control room (local HSI).

4. HSI design shall utilize the results of the task analysis and the I&C inventory to assure the adequacy of the HSI.

5. The HSI and working environment shall be adequate for the human performance requirements it supports. The HSI shall be capable of supporting critical operations under the worst plausible environmental conditions.

6. The HSI shall be free of elements which are not required for the accomplishment of any task.

7. The selection and design of HSI hardware and software approaches shall be based upon demonstrated criteria that maximize human task performance and minimize errors. Criteria can be based upon test results, demonstrated experience, and trade studies of identified options.

8. HFE standards shall be employed in HSI selection and design. Human engineering guidance regarding the design particulars shall be developed to (1) insure that the human-system interfaces are designed to currently accepted HFE guidelines and (2) insure proper consideration of human capabilities and limitations in the developing system. This guidance

shall be derived from sources such as expert judgement, design guidelines and standards, and quantitative (e.g., anthropometric) and qualitative (e.g., relative effectiveness of differing types of displays for different conditions) data. Procedures shall be employed to ensure HSI adherence with standards.

9. HFE/HSI problems shall be resolved using studies, experiments, and laboratory tests, e.g.,
- Mockups and models may be used to resolve access, workspace and related HFE problems and incorporating these solutions into system design
- Dynamic simulation and HSI prototypes shall be evaluated for use to evaluate design details of equipment requiring critical human performance
- The rationale for selection of design/evaluation tools shall be documented

10. Human factors engineering shall be applied to the design of equipment and software for maintainability, testing and inspection.

11. HSI design elements shall be evaluated to assure their acceptability for task performance and HFE, criteria, standards, and guidelines.

12. The HSI design shall incorporate the key HSI elements as defined in the SSAR and FSER.
- *include list and description of key features*
- *include valve position indication position*

13. The HSI design shall incorporate the I&C inventory as defined in the SSAR.
- *include summary table of inventory items*

Implementation Plan

1. The plan shall describe the designer's approach to Human-System Interface Design. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element H in Table X.

2. The Human-System Interface Design Implementation Plan shall address:
- literature and current practices review
- I&C requirements analysis and design
  - Compare Task Requirements to I&C Availability
  - Modifications to I&C Inventory
- General HSI approach selection
  - Trade Studies
  - Analyses
- The criteria to be used to meet General Criterion # 7, described above
- HFE design guidance development and documentation
- HSI detailed design and evaluations
  - Use of design/evaluation tools such as prototypes shall be specifically identified and rationale for selection

Analysis Results Report

At a minimum, the report shall address the following:
- Objectives

- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

** Under construction -Ignore this DAC for now - Proceed to Element J **

DESIGN COMMITMENT:

To assure that procedures reflect accepted HFE principles, a Plant and Emergency Operating Procedure Development Plan shall be developed. The plan shall be based upon accepted HFE practices at the time of its development.

INSPECTION/TEST/ANALYSIS:

• A ?? Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

• An analysis of ?? shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

• The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

• The ?? Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The task analysis shall be used to specify the procedures for operations (normal, abnormal, and emergency), test, maintenance and inspection.

Implementation Plan

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element I in Table Y.

1. The plan shall describe the designer's approach to . The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element I in Table X.

2. The ?? Implementation Plan shall address:

Analysis Results Report

At a minimum, the report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

DESIGN COMMITMENT:

The successful incorporation of human factors engineering into the final HSI design process and the acceptability of the resulting HSI shall be thoroughly evaluated as an integrated system using HFE evaluation procedures, guidelines, standards, and principles.

INSPECTION/TEST/ANALYSIS:

• A Human Factors Verification and Validation Implementation Plan shall be developed to assure that the analysis is conducted according to accepted HFE principles.

• An analysis of Human Factors Verification and Validation shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

• The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

• The Human Factors Verification and Validation Implementation Plan, Analysis Results Report, and HFE Design Team Evaluation Report shall be submitted to the NRC for review and approval.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The analysis shall meet all 10CFR regulatory requirements as specified under Element J in Table Y.

2. The evaluation shall verify that the performance of the HSI, when all elements are fully integrated into a system, meets (1) all HFE design goals as established in the program plan; and (2) all system functional requirements and properly support human operations, maintenance, test, and inspection task accomplishment.

3. The evaluation shall address at a minimum:
   - Human-Hardware interfaces
   - Human-software interfaces
   - Procedures
   - Workstation and console configurations
   - Control room design
   - Local control station design
   - Design of the overall work environment

4. Individual HSI elements shall be evaluated in a static and/or "part-task" mode to assure that all appropriate controls, displays, and data processing that are required are available and that they are designed according to generally accepted HFE guidelines, standards, and principles.

5. The integration of HSI elements with each other and with personnel shall be evaluated and validated through dynamic task performance evaluation using evaluation tools which are appropriate to the accomplishment of this objective. It is expected that a fully functional HSI prototype and plant simulator shall be used as part of these evaluations. If an alternative is

proposed its acceptability shall be documented in the implementation plan and approved by the staff in advance of testing. The evaluations shall have as their minimum objectives:

- Adequacy of entire HSI configuration for achievement of safety goals
- Confirm allocation of function and the structure of tasks assigned to personnel
- Adequacy of staffing and the HSI to support staff to accomplish their tasks.
- Adequacy of Procedures
- Confirm the adequacy of the dynamic aspects of all interfaces for task accomplishment
- Evaluation and demonstration of error tolerance to human and system failures

6. Dynamic evaluations shall evaluate HSI under a broad range of operational conditions and upsets, including at a minimum:

- Normal plant evolutions (e.g., start-up, full power, and shutdown operations)
- Instrument Failures (e.g., Safety System Logic & Control (SSLC)Unit, Fault Tolerant Controller (NSSS), Local "Field Unit" for MUX system, MUX Controller (BOP), Break in MUX line)
- HSI equipment and processing failure (e.g., loss of VDUs, loss of data processing, loss of large overview display)
- Transients (e.g., Turbine Trip, Loss of Offsite Power, Station Blackout, Loss of all FW, Loss of Service Water, Loss of power to selected buses/CR power supplies , and SRV transients)
- Accidents (e.g., Main steam line break, Positive Reactivity Addition, Control Rod Insertion at power, Control Rod Ejection, ATWS, and various-sized OCAs)

7. Performance measures for dynamic evaluations shall be adequate to test the achievement off all objectives, design goals, and performance requirements and shall include at a minimum:

- System performance measures relevant to safety
- Crew Primary Task Performance (e.g., task times, procedure violations)
- Crew Errors
- Situation Awareness
- Workload
- Crew communications and coordination
- Anthropometry evaluations
- Physical positioning and interactions

8. A verification shall be made that all issues documented in the Human Factors Issue Tracking System have be adequately addressed.

9. A verification shall be made that all critical human actions as defined by the HRA have be adequately supported in the design. The design of tests and evaluations to be performed as part of HFE V&V activities shall specifically examine these actions.

Implementation Plan

1. The plan shall describe the designer's approach to Human Factors Verification and Validation. The plan shall be based upon accepted HFE practices at the time of its development. The plan shall be based upon a review and identification of current practices and literature, including those documents under Element I in Table X.

2. The Human Factors Verification and Validation Implementation Plan shall address:

- HSI element evaluation

- Control, Data Processing, Display audit
- Comparison of HSI element design to HFE guidelines, standards, and principles

• Dynamic performance evaluation of fully integrated HSI
- General Objectives
- Test methodology and procedures
- Test participants (operators to participate in the test program)
- Test Conditions
- HSI description
- Performance measures
- Data analysis
- Criteria for evaluation of results
- Utilization of evaluations

• Documentation requirements
- Test & Evaluation Plans and Procedures
- Test Reports

Analysis Results Report

At a minimum, the report shall address the following:

• Objectives
• Description of the Methods
• Identification of any deviations from the implementation plan
• Results and Discussion
• Conclusions
• Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

At a minimum, the report shall address the following:

• The review methodology and procedures
• Compliance with Implementation Plan Procedures
• Review findings

Table Y
Human Factors Requirements In 10 CFR

(2 pages)

10 CFR REFERENCES	HFE ELEMENTS
Part 20: Standards for Protection Against Radiation	
20.203 - Caution signs, labels, signals, and controls.	H,I,B
20.207 - Storage and control of licensed materials in unrestricted areas.	B,E
Part 50: Domestic Licensing of Production and Utilization Facilities	
50.34 (f) - Additional TMI-related Requirements, Consider all sections but particularly:	
(1)(i) - Site specific PRA	D
(1)(v) - HPCI/RCIC initiation levels	B,E,F,G,I
(1)(vi) - Reduction of challenges to relief valves	B,E,G,H,I
(1)(vii) - Elimination of manual activation of ADS	B,E,F,G,H,I
(1)(viii) - Automation issues of ECCS restart	B,E,F,G,H,I
(1)(xi) - Depressurization methods	B,E,F,G,H,I
(1)(xii) - Hydrogen control systems	B,E,F,G,H,I
(2)(i) - Control room simulator	B,E,J
(2)(ii) - Improved plant procedures	I
(2)(iii) - Control room design that reflects state-of-the-art human factors principles	A
(2)(iv) - SPDS	B,E,F,G,H,I
(2)(v) - Indication of bypassed & inoperable systems	B,E,F,G,H,I
(2)(vi) - Vent systems in the control room	B,E,F,G,H,I
(2)(xi) - Indication of relief valves in control room	B,G,H
(2)(xvi) - ECCS & RPS actuation cycles	B,E,F,G,H,I
(2)(xvii) to (xix) - post accident instrumentation in control room	B,E,G,H,I
(2)(xxi) - Heat removal system controls	B,E,F,G,H,I
(2)(xxiv) - Reactor vessel level instrumentation	B,G,H,I
(2)(xxv) - TSC, OSC, and EOF	A,B,E,G,H,I
(2)(xxvii) - Radiation monitoring	B,E,F,G,H,I
(2)(xxviii) - Control room radiation protection	B,E,
(3)(i) - Incorporation of operating, design and construction experience	A,B
(3)(vii) - Management controls during design and construction	A,C,J
50.34a - Design objectives for equipment to control releases of radioactive material in effluents	B,E,F
50.44(iii) - High point vents in RCS, operable from control room	B,E,F,G,H,I
50.47 - Emergency planning, including procedures, facilities, etc.	B,E,G,H,I
50.48 - Fire Protection, references Appendix R and includes safe reactor shutdown requirements outside the main control room	B,E,F,G,H,I
50.54 - Conditions of licenses, contains control room staffing requirements	B,E,F,G
50.55a - Codes and standards - establishes inservice inspection and testing requirements, which should be considered when designing outside control room equipment and interfaces	B,E,G,H,I
50.62 - ATWS requirements, includes system specifications such as independence, reliability and automation	B,E,F,G,H,I
50.63 - Loss of all alternating current power, requires analyses, equipment and procedures	B,E,F,G,H,I

Appendix A - General Design Criteria for Nuclear Power Plants Throughout the GDC there are inspection and testing requirements specified for the various systems. These must be considered when designing the HSI throughout the plant. Some added specific criteria, as follows are also important. 12. Suppression of reactor power oscillations - They must be readily detected and suppressed 13. Instrumentation and control - Specifies I&C for variables and systems 19. Control Room - Specifies both a normal and remote control room 26. and 27. Reactivity control - Requires reliable control of reactivity changes 64. Monitoring radioactivity releases - Establishes monitoring requirements	A B,E,F,G,H,I B,E,G,H,I A,E B,E,F,G,H,I B,E,G,H,I
Appendix B - Quality Assurance Criteria - Establishes design control and other pertinent QA requirements	All
Appendix E - Emergency Planning - Establishes many pertinent EP requirements for facilities, procedures, etc.	A,B,E
Appendix I - ALARA Guides - Provides guidance for radiation dose reduction, which is particularly pertinent to the design stage of a NPP.	A,B,F,G,H,I,J
Appendix J - Primary containment leakage rate testing - This section is also pertinent to the design stage outside the control room. Existing provisions for LRT in NPPs consider human factors only marginally.	B,E,G,H,I
Part 52 - Early site permits; standard design certifications; and combined licenses for nuclear power plants. This part establishes the requirements for advanced reactors and is particularly relevant.	A
Part 55 - Operators' licenses - Subpart E - Written examinations and tests - Discusses source of information for required operator knowledge, skills and abilities.	I
Part 73 - Physical protection of plants and materials - Details protection and security requirements, which in existing plants have caused significant operational conflicts. These must be carefully considered at the design stage from a human engineering standpoint to avoid repetition of these problems.	A,B,E,G,H,I