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NOTE TO: J. Fox, GE

FROM: C. Poslusny, NRR

SUBJECT: TRANSMITTAL OF REVIEW DOCUMENTS

Enclosed are the following documents related to the FSER review of the ABWR SSAR and design certification material.

1. Agenda for the July 27, 1992 magement meeting
2. Preliminary list of FSER confirmatory items.
3. Preliminary list of FSER open items.
4. Preliminary evaluation of structural ITAAC.
5. HFE Program Review Model and Acceptance Criteria for Evlolutionary Plants.

If you have any questions regarding them please contact me on 504-1132.

Chet Poslusny

Chet Poslusny

cc: Docket File

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Per C Poslusny

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Attachment 1

ABWR OPEN ISSUES MEETING
July 27, 1992
Holiday Inn Bethesda, Maryland
Versailles I Room

Morning Session Beginning 8:00 a.m.

Introduction (Staff/GE)

Status of GE Outstanding Submittals (GE)

FSER Status (Staff)

- Overview of Findings
- Preliminary Open, Confirmatory Items Lists

PRA Review Status (Staff)

Severe Accident Review Status (Staff)

Technical Specification Review Status (Staff, GE)

OBE for the ABWR (GE, Staff)

Redesign for External Missiles (GE)

USI/GSI Review Feedback (Staff)

Afternoon Session

ITAAC (Staff)

- Staff Evaluation-Status, Open Items
- Roadmap Requirements- PRA, Chap 15, Sev. Accid., etc.
- Feedback on SLCS and Other ITAAC

Path to FDA (Staff,GE)

- Key Milestones
- Critical Path Items:
  - Resolution of Open/Confirmatory Items
  - QA Review of SSAR and ITAAC
  - EPRI RD Review
  - Preparation of Certified SSAR and DCD

Concluding Remarks (Staff, GE)

ABWR FSER CONFIRMATORY ISSUES

7/15/92

FSER ISSUE NO.	ISSUE
2.3.1	Design basis tornado revision
3.4.1	Removing references to LBB from the SSAR
3.5.1.4	C.3 of RG 1.117
3.6.1	Removing references to LBB from the SSAR
3.7.1	SSE damping values higher than 4%
3.7.2-1	To include the FRS procedure & revise FRS envelopes
3.7.2-2	To provide the basis for the uncertainty factors of the reactor building
3.7.2-3	To include the seismic structural displacement profile in the SSAR
3.7.2-4	To provide the basis for the uncertainty factors of the control building
3.8.1	To provide the detailed calculations for the containment shell
3.8.3	To provide the detailed calculations for the containment internal structures
3.8.4-1	To address the effects of winds, tornados...
3.8.4-2	To address the effects of winds & and used incorrectly calculated soil pressure load
3.8.4-3	To complete the implementation of QA programs
3.8.4-4	To provide the detailed calculations for the reactor and radwaste building substructure
3.8.6	To comply with the parameters used in the standard design of the ABWR
3.9.2.2	Dynami- analysis of piping
3.9.2.3	Reactor internals flow induced vibration
3.9.6.1	To disassembly & inspection of safety-related pumps
3.9.6.2.1	To disassembly & inspection of safety-check valves
3.9.6.2.2-1	Prototype testing of MOVs
3.9.6.2.2-2	To disassembly & inspection of safety-related MOVs
3.9.6.2.3	Containment isolation valves
3.9.6.3	Criteria for valves & pumps design specification
3.11.3.3	To revise all tables in Appendix 3I
3A-1	Dynamic seismic analysis of MS piping
3A-2	ITAAC verification of seismic/non-seismic interaction
3A-3	Mass point in dynamic piping model
3A-4	Pip flexibility between node point
3A-5	Effects of equip ent attached to piping
3A-6	Code case N-411 damping values
3A-7	Use of code cases N-411 and N-420
3A-8	High frequency mode analysis
3A-9	OBE equal to one half of SSE
3A-10	Applicable codes for ASME class 1,2 & 3
5.4.5	RCIC minimum flow (800 GPM)
5.4.7	RHR suction piping pressure increase documentation
6.2.1.7	Subcompartment Pressure analysis (revise table 6.2-2)
6.2.5	Awaiting SSAR Sec. 6.2.5.2.7 revision
6.5.1-1	Revising SSAR Sec. 9.4.1
6.5.1-2	Revising SSAr Sec. 6.5.1 App A & B

	pressure control...
7.1.4-1	Awaiting SSAR Sec. 7.1.1.4.2 revision
7.1.4-2	Awaiting SSAR Sec. 7.1.1.6.1 revision
7.1.4-3	OPRM in the ITAAC/DAC & Tier 1
7.2.2.1-1	A maximum transmission distance verification
7.2.2.1-2	The overall accuracy of both the input and output shall be less than 1.4 % full scale
7.2.2.2	Revised SSAR figure 7.A.2-1 APP. 7A
7.2.5-1	Revised SSAR figure 7.2-1
7.2.5-2	Commitment to include the EPAs in the ABWR design
7.2.8-1	Commitment to provide a safety and hazards analysis, a sneak circuit analysis and a timing analysis
7.2.8-2	Commitment to use of software metrics
7.2.8-3	Commercial dedication of software for use in a safety system
7.2.8-4	Commercial dedication to include in the ITAAC
7.2.8-5	Low & upper range s of the EMI spectrum
7.3.2	ALU Vs. SLC term
7.4.1.1	ARI descritption
7.5.2	Revised SSAR Table 7.5-7
7.6.1.3	Revised SSAR Sec 7.6
7.7.1.4	RPS tripped & reset conditions logging requirement
7.10.2-1	Commit to EFPRI requirements
7.10.2-2	Elimination of the need to lift leads and install jumpers to perform testing
8.2.2.1	Awaiting SSAR revision
8.2.2.2	Awaiting SSAR revision
8.2.2.3	Awaiting SSAR revision
8.2.2.4	Awaiting SSAR revision
8.2.2.5	Awaiting SSAR revision
8.2.2.6	Awaiting SSAR revision
8.2.2.7	Awaiting SSAR revision
8.2.3.1	Awaiting SSAR revision
8.2.3.2	Awaiting SSAR revision
8.2.3.3	Awaiting SSAR revision
8.2.3.3A	Awaiting SSAR revision
8.2.3.3B	Awaiting SSAR revision
8.2.3.3C	Awaiting SSAR revision
8.2.3.3D.1	Awaiting SSAR revision
8.2.3.3D.2	Awaiting SSAR revision
8.2.3.4	Awaiting SSAR revision
8.2.3.5	Awaiting SSAR revision
8.2.4	Awaiting SSAR revision
8.3.2.1	Awaiting SSAR revision
8.3.2.2	Awaiting SSAR revision
8.3.2.3	Awaiting SSAR revision
8.3.2.4	Awaiting SSAR revision
8.3.2.4A	Awaiting SSAR revision
8.3.2.4B	Awaiting SSAR revision
8.3.2.4C	Awaiting SSAR revision
8.3.2.5	Awaiting SSAR revision
8.3.2.6	Awaiting SSAR revision
8.3.2.7	Awaiting SSAR revision
8.3.2.9A	Awaiting SSAR revision

8.3.2.9B	Awaiting SSAR revision
8.3.3.1	Awaiting SSAR revision
8.3.3.2	Awaiting SSAR revision
8.3.3.3	Awaiting SSAR revision
8.3.3.4	Awaiting SSAR revision
8.3.3.5	Awaiting SSAR revision
8.3.3.6	Awaiting SSAR revision
8.3.3.7	Awaiting SSAR revision
8.3.3.8	Awaiting SSAR revision
8.3.3.10	Awaiting SSAR revision
8.3.3.11	Awaiting SSAR revision
8.3.3.12	Awaiting SSAR revision
8.3.3.14	Awaiting SSAR revision
8.3.3.15	Awaiting SSAR revision
8.3.4.1	Awaiting SSAR revision
8.3.4.4	Awaiting SSAR revision
8.3.5	Awaiting SSAR revision
8.3.6.1	Awaiting SSAR revision
8.3.6.2	Awaiting SSAR revision
8.3.7	Awaiting SSAR revision
8.3.8.1	Awaiting SSAR revision
8.3.8.2	Awaiting SSAR revision
8.3.8.4	Awaiting SSAR revision
8.3.8.5	Awaiting SSAR revision
8.3.8.6	Awaiting SSAR revision
8.3.8.7	Awaiting SSAR revision
8.3.9.1	Awaiting SSAR revision
8.3.9.2	Awaiting SSAR revision
8.3.9.3	Awaiting SSAR revision
9.1.2	The spent fuel storage racks
9.1.3	The spent fuel cooling sys.
9.1.5	Revising the response to RAI 410.43
9.2.13-1	Awaiting SSAR Sec. 9.2..13.2 revision
9.2.13-2	P&ID update
9.2.14	Awaiting SSAR revision
9.3.1-1	Reference primary containment pentrations
9.3.1-2	Confirmation of the failure modes of the valves
9.3.1-3	Revising the response to RAI 430.21d
9.3.5	SLCS Valves into Reliability Assurance Program
9.3.8-1	Revising the table 3.2-1 & fig. 11-2
9.3.8-2	Interface requirements
9.4.1.1	Providing smoke detectors at the air intakes
9.5.1.2.2	SGTS revision
9.5.4.2-1	Revising P&ID
9.5.4.2-2	To include the level switches & stick gauges
9.5.4.2-3	Revising figure 9.5.6 to inlude the fuel storage tanks and their associated instrumentation
9.5.5	Revising figure 9.5.7 & Sec. 9.5.5
9.5.6-1	Revising figure 9.5.8 to include pre & after filters into the design
9.5.6-2	D/G start & air system
9.5.6-3	To incorporate the coolers in the starting air sys. description
9.5.7-1	Revising figure 9.5-9

9.5.7-2	To prevent crankcase explosions
9.5.7-3	D/G lubrication system
9.5.7-4	GDC 4, RG 1.115, RG 1.117 & NUREG/CR-0660 requirements
9.5.7-5	Modifying the response to RAI 430.294
10.3	MSIV interface requirement
10.4.6	Condensate cleanup
10.4.7	The use of safety grade power for the manual shutoff gate valve
11.2.2	IE-80-05
11.5	Process & effluent rad. monitoring sys.
12.1.2	TIP system concern
12.2.3	Deletion of 2 interface items
12.3.1-1	Turbine bldg. figures inconsistencies
12.3.1-2	Corrosion Product control features
14.2-1	Reference RG 1.68.3 in Table 1.8-20
14.2-2	A power-flow operating map figure 14.1-1
14.2-3	Table 14.2-1, a list of startup tests and test condition
14.2-4	Word should in Section 14.2.2
14.2-5	To use the RG 1.68 Position C.1 criteria
14.2-6	Revised Section 14.2.12.1.51 to cross reference Sections 3.9.2.1 and 5.4.14.4
14.2-7	Revised Section 14.2.12.2 to add Subsection 14.2.12.2.39
14.2-8	Revised Section 14.2.12.2 to add Subsection 14.2.12.2.36
14.2-9	Revised Section 14.2.12.2 to add Subsection 14.2.12.2.37
14.2-10	Revised Section 14.2.12.2 to add Subsection 14.2.12.2.38
14.2-11	The test abstracts and revised section 14A.2.4
14.2-13	RG 1.56
14.2-14	The test matrix feedwater system performance & control system tests
14.2-15	The testing of low pressure portions of RHR system from RCs at high pressure
14.2-16	Verification of proper setpoint of system relief valves per ASME Code requirements
15.1	ODYN & REDY Documentation
18.4.2-1	Human-systems interface (HSI) design and evaluation process
18.4.2-2	Tests and analysis to support design implementation: a) Analysis conducted to date and b) further testing
18.4.2-3	Control room prototype: a) Standardized features and b) Prototype evaluation
18.4.2-4	Operator workload
18.4.2-5	Tests, evaluations, and studies to support design approaches
18.4.3	Inventory
18.4.2-1	Adequacy of HSI design requirements
18.4.2-2	Safety parameter display system design scope
18.4.4	Remote shutdown system design rationale
18.4.7-1	Operator workload analysis (ITAAC/DAC)
18.4.7-2	Tests and analysis to support design implementation: a) Analysis conducted to date and b) further testing (ITAAC/DAC)
18.4.7-3	Control room prototype: a) Standardized features and b) Prototype evaluation (ITAAC/DAC)

18.4.7-4	ABWR human factors program plan (ITAAC/DAC)
18.4.7-5	Detailed task analysis (ITAAC/DAC)
18.4.7-6	HSI design requirements for cathode ray tube (CRT), flat panel, and large-screen displays (ITAAC/DAC)
18.4.7-7	CRT display information (ITAAC/DAC)
18.4.7-8	Alarm suppression criteria and alarm points (ITAAC/DAC)
18.4.7-9	Procedure development (ITAAC/DAC)
19.2.2.2	Severe accident fires information in SSAR
19.5.3-1	Updated PRA
19.5.3-2	Awaiting SSAR revision
19.5.5	The fire water sys. in the RAP
19.5.6.2	Updated PRA
19.5.6.3	Sensitivity study of its surveillance intervals
19.5.8	Updated PRA
19.5.9	Updated PRA
19.6.3.2-1	Seismic capacity of 1.2 g
19.6.3.2-2	Reduction of the capacities of the D/G electrical equipment
19.6.3.2-3	EPRI guidance
19.6.3.2-4	Correct the seismic Class II CET
19.6.3.5	Correct the treatment of fire water in the seismic containment event trees
19.6.3.6	Adequacy of the sequence classification
19.6.3.7	The HCLPF values
19.7.9	Correct weather data

Total : 213 Confirmatory Items

ABWR OPEN ITEMS 7/15/92
FSER SECTIONS IN PROCESS

FSER NUMBER	SUBJECT
2.3.6-1	Turbine main steam ITAAC (3 items)
2.3.6-2	Control room HVAC ITAAC (9 Items)
3.2.1-1	The Floor Response Spectra Input
3.2.1-2	Turbine building seismic analysis
3.2.1-3	ITAAC for plant specific walkdown
3.2.1.1	ITAAC For Non-Seismic Interaction (ITAAC)
3.4.1	Flood protection should be included in individual ITAAC
3.4.1-1	A pipe break in MST
3.4.1-2	A pipe break in RSW
3.5.1.1	ITAAC for internal generated missiles from outside
3.5.1.4-1	Seismic model will have to modified by new tornado missile requirement
3.5.1.4-2	ITAAC for missiles generated from natural phenomena
3.5.2	ITAAC for external generated missiles
3.6.1-1	ITAAC for protection of safety-related equipment from the effects of postulated piping failures
3.6.1-2	MCR protection from a pipe failure
3.6.2-1	Computer program to be used for pipe whip analyses and design methodology
3.6.2-2	Update its reference to SRP and ANSI/ANS-58.2 (1988)
3.7.2-1	Specify the PGA of the OBE = .15g
3.7.2-2	Analy. Against Seismic Sliding Determination
3.7.2-3	Acct. for Dynamic Effect Of DEFSS
3.7.2-4	CB Structure - Structure Interaction Effect
3.7.2-5	Diff. Between 2D & 3D SSI Analysis of CB
3.7.2-6	Accuracy Buildg. Dimensions, CAT 1 Structures
3.7.2-7	The seismic input to the MSL analysis
3.7.2-8	The structural integrity of the turbine
3.7.2-9	Confirmation of plant specific seismic design adequacy
3.7.2-10	Procdure for The Seismic Analysis & Evalu. of Buried Piping & Tunnels Above Ground Tanks
3.8.1-1	Did not specify the edition of ASME Code in the concrete design
3.8.1-2	Did not specify the edition of ASME Code in concrete containment components design
3.8.1-3	Did not specify the edition of ASME Code in the structural integrity test of ABWR containment
3.8.3-1	ANSI/AISC N690 Has Not Been Approved By NRC
3.8.3-2	Did not specify the edition of ASME code in for the concrete diaphragm floors

3.8.4-1	Turbine Builg. Not Fail During & After a SSE
3.8.4-2	Hydrodynamic Load on Reactor Buildg.
3.8.4-3	New tornado design basis impact
3.8.4-4	No CB & Radwaste Bldgs. Sub Sys. Desript. & Design information in SSAR.
3.8.4-5	Design information such as the factor of safety against sliding, overturning ...
3.8.5-1	Did not sp fy the edition of ASME Code for the seismic Cat I foundations
3.8.5-2	No foundation Infor. for CB & Radwaste Bldg.
3.8.5-3	The Accuracy of Foundation dimensions for Rx, CB & Radwaste Bldgs.
3.8.7-1	Generic ABWR Bldg. ITAAC (5 Items)
3.8.7-2	Reactor Bldg. ITAAC (5 Items)
3.8.7-3	CB ITAAC (4 Items)
3.8.7-4	Radwaste Bldg. ITAAC (2 Items)
3.8.7-5	Yard Structure - Stack Sys. ITAAC (3 Items)
3.8.7-6	Site Parameters-Table 5.0 ITAAC (1 Item)
3.8.7-7	Did not provide design procedure & criteria for the seismic Cat I cable trays & conduits
3.9.1-1	Mechanical component design piping
3.9.1-2	Confirmatory of piping analyses
3.9.2.2-1	Seismic Subsystem Analysis methods
3.9.2.2-2	Any additional flexibility between bldg. Node points and the pipe supoort
3.9.2.2-3	How the flexibility and masses of equip. attached to the piping are to be modelled
3.9.2.2-4	Criteria for decoupling of the piping sys. in the analysis model
3.9.2.2-5	The ABWR small-bore piping design
3.9.2.2-6	Use the Modal damping for composite structures as an option for piping analysis
3.9.2.2-7	The ABWR burried piping
3.9.3.1-1	The enviromental effects its fatigue analysis
3.9.3.1-2	Additional justification for the methodology including testing to support thermal stratification load definition
3.9.3.1-3	Thermal analyses for all temperature conditions above ambient
3.9.3.3	Design criteria infor. for structure design of line instrumentation lines
3.9.6.2.2	Generic MOV ITAAC
3.9.6.2.3-1	Containment Isolation Valves Leakage Rates
3.9.6.2.3-2	Surv. Requirements of ABWR Pressure Isolation Valves
3.9.6.3	Development of An Acceptable IST Plan
3.9.6.4	Generic Other Power Operated Valves ITAAC
3.10.3	Design Procedures & Criteria for the Seismic CAT Cable Trays and Conduit
3.11.2.3	Integrated gamma accident dose for EQ in containment
3.11.3.2.1	Reg. 1.89
3.11.3.3-1	Environmental of electrical equipment

3.11.3.3-2	The integrated gamma accident dose
3A-1	Structural Design of Small Bore Piping Systems & Instrumentation Lines, Including Seismic Design (ITAAC)
3A-2	Buried Piping Design (ITAAC)
3A-3	Results of Staff confirmatory Analysis on Computer Modeling Adequacy (ITAAC)
3A-4	Seismic Input (Envelope Vs. Site-Specific) Soil Properties (ITAAC)
3A-5	Amplified Building Response spectra(ITAAC)
3A-6	60 years design life cycle factor of 1.5 (ITAAC)
3A-7	Envir. effects in fatigue design (class 1) (ITAAC)
3A-8	Envir. effects in fatigue design (class 2) (ITAAC)
3A-9	Methodology to address Thermal stripping (ITAAC)
3A-10	Modal Damping for Composite Structures(ITAAC)
3A-11	Minimum Temperature for Thermal Analyses (ITAAC)
3A-12	Pipe Support Criteria (ITAAC)
3A-13	Description of computer program for pipe WHIP analyses and restraints (ITAAC)
3A-14	ANSI/ANS Standards for High Energy Line Break Criteria (ITAAC)
3A-15	Generic piping Design ITAAC
3A-16	ABWR Welding ITAAC
4.4-1	LPM ITAAC (not reference Reg. 1.133)
4.4-2	ATWS stability
5.2.2	SRV, Fuel ITAAC
4.6	Control rod ITAAC
5.2.5	RCS leakage detection ITAAC
5.3.2	Show How Neutron Population Predicted
5.4.1	Recirculation Flow ITAAC
5.4.5	RCIC ITAAC
5.4.7	RHR ITAAC
6.2.1.2.1	Hydrodynamic loads
6.2.3.1	ITAAC for the funtional of secondary containment
6.2.4-1	TMI II.E.4.2
6.2.4-2	Valve closure condition
6.2.4-3	FCS isolation valves open/closure time
6.2.4.1-1	Isolation barrier design
6.2.4.1-2	Prohibited simulating venting of the dry-well & wetwell
6.2.4.1-3	Redundant & independent containment isolation on each purge & exhaust line
6.2.4.1-4	ITAAC for containment isolation system
6.2.5-1	Containment purge during operations
6.2.5-2	GE did not provide cost & benefit inform. for alternate sys.
6.2.5-3	Hydrogen pentration should be included

	in SSAR section 6.2.5.2.7
6.2.5-4	Containment ventilation valves position
6.2.5-5	ITAAC for containment leakage testing
6.2.6-1	Type C tests
6.2.6-2	Test methodology on ECCS isolation valves
6.2.6-3	Each barrier at each penetration and closed piping loop outside is subject to leak rate te.'
6.2.6-4	Test procedures
6.2.6-5	Valve hydrostatic test
6.2.6-6	30 day water legs seal
6.2.6-7	ILRTs and LLRTs
6.2.6-8	Leak rate testing
6.2.6-9	Bypass leakage paths
6.2.6-10	Hydrogen recombiners factors in ILRT results
6.2.7	EQ of electric components
6.3	HPCF ITAAC
6.4	CR Habitability ITAAC
6.5.1	SGTS (Table 6.5.1-1 R_vision)
7.1.3.2	EPRI requirements
7.2.2	Essential multiplexin system ITAAC
7.2.3	Indication of Bypass or inoperable status
7.2.6	Redundancy & Diversity
7.2.7	Setpoints ITAAC
7.2.8	Hardware and software qualification ITAAC
7.4.1.1	Alternate rod insertion system
7.4.1.2	Standby liquid control system instrumentation ITAAC
7.4.1.3	Reactor shutdown cooloing mode of the RHR sys. ITAAC
7.4.1.4	Remote shutdown system ITAAC
7.6.1.1	Neutron monitoring system ITAAC
7.6.1.2	Process radiation monitoring ITAAC
7.6.1.3	High/loww pressure interlocks ITAAC
7.6.1.5	Wetwell to drywell vacum breaker system ITAAC
7.6.1.6	Containment atmossphere monitoring system ITAAC
7.6.1.7	Suppresion pool temperature monitoring ITAAC
7.7.1.1	Nuclear boiling system ITAAC
7.7.1.2	Rod control and information ITAAC
7.7.1.3	Recirculation flow control ITAAC
7.7.1.4	Feedwater control system ITAAC
7.7.1.5	Process computer ITAAC
7.7.1.6	Neutron monitoring system ITAAC
7.7.1.7	Automatic power regulator system ITAAC
7.7.1.8	Steam bypass and pressure control ITAAC
7.7.1.9	Non-essential multiplexing ITAAC
7.7.1.10	Fire protection system instr. ITAAC
7.7.1.15	Communications system ITAAC
7.10	USIs and GSIs
7.11	Technical Specifications
8.2.1.4	ITAAC for interfaces
8.2.2.1	ITAAC for physical separation (circuit &

	transformers)
8.2.2.2	ITAAC for physical separation of power, intru. and control for the offsite power sys.
8.2.2.3	ITAAC for elctrical independence
8.2.2.4	ITAAC for testing of the offsite power sys.
8.2.2.5	ITAAC for generator breaker
8.2.2.6	ITAAC for capacity & capabilit. of the offsite power sys.
8.2.2.7	ITAAC for grounding
8.2.3.1	ITAAC for independence between offsite circuits & onsite class IE DC sys.
8.2.3.2	ITAAC for independence during loss of, or degraded, offsite voltage
8.2.3.3	ITAAC for independence during parallel ops. of the offsite & onsite sys. during periodic load test of DC
8.2.3.3A	ITAAC for LOCA during parallel ops.
8.2.3.3B	ITAAC for LOPP during parallel ops.
8.2.3.3C	ITACC for duration of parallel ops.
8.2.3.3D.1	ITAAC for D/G protective relaying with the D/G operating in parallel with the offsite sys.
8.2.3.3D.2	ITAAC for synchronizing interlocks
8.2.3.4	ITAAC for independence during ops./and or/ failure of non-safety load
8.2.3.5	ITAAC for physical separation between offsite and onsite class IE circuits
8.2.3.5-1	Physical separation be ween offsite & onsite class IE circuits
8.2.4	ITAAC for operating restrictions
8.3.2.1	ITAAC for conduits to open tray separation
8.3.2.2	ITAAC for separation of neutron monitoring raceways
8.3.2.3	ITAAC for separation of DC emergency lighting raceways
8.3.2.4A	ITAAC for separation between class IE penetrations of independent divisions
8.3.2.4B	ITAAC for separation between class IE to non-class IE penetration
8.3.2.5	ITAAC for separation/protection of cables located outside cabinets/panels
8.3.2.6	ITAAC for separation of cables inside cabinets/panels
8.3.2.7	ITAAC for separation of cables aprroaching and/or exiting cabinets/panels
8.3.2.8	ITAAC for independence/physical separation of equip.
8.3.2.9A	ITAAC for identification of power, instru., and control equip. and cables/raceways
8.3.2.9B	ITAAC for identification of neutron -monitoring,scram solenoid and DC emergency lighting cables/raceways.
8.3.2.9B-1	Identification of neutron-monitoring, scram solenoid and DC emergency lighting cables/

	raceways.
8.3.3.1	ITAAC for protection of electrical penetrations
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	19.7.3-2	Containemnt venting time
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	19.7.5.1	Core concrete interaction
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	19.7.6.2-1	Fuel coolant interaction failure
	19.7.6.2-2	Steam explosions
	19.7.7	Containment analysis
	19.8	Source term uncertainty analysis
	19.10	The integrated risk results
	19.11.4-1	The RWCU suction line arrangement
	19.11.4-2	The RWCU concern
	II.B.8	TMI: Dedicated Containment Penetration
*	II.K.3(24)	TMI: HPCS, RCIC Space Cooling
*	II.K.3(28)	TMI: ADS Performance
*	II.B.0	TMI: Hydrogen Control Design
*	II.E.4.1	TMI: Hydrogen Recombiners
*	II.E.4.2	TMI: containment Isolation
*	II.E.4.4	TMI: Containment Purge/Venting
*	II.F.1	TMI: Accident Monitoring Instrumentation
	20	Shutdown Risk (GL-88-17)
	20	Intersytems LOCA

TOTAL: 338 OPEN ITEMS: 8 DLOP ITEMS, 74 DET ITEMS, 202 DST ITEMS, AND 54 DREP ITEMS

160 ITAAC ITEMS
178 NON-ITAAC ITEMS

Note: * TMI items will be addressed in Chater 20.3 of ABWR FSER

Review Comments on

GE Tier 1 Design Certification Material for

the ABWR - Stage 3 Submittal

Structural and Geosciences Branch

The staff reviewed Sections 2.15.10 through 2.15.14, 2.16.1, and 5.0 of GE's "Tier 1 Design Certification Material for the ABWR Design - Stage 3 Submittal," dated May 30, 1992 which includes design descriptions and ITAAC material for the reactor building, turbine building, control building, radwaste building, service building, stack system (yard structure), and site parameters. The staff's generic concerns related to all ABWR buildings and building-specific findings as well as the concerns applied to the site paramaters are summarized below.

The staff identified seven generic ABWR building concerns:

(1) The purpose and scope of the "plant walk through" and "visual inspection" should be provided. Inspection should not be limited to "visual inspection." Dimensional measurements need also be performed. In addition, checking of concrete cracking should be required in the inspections.

(2) Minimum thickness of roof and interior walls should be provided in addition to wall, floor, and basemat thicknesses. The concrete pipe chase needs to be presented in appropriate figures.

(3) Minimum requirements for HVAC damper tornado missile barriers need to be provided.

(4) As discussed in FSER Section 3.7.2, site-specific seismic evaluation need be performed if the site-specific soil condition is not one of the fourteen generic site conditions.

(5) GE should provide the concrete properties (e.g., crushing strength, shear modulus, Poisson's ratio, etc.) in this document because these properties are needed in developing the dynamic model for the seismic analysis.

(6) For each seismic Category I structure, GE should provide the environmental design parameters, such as design pressure, design temperature, humidity, radiation, and other environmental parameters that are necessary to perform the environmental qualification of equipment located within the subcompartment.

(7) As a result of the second design calculation audit conducted on March 30 through April 3 of 1992, the staff found that the implementation of the QA program for some of the design calculations was not completed. GE should complete all QA implementation for all seismic Category I structures and finalize the thickness of the walls and floors shown in this document.

The staff's structure-specific concerns for the design descriptions and the ITAAC of the individual seismic Category I and other ABWR structures including the site parameters are listed in the following.

Reactor Building

(1) The directions of the planar dimensions (59 meters x 56 meters) specified in the "Design Descriptions" are different from those specified in the "Major Nominal Dimensions of Seismic Category I Structures." A resolution of this discrepancy is needed.

(2) The directions (0-180 degree direction and 90-270 degree direction) specified in this document are inconsistent with the directions (N-S direction and E-W direction) as specified in Amendment 6 of the SSAR. GE should resolve this discrepancy.

(3) The thicknesses of the exterior walls at the first and third through eighth levels are inconsistent with the exterior wall thickness shown in Figures 2.15.10c through 2.15.10n.

(4) The exposed exterior walls and roofs of the reactor building as well as the tornado dampers should be designed for a pressure drop of 13.8 KPa [2.0 psi] as specified in the revised SSAR Section 3.3.2 and Table 2.0-1 instead of 10.1 KPa [1.46 psi].

(5) The divisional diesel generators and supporting equipment, which are located at grade level, should also be protected from the external missiles such as aircraft, moving vehicle, etc.

(6) GE should revise the dimensions of the super-structures and roof to be consistent with GE May 29, 1992 submittal.

Control Building

(1) The planar dimensions and the soil embedment depth shown in Sections 3A.2 and 3G.3.2 of the SSAR and in this document are inconsistent with each other. This concern has previously been raised in Sections 3.7.2 and 3.8.4 of the FSER. GE should verify the accuracy of these dimensions.

(2) The building directions referenced in this document are inconsistent with those referenced in Amendment 6 of the SSAR. GE should resolve this discrepancy.

(3) The thickness of the basemat should be considered as one of the major nominal dimensions and shown in the design description section because this dimension is needed to develop the dynamic model for the seismic analysis.

(4) The design basis tornado wind loads (maximum wind speed, pressure drop, etc.) should be updated for consistency with those specified in the revised SSAR Section 3.3.2 and Table 2.0-1.

Radwaste Building

(1) The planar dimensions of 54.2 meters x 41.2 meters [178 feet x 135 feet] as shown in this document are different from the planar dimensions of 53 meters x 40 meters [174 feet x 131 feet] as specified in Amendment 7 of the SSAR. GE should verify the accuracy of these planar dimensions.

(2) GE should clarify if the building height of 13.8 meters [45 feet] is measured from the top of the basemat or from the bottom of the basemat to the roof.

Yard Structure - Stack System

(1) GE should provide the analysis approach, input data, and design requirements in the SSAR prior to confirming that the design, fabrication, and installation meet the design requirements.

(2) GE should take a measurement instead of visual inspection to verify that the stack height is 76 meters [249 feet] above grade.

(3) GE should provide Tier 1 information for the field-erected tanks if they are classified as seismic Category I.

Site Parameters - Table 5.0

(a) All units and dimensions used in this table should be in metric system with English units or dimensions provided in brackets.

(b) The site parameters listed in this table should be consistent with the bounding values committed in the SSAR and accepted by the staff. According to the design information documented in the SSAR (up to Amendment 16) and the revised SSAR dated May 28, 1992, and the staff's review results stated in the FSER, the site parameter "Precipitation," "Tornado," "Soil Properties," and "Seismology" should be either added to this table or changed as follows:

Precipitation (for Roof Design)

15.75 cm/5 min (6.2 in/5 min) should be added to the maximum rainfall rate.

Tornado

According to the revised SSAR dated May 28, 1992, all the design parameters should be changed as follows:

- Maximum tornado wind speed: 480 km/hr (300 mph)
- Translational Velocity: 97 km/hr (60 mph)
- Radius: 45.75 m (150 ft)

- Maximum atm ΔP: 13.8 KPa (2.0 lb/in^2)
- Rate of ..essure Drop: 8.3 KPa (1.2 lb/in^2)
- Missile Spectra: Per SRP Section 3.5.1.4 Spectrum I

Soil Properties

(i) Add Note No. (9) to Minimum Bearing Capacity (demand): 720 MPa (15 ksf[(9)])

(ii) Add the third bullet to this site parameter

- Liquification Potential: None at plant site resulting from OBE and SSE

Seismology

(i) Note No. (9) for the Second bullet "SSE PGA: 0.3 g" should be replaced by Note No. (7).

(ii) The basis "Per applicable regulation" for the SSE response spectra should be changed to "Per RG 1.60 Ground Response Spectra."

(iii) Add Note No. (10) to the fourth bullet and read as "SSE Time History: Envelope SSE Response Spectra[(10)]"

(c) Note No. (4) should read, "10,000,000 year tornado recurrence interval. The phrase, "with associated---ANSI/ANS 2.3," should be eliminated.

(d) Note No. (5) should be revised as, "Maximum value for 1 hour 1 sq. mile PMP with ratio of 5 minutes to 1 hour PMP as found in National Weather Service Publication HMR No. 52. Maximum short term rate: 6.2 in/5 min."

(e) Note No. (9) should be changed as, "The minimum bearing capacity should be referred to the static bearing capacity."

(f) The new Note No. (10) should read, "The response spectra of the SSE time history to be used in the free field must envelop the free field design response spectra for all damping values to be used in the response analysis. In addition, the time history should also be justified to show its adequacy by demonstrating sufficient energy at the frequencies of interest through the generation of the power spectrum density (PSD) function, which is greater than the target PSD function throughout the frequency range of significance."

HFE PROGRAM REVIEW MODEL AND ACCEPTANCE CRITERIA FOR EVOLUTIONARY REACTORS

(7/10/92)

CONTENTS

1 MODEL DEVELOPMENT

1.1 Objectives

One issue to emerge from the review process of evolutionary reactor control room designs was that complete detailed HSI design information would not be available for review prior to design certification and that certification would be based partially on the approval of a design and implementation process plan. The process must contain: (1) descriptions of all required HFE program elements for the design, development and implementation of the evolutionary reactor 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 designers process, it is necessary to: (1) assess whether all the appropriate HFE elements are included, (2) identify what materials are to be reviewed for each element, and (3) evaluate the proposed DAC/ITAAC to verify each of the elements. Since a 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 not available. To conduct the review, it is important to identify which aspects of the process are required to assure that safety goals are achieved and to identify the review criteria by which each element can be assessed. Review criteria independent of that provided by the designer is required to assure that the design plan reflects currently acceptable human factors engineering practices and that it is a thorough, complete, and workable plan. Thus, a technical basis for review of the process was developed and is described in this section. The specific objectives of this effort are:

1. To develop an HFE program review model to serve as a technical basis for the review of the process proposed for certification. The model requirements are that it 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 the HFE elements in a system development, design, and evaluation process that are necessary and sufficient requisites to successful integration of the human component in complex systems.

3. To identify which aspects of each HFE element are key to a safety review and are required to monitor the process.

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

1.2 Scope

The scope of the HFE Program Review Model was restricted by two factors. First, those elements of a complete HFE program that are already adequately addressed by existing NRC requirements for license applicants were excluded from the scope of the model. Included in this category were training program development and the details of procedure development. The second category of exclusion were those elements that are the responsibility of other NRC review teams. This category includes human reliability analysis which, while important to HFE program development, is the responsibility of the SSAR Chapter 19 reviewers. Therefore, the scope of the model development described below was restricted to those aspects of HFE design review remaining after the above elements are excluded.

1.3 Development Method

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 Department of Defense (DoD) MANPRINT program (Booher, 1990, DoD, 1989; DoD, 1990a). 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.

The generic HFE Program Review Model was developed based largely on applied general systems theory (Bailey, 1982; DeGreen, 1970; Gagne et al., 1988; VanCott et al., 1972; Woodson, 1981) and the Department of Defense (DoD) system development process which is rooted in systems theory (DoD, 1979a; DoD, 1990b; Kockler et al., 1990). Other DoD documents were utilized as well (see References section).

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 goals, and with specific management processes to attain them. System engineering has been defined 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 et al., 1990).

Utilization of the DoD system development as an input to the development of the Generic HFE Program Model was based on several factors. DoD policy identifies the human as a specific element of the total system (DoD, 1990a). A systems 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 compared with industrial/commercial system developers), 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 HFE 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; and
- the verification of system performance.

The effective integration of HFE considerations into the design is accomplished by: (1) providing a structured top-down approach to system development which is iterative, integrative, interdisciplinary and requirements driven and (2) providing a management structure which details the HFE considerations in each step of the overall process. A structured top-down approach to NPP HFE is consistent with the approach to new control room design as described in Appendix B of NUREG-0700 (NRC, 1981) and the more recent internationally accepted standard, IEC 964 (1989) for advanced control room design. The approach is also consistent with the recognition that human factors issues and problems emerge throughout the NPP design and evaluation process and therefore, human factors issues are best addressed with a comprehensive top-down program.

The systems engineering approach was expanded to develop an HFE Program Review Model to be used for the evolutionary reactor design and implementation process review by the incorporation of NRC HFE requirements.

2 GENERAL MODEL DESCRIPTION

In this section an overview of the model is presented to generally describe the HFE elements, products reviewed for each element, and the acceptance criteria used to evaluate the element.

The model is intended as the programmatic approach to achieving a design commitment to HFE. The overall commitment and scope of the HFE effort can be stated as follows: Human-system interfaces (HSI) shall be provided for the operation, maintenance, test, and inspection of the NPP 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). For the purposes of model development "state of the art" human factors principles are defined as those principles currently accepted by human factors practitioners. "Current" is defined with reference to the time at which this model was developed. "Accepted" is defined as a practice, method, or guide which is (1) documented in the human factors literature within a standard or guidance document that has undergone a peer-review process, and/or (2) justified through scientific/industry research practices.

All aspects of HSI should be developed, designed, and evaluated based upon a structured top-down system analysis using accepted 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.

The model developed to achieve this commitment contains eight elements:

- Element 1 - Human Factors Engineering Program Management
- Element 2 - Operating Experience Review
- Element 3 - System Functional Requirements Analysis
- Element 4 - Allocation of Function
- Element 5 - Task Analysis
- Element 6 - Human-System Interface Design
- Element 7 - Plant and Emergency Operating Procedure Development
- Element 8 - Human Factors Verification and Validation.

The elements and their interrelationships are illustrated in Figure A.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 and Validation

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

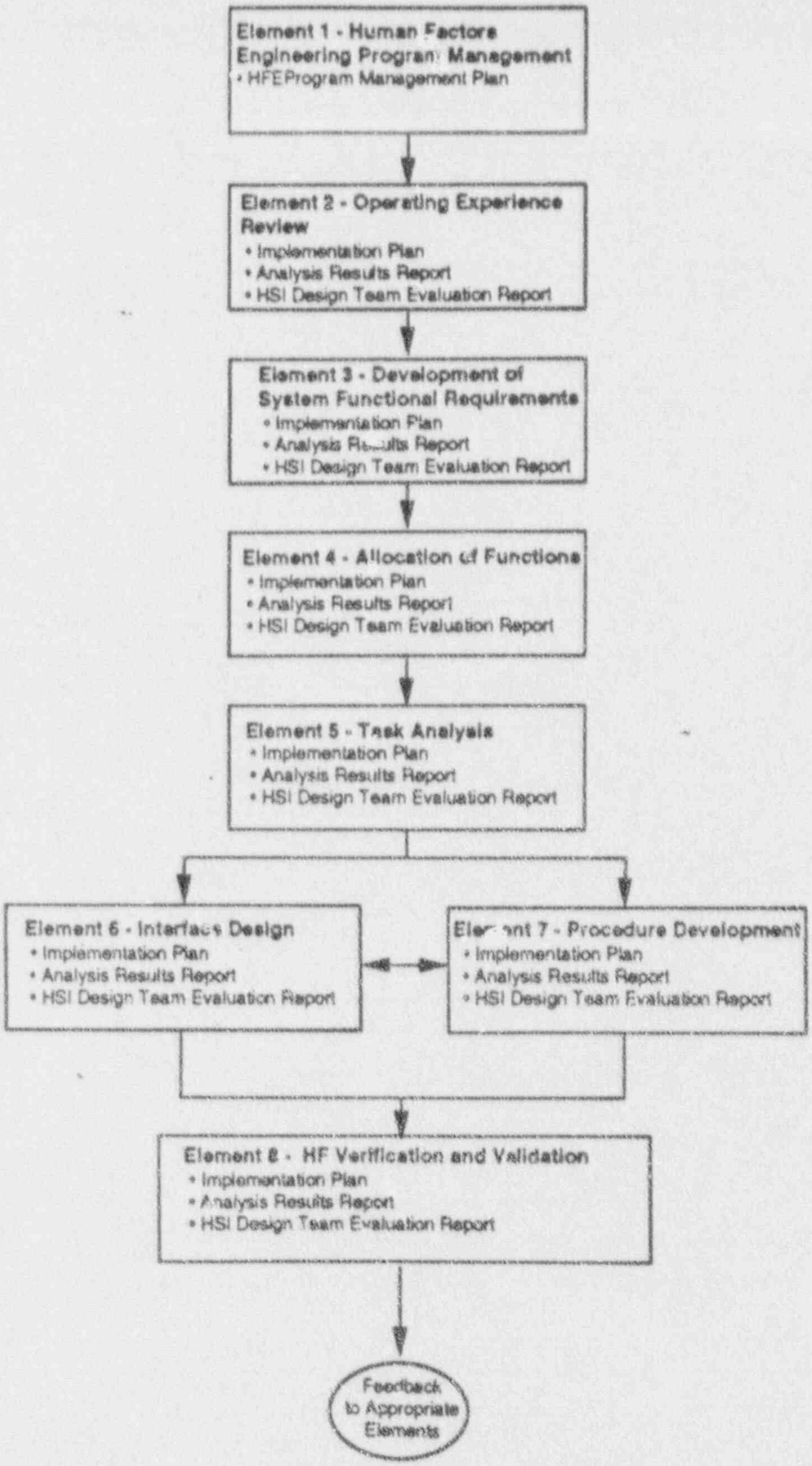

Figure A1. HFE Program Review Model Elements

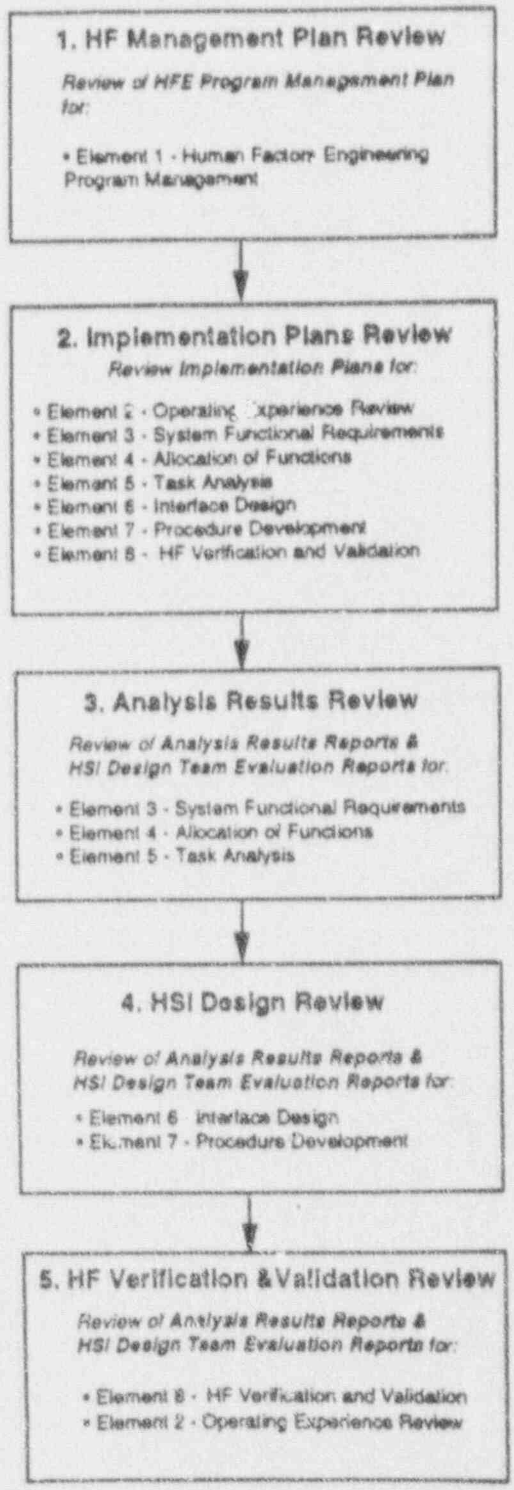

Figure A2. HFE Program Review Stages

A brief description of the purpose of each element follows:

Element 1 - Human Factors Engineering Program Management

To assure the integration of HFE into system development and the achievement of the goals of the HFE effort, an HSI Design Team and an HFE Program Plan shall be established to assure the proper development, execution, oversight, and documentation of the human factors engineering program. As part of the program plan an HFE issues tracking system (to document and track HFE related problems/concerns/issues and their solutions throughout the HFE program) will be established.

Element 2 - Operating Experience Review

The accident at Three Mile Island in 1979 and other reactor incidents have illustrated significant problems in the actual design and the design philosophy of NPP HSIs. There have been many studies as a result of these accidents/incidents. Utilities have implemented both NRC mandated changes and additional improvements on their own initiative. However, the changes were formed based on the constraints associated with backfits to existing control rooms (CRs) using early 1980s technology which limited the scope of corrective actions that might have been considered, i.e., more effective fixes could be used in the case of a designing a new CR with the modern technology typical of advanced CRs. Problems and issues encountered in similar systems of previous designs shall be identified and analyzed so that they are avoided in the development of the current system or, in the case of positive features, to ensure their retention.

Element 3 - System Functional Requirements Analysis

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.

Element 4 - Allocation of Functions

The allocation of functions shall take advantage of human strengths and avoids allocating functions which would be impacted by human limitations. To assure that the allocation of functions 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.

Element 5 - Task Analysis

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.

Element 6 - Human-System Interface Design

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.

Element 7 - Plant and Emergency Operating Procedure Development

Plant and Emergency Operating Procedures shall be developed to support and guide human interaction with plant systems and to control plant-related events and activities. Human engineering principles and criteria shall be applied along with all other design requirements to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated. The types of procedures covered in the element are:

- plant and system operations (including start-up, power, and shutdown operations),
- abnormal & emergency operations,
- preoperational, start-up, and surveillance tests, and
- alarm response.

Element 8 - Human Factors Verification and Validation

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

The specification for the NRC review materials and the acceptance criteria to be used for their evaluation are identified in the next section. Generically, each element 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.

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) to assure the achievement of the objective. Generally these are divided into three activities: planning, "analysis," and review. The set of materials to be provided to the NRC for review of the element is specified.

Design Acceptance Criteria

Acceptance criteria are typically divided into four sections: General Criteria, Implementation Plan, Analysis Report, and HSI Design Team Review Report. The General Criteria represent the major statement of design acceptance criteria. These are the criteria the element is required to meet and which should govern the Implementation Plan, Analysis Report, and HSI Design Team Review Report development. The general criteria are derived from accepted HFE practices. These are the criteria derived from the HFE model development and HFE literature and current practices review.

The HFE Program Review Model requires that HFE elements be governed by accepted HFE practices as specified in applicable codes, standards, and guidelines. Each element requires an identification of the codes, standards, and guidelines which are to be applied. Applicable codes, standards, and guidelines for the HFE Program Review Model Elements are provided below. With respect to Element 2 - Operating Experience Review, the documents listed also provide further issue description. While these documents contain generally recognized acceptable approaches to the conduct of the HFE activity described by the element, several caveats should be identified:

· There may be inconsistencies or contradictions within and between documents. Such conflicts should be resolved on a case-by-case basis depending upon the specific application under review.

· Not each document listed under a given element necessarily address all aspects of the element. In the conduct of a review of each element a combination of the applicable section of several of the identified document may be appropriate.

· It should not be inferred that the listed documents provide complete guidance for each and every activity encompassed by the element. HFE is not at a state of maturity to be confident that all HFE activities are adequately covered in codes, standards, and guidelines.

· The listed documents represent currently accepted documents in the human factors community. Alternative approached can be found acceptable if judged by the reviewer to be based in firm rationale. Proposed alternative approaches should be evaluated on a case-by-case basis.

3 ELEMENT DESCRIPTIONS AND ACCEPTANCE CRITERIA

3.1 Element 1 - Human Factors Engineering Program Management

DESIGN COMMITMENT:

Human-system interfaces (HSI) shall be provided for the operation, maintenance, test, and inspection of the NPP 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 broad sense and shall include all operations, maintenance, test, and inspection interfaces, procedures, and training needs. The tier 1 commitment addresses main control room and remote shutdown system functions and equipment. Local control stations should be included in the overall program.

State of the art human factors principles is defined as those principles currently accepted by human factors practitioners. "Current" is defined with reference to the time at which a program management or implementation plan is prepared. "Accepted" is defined as a practice, method, or guide which is (1) documented in the human factors literature within a standard or guidance document that has undergone a peer-review process and/or (2) can be justified through scientific/industry research/practices.

INSPECTION/TEST/ANALYSIS:

To assure the integration of HFE into system development: a HSI Design Team shall be established and a HFE Program Plan shall be established to assure the proper development, execution, oversight, and documentation of the human factors engineering program.

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. The general objectives of this program shall be stated in "human-centered" terms which, as the HFE program develops, shall be objectively defined and shall serve as criteria for test and evaluation activities. Generic "human-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 and will provide for error detection and recovery capability.

2. The program shall be developed using the following documents as guidance:

MIL-H-46855B: *Human engineering requirements for military systems, equipment and facilities*, 1979, (Department of Defense).

AR 602-1: *Human factors engineering program*, 1983, (Department of Defense).

DI-HFAC-80740: *Human engineering program plan*, 1989, (Department of Defense).

AR 602-2: *Manpower and personnel integration (MANPRINT) in the materiel acquisition process*, 1990, (Department of Defense).

DOD-HDBK-763: *Human engineering procedures guide*, 1991, (Department of Defense).

IEEE Std 1023-1988: *IEEE guide to the application of human factors engineering to systems, equipment, and facilities of nuclear power generating stations*, 1988, (IEEE).

HSI Design Team

1. An HSI Design Team shall have the responsibility, authority and placement within the organization (as defined below) 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.

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

   - Control and instrumentation equipment

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

4. 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 control further processing, delivery, installation or use of HFE/HSI products until the disposition of a non-conformance, deficiency or unsatisfactory condition has been achieved.

5. The HSI Design 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.

6. The HSI Design Team shall include the following expertise:

Technical Project Management

- Bachelor's degree,
- five years' experience in nuclear power plant design or operations, and
- three years' management experience.

Systems Engineering

- Bachelor's of Science degree, and
- four years' cumulative experience in at least three of the following areas of systems engineering; design, development, integration, operation, and test and evaluation.

Nuclear Engineering

- Bachelor's of Science degree, and
- four years' nuclear design, development, test or operations experience

Control and Instrumentation Engineering

- Bachelor's of Science degree,
- four years' experience in design of process control systems, and
- experience in at least one of the following areas of C&I engineering; development, power plant operations, and test and evaluation.

Architect Engineering

- Bachelor's of Science degree, and
- four years' experience in design of power plant control rooms.

Human Factors

- Bachelor's degree in human factors engineering, engineering psychology or related science,

- four years' cumulative experience related to the human factors aspects of human-computer interfaces. Qualifying experience shall include experience in at lease two of the following human factors related activities; design, development, and test and evaluation, and

- four years' cumulative experience related to the human factors field of ergonomics. Again, qualifying experience shall include experience in at least two of the following areas of human factors activities; design, development, and test and evaluation.

Plant Operations

- Have or have held a Senior Reactor Operator license, and
- two years' experience in relevant nuclear power plant operations.

Computer System Engineering

- Bachelor's degree in Electrical Engineering or Computer Science, or graduate degree in other engineering discipline (e.g., Mechanical Engineering or Chemical Engineering), and
- four years' experience in the design of digital computer systems and real time systems applications.

Plant Procedure Development

- Bachelor's degree, and
- four years' experience in developing nuclear power plant operating procedures.

Personnel Training

- Bachelor's degree,
- four years' experience in the development of personnel training programs for power plants, and
- experience in the application of systematic training development methods.

Systems Safety Engineering

- Bachelor's degree in Science,
- certification by the Board of Certified Safety Professionals in System Safety, and
- four years' experience in System Safety Engineering.

Reliability/Availability/Maintainability/Inspectability (RAMI) Engineering

Maintainability/Inspectability Engineering

- Bachelor's of Science degree,
- four years' cumulative experience in at least two of the following areas of power plant maintainability and inspectability engineering activity; design, development, integration and test and evaluation, and
- experience in analyzing and resolving plant system and/or equipment related maintenance problems.

Reliability/Availability Engineering

- Bachelor's degree,
- four years' cumulative experience in at least two of the following areas of power plant reliability engineering activity; design, development, integration, and test and evaluation, and
- knowledge of computer-based, human-interface systems.

7. The education and related professional experience of the HSI Design Team personnel shall satisfy the minimum personal qualification requirements specified in (6) above, for each of the areas of required skills. In those skill areas where related professional experience is specified, qualifying experience of the individual HFE design team personnel shall include experience in the technologies and techniques, of the particular skill area, utilized in the HSI design and implementation activities. The required professional experience presented in those personal qualifications are to be satisfied by the HSI Design Team as a collective whole. Therefore, satisfaction of the professional experience requirements associated with a particular skill area may be realized through the combination of the professional experience of two or more members of the HSI Design Team who each, individually, satisfy the other defined credentials of the particular skill area but who do not possess all of the specified professional experience. Similarly, an individual member of the HSI Design Team may possess all of the credentials sufficient to satisfy the qualification requirements for two or more of the defined skill areas.

8. Alternative personal credentials may be accepted as the basis for satisfying the minimum personal qualification requirements specified in 6 above. Acceptance of such alternative personal credentials shall be evaluated on a case-by-case basis and approved, documented and retained in auditable plant construction files by the COL Applicant. The following factors are examples of alternative credentials which are considered acceptable:

   * A Professional Engineer's license in the required skill area may be substituted for the required Bachelor's degree.

   * Successful completion of all technical portions of an engineering, technology or related science baccalaureate program may be

substituted for the Bachelor's degree. The successful completion will be determined by a transcript or other certification by an accredited institution. For example, completion of 80 semester credit hours may be substituted for the baccalaureate requirement. The courses shall be in appropriate technical subjects relevant to the required skill areas of the HFE MMIS Design Team for which the individual will be responsible.

- Related experience may substitute for education at the rate of six semester credit hours for each year of experience up to a maximum of 60 hours credit.

- Where course work is related to job assignments, post secondary education may be substituted for experience at the rate of two years of education for one year experience. Total credit for post secondary education shall not exceed two years experience credit.

<u>HFE Issue Tracking System</u>

1. The tracking system shall address human factors issues that are (1) known to the industry (defined in the operating experience review,see Element 2) and (2) those identified throughout the life cycle of the ABWR system design, development and evaluation.

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

3. Each issue/concern that meets or exceeds the threshold effects established by the 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 Team, shall be documented in detail, along with information regarding Team acceptance (e.g., person accepting, date, etc.).

4. 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.

<u>HFE Program and Management Plan</u>

1. An HFE Program Management plan shall be developed to describe how the human factors program shall be accomplished, i.e., the plan shall describe the HSI Design 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. Generally, it shall address:

- The scope of the HSI Design 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.

- The process through which the Team will execute its responsibilities.

- 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.

- The members and qualification of the Team members.

- 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.

- The procedures and documentation requirements of the HFE Issues Tracking System.

2. The HFE Program Management Plan shall provide the following information:

    1. Purpose and organization of the plan
    2. Literature and current practices review
    3. Overall HFE program goals and objectives
    4. The relationship between the HFE program and the overall plant design program (organization and schedule).
    5. HSI Design 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 HSI Design Team.
  - Provide job descriptions of personnel of the HSI Design Team.
  - Indicate the assignment of key personnel and provide their qualifications with regard to the areas of expertise indicated above.

6. HFE Issue Tracking System

• 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

7. HFE Requirements

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

8. HFE program

Identify and describe the development of implementation plans, analyses, and evaluation/verification of:

- Operating Experience Review
- System Functional Requirements Development
- Allocation of Function
- Task Analysis
- Interface Design
- Plant and Emergency Operating Procedure Development
- HF Verification and Validation

9. 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 integrated plant sequence of events.

- Provide a program schedule of HFE tasks showing:

  - relationships between HFE elements and activities.
  - reports
  - reviews

- Identify integrated design activities applicable to the HFE program but specified in other areas.

10. HFE documentation

- Identify and briefly describe each required HFE documented item.
- Identify procedures for accessibility and retention.
- Describe the supporting documentation and its audit trail maintained for NRC audits.

11. 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.

3.2 Element 2 - Operating Experience Review

DESIGN COMMITMENT:

The accident at Three Mile Island in 1979 and other reactor incidents have illustrated significant problems in the actual design and the design philosophy of NPP HSIs. There have been many studies as a result of these accidents/incidents. Utilities have implemented both NRC mandated changes and additional improvements on their own initiative. However, the changes were formed based on the constraints associated with backfits to existing CRs using early 1980s technology which limited the scope of corrective actions that might have been considered, i.e., more effective fixes could be used in the case of a designing a new CR with the modern technology typical of advanced CRs. Problems and issues encountered in similar systems of previous designs shall be identified and analyzed so that they are avoided in the development of the current system or, in the case of positive features, to ensure their retention.

INSPECTION/TEST/ANALYSIS:

- An Operating Experience Review Implementation Plan shall be developed.
- An analysis of operating experience 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 HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The following industry operating experience issues shall be reviewed:

   - See the list of issues identified in the "Operating Experience Review Issues" attachment at the end of this document

2. The issues shall be reviewed and analyzed for:

   - 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 following topics should be included in interviews as a minimum:
   - Display factors
   - Control factors
   - Information processing factors
   - Communication factors
   - Procedures

- Training factors
- Staffing and Job Design

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

5. The following sources both industry wide and plant or subsystem relevant should be included in review of the identified issues:

   - 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

6. Each operating experience issue shall be documented in the HFE Tracking System.

7. The program shall be developed using the following documents as guidance and issue definition:

NUREG-0737: *Clarification of TMI action plan requirements* (Supplement 1, Item I.C.5 "Feedback of Operating Experience to Plant Staff"), 1983, (U.S. Nuclear Regulatory Commission).

NUREG-0933: *A prioritization of generic safety issues* (Main Report and Supplements 1-12), 1991, (U.S. Nuclear Regulatory Commission).

Draft NUREG-1449: *Shutdown and low-power operation at commercial nuclear power plants in the United States*, 1992, (U.S. Nuclear Regulatory Commission).

EGG-HFRU-9446: The onsite analysis of the human factors of operating events, 1991, (U.S. Nuclear Regulatory Commission - Meyer).

Implementation Plan

The plan shall describe the designer's approach to Operating Experience Review. The plan shall address the following:

- 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

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

<u>HSI Design Team Evaluation Report</u>

The report shall address the following:

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

3.3 Element 3 - System Functional Requirements Analysis

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.

- 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 HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. System requirements shall determine system functions and the function shall determine the performance necessary to carry out the function.

2. 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),

3. Safety functions shall be identified and any functional interrelationship with non-safety systems shall be identified.

4. 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.

5. Functions shall be described initially in graphic form. Function diagramming shall be 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.

6. 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.

7. Functional operations or activities shall 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)

8. The function analysis shall be kept current over the life cycle of design development.

9. Verification

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

10. The effort shall be performed using the following documents as guidance:

IEC 964: *Design for control rooms of nuclear power plants* , 1989, (Bureau Central de la Commission Electrotrotechnique Internationale).

MIL-H-46855B: *Human engineering requirements for military systems, equipment and facilities*, 1979, (Department of Defense).

AD/A223 168: *Systems engineering management guide*, 1990, (Department of Defense - Defense Systems Management College - Kockler, F.et al.).

Implementation Plan

The plan shall describe the designer's approach to System Functional Requirements Analysis.
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 addressing:

    - Observable parameters which will indicate system status
    - Control process and measure/data required to achieve the function
    - How to determine proper discharge of function

- 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
    - Identity 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 system function verification methodology.

<u>Analysis Results Report</u>

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

HSI Design Team Evaluation Report

The report shall address the following:

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

3.4 Element 4 - Allocation of Function

DESIGN COMMITMENT:

The allocation of functions shall take 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.

INSPECTION/TEST/ANALYSIS:

- An Allocation of Function Implementation Plan shall be developed.
- 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 b the HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

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

2. The allocation of functions to personnel, system elements, and personnel-system combinations shall be made to 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.

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

4. As alternative allocation concepts are developed, analyses and trade-off studies shall be conducted to determine adequate configurations of personnel- and system- performed functions. Analyses shall confirm that the personnel elements can properly perform tasks allocated to them while maintaining 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.

5. 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.

6. Function assignment shall be evaluated.

7. The effort shall be performed using the following documents as guidance:

NUREG/CR-2623: *The allocation of functions in man-machine systems: A perspective and literature review*, 1982, (U.S. Nuclear Regulatory Commission - Price, H., et al.).

NUREG/CR-3331: *A methodology for allocation nuclear power plant control functions to human and automated control*, 1983, (U.S. Nuclear Regulatory Commission - Pulliam, R., et al.).

IEC 964: *Design for control rooms of nuclear power plants*, 1989, (Bureau Central de la Commission Electrotrotechnique Internationale).

AD/A223 168: *Systems engineering management guide*, 1990, (Department of Defense - Defense Systems Management College - Kockler, F.et al.).

Implementation Plan

The plan shall describe the designer's approach to Allocation of Function. The Allocation of Function Implementation Plan shall address:

- 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
- Evaluation of function assignment
    - The plan shall describe the tests and analyses that will be performed to evaluate the function allocation

Analysis Results Report

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

HSI Design Team Evaluation Report

The report shall address the following:

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

3.5 Element 5 - Task Analysis

DESIGN COMMITMENT.

Task analysis shall identify the behavioral requirements of the tasks the personnel subsystem is required to perform in order to achieve the functions allocated to them. A task shall be a group of activities that have a common purpose, often occurring in temporal proximity, and which utilize the same displays and controls. 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 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.
- 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 HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. 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.

2. The analysis shall link the identified and described tasks in operational sequence diagrams. A review of the descriptions and operational sequence diagrams shall identify which tasks can be considered "critical" in terms of importance for function achievement, potential for human error, and impact of task failure. Human actions which are found to affect plant risk in PRA sensitivity analyses shall also be considered "critical." 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.

3. Task analysis shall begin on a gross level and involve the development of detailed narrative descriptions of what personnel must do. Task analyses shall define 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

- 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

4. 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.

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

6. The effort shall be performed using the following documents as guidance:

NUREG/CR-3371: *Task analysis of nuclear power plant control room crews*, 1983, (U.S. Nuclear Regulatory Commission - Burgy, D. et al.).

IEC 964: *Design for control rooms of nuclear power plants* , 1989, (Bureau Central de la Commission Electrotrotechnique Internationale).

DI-H-7055: *Critical task analysis report*, 1979, (Department of Defense).

MIL-STD-1478: *Task performance analysis*, 1991, (Department of Defense).

<u>Implementation Plan</u>

The plan shall describe the designer's approach to task analysis. The Task Analysis Implementation Plan shall address:

- 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 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

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

HSI Design Team Evaluation Report

The report shall address the following:

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

3.6 Element 6 - Human-System Interface Design

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.
- 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 HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The design configuration shall satisfy the functional and technical design requirements and insure that the HSI will meet the appropriate HFE guidance and criteria.
2. The HFE effort shall be applied to HSI both inside and outside of the control room (local HSI).
3. HSI design shall utilize the results of the task analysis and the I&C inventory to assure the adequacy of the HSI.
4. 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 credible environmental conditions.
5. The HSI shall be free of elements which are not required for the accomplishment of any task.
6. The selection and design of HSI hardware and software approaches shall be based upon demonstrated criteria that support the achievement of human task performance requirements. Criteria can be based upon test results, demonstrated experience, and trade studies of identified options.
7. HFE standards shall be employed in HSI selection and design. Human engineering guidance regarding the design particulars shall be developed by the HSI designer 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.

8. 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

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

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

11. The effort shall be performed using the following documents as guidance:

NUREG-0696: *Functional criteria for emergency response facilities*, 1980, (U.S. Nuclear Regulatory Commission).

NUREG-0700: *Guidelines for control room design reviews*, 1981, (U.S. Nuclear Regulatory Commission).

NUREG-0800: *Standard review plan* (Rev 1), 1984, (U.S. Nuclear Regulatory Commission).

NUREG/CR-5908: *Advanced human-system interface design review guideline*, 1992, (U.S. Nuclear Regulatory Commission - O'Hara, et al.).

EPRI NP-4350: *Human engineering design guidelines for maintainability*, 1985, (Electric Power Research Institute - Pack R., et al.).

EPRI NP-3659: *Human factors guide for nuclear power plant control room development*, 1984, (Electric Power Research Institute - Kinkade, R.G., and Anderson, J.).

EPRI NP-3701: *Computer-generated display system guidelines (Vols 1&2)*, 1984, (Electric Power Research Institute - Frey, R. et al.).

IEC 964: *Design for control rooms of nuclear power plants* , 1989, (Bureau Central de la Commission Electrotrotechnique Internationale).

ANSI HFS-100: *American national standard for human factors engineering of visual display terminal workstations*, 1988, (American National Standards Institute).

Human-computer interface style guide (Version 1), 1992, (Department of Defense - Defense Information Systems Agency).

MIL-HDBK-759A: *Human factors engineering design for army materiel*, 1981, (Department of Defense).

MIL-STD-1472D: *Human engineering design criteria for military systems, equipment and facilities*, 1989, (Department of Defense).

DoD-HDBK-761A: *Human engineering guidelines for management information systems*, 1990, (Department of Defense).

ESD-TR-86-278: *Guidelines for designing user interface software*, 1986, (Department of Defense).

Implementation Plan

The plan shall describe the designer's approach to Human-System Interface Design. The Human-System Interface Design Implementation Plan shall address:

- 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 (selection and design of HSI hardware and software approaches), 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

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

<u>HSI Design Team Evaluation Report</u>

The report shall address the following:

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

3.7 Element 7 - Plant and Emergency Operating Procedure Development

DESIGN COMMITMENT:

Plant and Emergency Operating Procedures shall be developed to support and guide human interaction with plant systems and to control plant-related events and activities. Human engineering principles and criteria shall be applied along with all other design requirements to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated. The types of procedures covered in the element are:

- plant & system operations (including start-up, power, and shutdown operations)
- abnormal & emergency operations
- preoperational, start-up, and surveillance tests
- alarm response

INSPECTION/TEST/ANALYSIS:

- A Plant and Emergency Operating Procedure Development Implementation Plan shall be developed.
- The procedures shall be developed in accordance with the plan and the results will be documented in a Procedure Development Report.
- The procedure development shall be reviewed by the HSI Design Team and shall be documented in an Evaluation Report.

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.

2. The basis for procedure development shall include:

   - Plant design bases
   - system-based technical requirements and specifications
   - the task analyses for operations (normal, abnormal, and emergency)
   - significant human actions identified in the HRA/PRA
   - initiating events to be considered in the EOPs shall include those events present in the design bases.

3. A Writer's Guide shall be developed to establish the process for developing technical procedures that are complete, accurate, consistent, and easy to understand and follow. The Guide shall contain sufficiently objective criteria so that procedures developed in accordance with the Guide shall be consistent in organization, style, and content. The

Guide shall be used for all procedures within the scope of this Element. The Writer's Guide shall provide instructions for procedure content and format (including the writing of action steps and the specification of acceptable acronym lists and acceptable terms to be used).

4. The content of the procedures shall incorporate the following elements:

   - Title
   - Statement of Applicability
   - References
   - Prerequisites
   - Precautions (including warnings, cautions, and notes)
   - Limitations and Actions
   - Required Human Actions
   - Acceptance Criteria
   - Checkoff Lists

5. All procedures shall be verified and validated. A review shall be conducted to assure procedures are correct and can be performed. Final validation of operating procedures shall be performed in a simulation of the integrated system as part of V&V activities described in Element 8.

6. An analysis shall be conducted to determine the impact of providing computer-based procedures and to specify where such an approach would improve procedure utilization and reduce operating crew errors related to procedure use.

7. The effort shall be performed using the following documents as guidance:

NUREG-0899: *Guidelines for the preparation of emergency operating procedures*, 1982, (U.S. Nuclear Regulatory Commission).

NUREG-1358: *Lessons learned from the special inspection program for emergency operating procedures*, 1989, (U.S. Nuclear Regulatory Commission).

NUREG/CR-5228: *Techniques for preparing flowchart format emergency operating procedures* (Vols. 1&2), 1989, (U.S. Nuclear Regulatory Commission - Barnes, V. et al.).

NRC Regulatory Guide 1.33 (Rev. 2): *Quality assurance program requirements* , 1978, (U.S. Nuclear Regulatory Commission).

ANSI-N18. 7-1976: *Administrative controls and quality assurance for the operational phase of nuclear power plants*, 1976, (American National Standards Institute).

Implementation Plan

The Plant and Emergency Operating Procedure Development Implementation Plan shall address:

- Identification of source data/information to be used as a basis for procedure development
- Methodology for the evaluation of procedures (plan shall describe tests and analyses that will be used to evaluate procedures)
- Requirements for the effective development and use of a Procedural Writer's Guide
- Procedures for training program - procedure integration
- Verification and validation procedures
- Procedure development documentation requirements

<u>Procedure Development Report</u>

The report shall address the following:

- Objectives
- Description of the Methods Used
- Identification of any deviations from the implementation plan
- Results, including a list of procedures developed, and a discussion of the resulting procedures including sample procedures
- Conclusions
- Recommendations/Implications for HSI Design

<u>HSI Design Team Evaluation Report</u>

The report shall address the following:

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

3.8 Element 8 - Human Factors Verification and Validation

DESIGN COMMITMENT:

The successful incorporation of human factors engineering into the final HSI design 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.
- 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 HSI Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. 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 support human operations, maintenance, test, and inspection task accomplishment.

2. The evaluation shall address:

    - Human-Hardware interfaces
    - Human-software interfaces
    - Procedures
    - Workstation and console configurations
    - Control room design
    - Remote shutdown system
    - Design of the overall work environment

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

4. 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. A fully functional HSI prototype and plant simulator shall be used as part of these evaluations. If an alternative to a HSI

prototype is proposed its acceptability shall be documented in the implementation plan. The evaluations shall have as their 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

5. Dynamic evaluations shall evaluate HSI under a range of operational conditions and upsets, and shall include:

   - 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 LOCAs)

6. 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

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

8. A verification shall be made that all critical human actions as defined by the task analysis and PRA/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.

9. The effort shall be performed using the following documents as guidance:

NUREG-0700: *Guidelines for control room design reviews*, 1981, (U.S. Nuclear Regulatory Commission).

NUREG-0800: *Standard review plan* (Rev 1), 1984, (U.S. Nuclear Regulatory Commission).

NUREG/CR-5908: *Advanced human-system interface design review guideline (Draft)*, 1992, (U.S. Nuclear Regulatory Commission - O'Hara, et al.).

EPRI NP-3701: *Computer-generated display system guidelines (Vols 1&2)*, 1984, (Electric Power Research Institute - Frey, R. et al.).

IEEE Std 845-1988: *IEEE guide to evaluation of man-machine performance in nuclear power generating station control rooms and other peripheries*, 1988, (IEEE).

IEC 964: *Design for control rooms of nuclear power plants* , 1989, (Bureau Central de la Commission Electrotrotechnique Internationale).

AR 602-1: *Human factors engineering program*. 1983, (Department of Defense).

TOP 1-2-610: *Test operating procedure* - Parts 1 & 2, 1990, (Department of Defense).

DODI 5000.2: *Defense acquisition management policies and procedures*, 1991, (Department of Defense).

Implementation Plan

The plan shall describe the designer's approach to Human Factors Verification and Validation. 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

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

HSI Design Team Evaluation Report

The report shall address the following:

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

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Attachment

Operating Experience Review Issues

Operating Experience Review Issues

The accident at Three Mile Island in 1979 and other reactor incidents have illustrated significant problems in the actual design and the design philosophy of NPP HSIs. There have been many studies as a result of these accidents/incidents. Utilities have implemented both NRC mandated changes and additional improvements on their own initiative. However, the changes were formed based on the constraints associated with backfits to existing control rooms (CRs) using early 1980s technology which limited the scope of corrective actions that might have been considered, i.e., more effective fixes could be used in the case of a designing a new CR with the modern technology typical of advanced CRs. Problems and issues encountered in similar systems of previous designs should be identified and analyzed so that they are avoided in the development of the current system or, in the case of positive features, to ensure their retention.

Many of the issues identified below are broad and involve system design considerations that are broader than human factors alone. However, each has a human factors component which should not be overlooked by the COL during the design and implementation process. Thus for each issue identified below, a brief explanation of the HFE aspects of the issue are provided. These explanations are provided as examples only and are not intended to be a complete specification of the HFE components of the issue (which should be addressed by the COL in the design specific treatment of the issue). Each of the issues listed below should be included in the Operating Experience Review as part of the COL's design and implementation process.

The issues are organized into the following categories, based on the issues source:

1. USI Issues
2. TMI Issues
3. NRC Generic Letters
4. AEOD Studies
5. Low Power and Shutdown Issues

1. USI ISSUES

1. A-44, Station blackout: This is a large and significant issue with many human factors related aspects, including controls, displays, training, and procedures.

2. A-47, Safety implications of control systems: This issue relates to the implications of failures of non-safety related control systems and their interaction with control room operators.

3. B-17, Criteria for safety related operator action: This issue involves the development of a time criterion for safety-related operator actions including a determination of whether automatic actuation is required.

4. B-32, Ice effects on safety related water supplies: The build-up of ice on service water intakes can occur gradually and can require improved instrumentation to allow operators to detect its occurrence before it causes system inoperability.

5. GI-2, Failure of protective devices on essential equipment: A large number of LERs have noted the incapacitation of safety-related equipment due to the failure of protective devices such as fuses and circuit breakers. Operators are not always aware of the failure of the equipment due to the design of the instrumentation.

6. GI-23, Reactor coolant pump seal failures: This is a multi-faceted issue, which includes a number of proposed resolutions. One sub-issue is the provision of adequate seal instrumentation to allow the operators to take corrective actions to prevent catastrophic failure of seals.

7. GI-51, Improving the reliability of open cycle service water systems: The build-up of clams, mussels, and corrosion products can cause the degradation of open cycle SW systems. Added instrumentation is one means of providing operators with the capability to monitor this build-up and take corrective action prior to loss of system functionality.

8. GI-57, Effects of fire protection system actuation on safety-related equipment: This issue resulted from spurious and inadvertent actuations of fire protection systems, often resulting from operator errors during testing or maintenance. Design of systems should prevent such errors to the extent possible.

9. GI-75, Generic implications of ATWS events at the Salem NPP: This GI has many sub-issues, several of which are related to human factors, for example, scram data for post-scram analysis, capability for post-maintenance testing of RPS, and a specific sub-issue titled "review of human factors issues."

10. GI-76, Instrumentation & control power interactions: This issue raises several concerns, including control & instrumentation faults the could blind or partially blind the operators to the status of the plant.

11. GI-96, RHR suction valve testing: The design of the RHR suction valves with respect to valve position indication and instrumentation to detect potential leakage from high to low pressure areas is important to the prevention of ISLOCAs. This is important for normal operations and for testing.

12. GI-101, Break plus single failure in BWR water level instrumentation: This issue attempts to ensure that robust information is available to the operators for both reactor water level and for plant status during the progression of an accident.

13. GI-105, Interfacing system LOCA at BWRs: This issue relates to pressure isolation valves for BWRs. Many failures in this area were due to personnel errors. The design should address human factors considerations to correct these potential errors. (The NRC work in the ISLOCA area has generally

determined that human factors is an area needing considerable attention and which has contributed to a number of the ISLOCA precursor events.)

14. GI-110, Equipment protective devices of engineered safety features: There have been failures and incapacitation of ESF equipment due to the failure or intentional bypass by protective devices. Both the design of these protective devices and the appropriate indication to control room operators is important.

15. GI-116, Accident management: This issue relates to improved operator training and procedures for managing accidents beyond the design basis of the plant.

16. GI-117, Allowable equipment outage times for diverse, simultaneous equipment outages: A key aspect of this item is providing operators with needed assistance in identifying risk significant combinations of equipment outages. The information needed would include valve alignments, switch settings, as well as components declared inoperable.

17. GI-120, Online testability of protection systems: The designs for online testability should be careful to include appropriate human factors to ensure safe testing.

18. GI-128, Electrical power reliability: This issue includes power to vital instrument buses, DC power supplies, and electrical interlocks. All of these issues are strongly dependent on proper indication and operator action for high reliability.

19. GI-130, Essential service water pump failures at multi-plant sites: This issue relates to the arrangement of SW pumps and piping, including cross-ties at multi-unit sites. Both the arrangement and the operators' ability to monitor the status of cross ties is important. This item mentions potential applicability to single unit sites also.

2. TMI ISSUES

1. lv, HPCI and RCIC separation: the design should consider control room alarm and indication of the initiation levels and low:level restart values.

2. lvi, Reduction of challenges to SRVs: the design should consider control room alarm and indication of SRV status and important parameters.

3. lvii, ADS study: determination of the "optimum" ADS for elimination of manual activation should consider the operator's need to monitor the system and should include an analysis of the time required for operators to perform manual back:up if required.

4. lviii, Automatic restart of Core Spray and LPCI: this issue involves allocation of function considerations in terms of automatic restart of a system following manual stoppage by the operators. Considerations of whether

automatic restart should be available, how it should be implemented, and what alarm and indications are needed in the control room are required.

5. 1xi, Depressurization by means other than ADS: consideration of depressurization will involve the provision of alarms and indication in the control room. Some methods may also require operator actions which should be subject to the full design and implementation process.

6. 1xii, Alternate hydrogen control systems: the evaluation of design alternatives for hydrogen control systems should include the information needs of the operators to assess the conditions which would require system initiation and the degree of automation of the systems.

7. 2iv, SPDS: the selection and display of important safety parameters and their integration into the overall design of the control room is a primary HFE issue.

8. 2v, Automatic indication of bypassed and inoperable systems: providing operators with the capability to monitor the status of automatic systems is an important function of the control room information display system and an important component to the maintenance of the operators' situation awareness.

9. 2vi, Venting of noncondensible gases: operator monitoring of the status of noncondensible gases in the reactor coolant system and having clear, unambiguous indication of the conditions under which gas release must be initiated should be evaluated for HFE design implications.

10. 2xi, Direct indication of SRVs in control room: the alarming and indication of SRV status should be clear and unambiguous and should be evaluated for HFE design implications.

11. 2xvi, Number of actuation cycles for ECCS and RPS: as part of the specification allowable actuation cycles, the method that cycles will be defined, recorded, and tracked by the operating crew should be evaluated for HFE design implications.

12. 2xvii, Control room instrumentation for various parameters: the selection and display of important parameters and their integration into the overall design of the control room is a primary HFE issue.

13. 2xviii, Control room instrumentation for inadequate core cooling: the selection and display of important parameters and their integration into the overall design of the control room is a primary HFE issue.

14. 2xix, Instrumentation for post:accident monitoring: the selection and display of important parameters and their integration into the overall design of the control room is a primary HFE issue.

15. 2xxi, Auxiliary heat removal systems design to facilitate manual/auto actions: the specification and evaluation of manual and automatic actions should be subject to the function allocation analyses performed as part of the design and implementation process.

16. 2xxiv, Recording of reactor vessel level: the selection and display of important parameters and their integration into the overall design of the control room is a primary HFE issue.

17. 2xxv, TSC, OSC and EOF: the design of the TSC, OSC and EOF should include HFE considerations to assure that the personnel located in these facilities can most effectively perform their safety:related functions. Poor HFE design of these facilities may interfere with the performance of operators in a well:designed control room.

18. 2xxvii, Monitoring of in:plant and airborne radiation: the selection and display of important parameters and their integration into the overall design of the control room is a primary HFE issue.

19. 2xxviii, Control room habitability: while potential pathways for radioactivity to impact control room habitability may be identified and design solutions developed to preclude such problems may be developed, the control room operating crew should be aware of potential pathways. If warranted, evaluations of methods to monitor in the control room the integrity of the design solutions and the presence of radiation in the pathways should be considered.

3. NRC GENERIC LETTERS

1. 91-06, Resolution of Generic Issue A-30, "Adequacy of Safety-Related DC Power Supplies," Pursuant to 10 CFR 50.54(f). In this generic letter, NRC proposes certain monitoring, surveillance, and maintenance provisions for safety-related DC systems.

2. 91-07 GI-23, "Reactor Coolant Pump Seal Failures" and its possible effect on Station Blackout.
This generic letter discusses the interaction between GI-23 and A-44, both of which have human factors aspects.

3. 91-11 Resolution of Generic Issues 48, "LCOs for Class 1E Vital Instrument Buses," and 49, "Interlocks and LCOs for Class 1E Tie Breakers" Pursuant to 10 CFR 50.54(f). This generic letter addresses several issues related to electrical systems including the reduction of human errors, control of equipment status, and testing.

4. AEOD STUDIES

The NRC's Office for Analysis and Evaluation of Operational Data (AEOD) conducted a program to identify human factors and human performance issues associated with operating events at nuclear power plants (e.g., Meyer, 1991). These reports should be reviewed by the COL in order to determine human factors issues that may impact the development, design, and evaluation of the ABWR.

5. LOW POWER AND SHUTDOWN ISSUES

A current area of active NRC work is that of the risk associated with operation during low power and shutdown. The NRC has identified the operator-centered and human factors issues as particularly important in this area. The COL applicant should address those human factors finally developed by the NRC as a resolution to this issue. The most current status of these issues is contained in Draft NUREG-1449, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States."