January 5, 1994

Docket No. 52-003

Mr. Nicholas J. Liparulo
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Dear Mr. Liparulo:

SUBJECT: HUMAN FACTORS ENGINEERING REVIEW INFORMATION

During the December 13, 1993, meeting between the Nuclear Regulatory Commission (NRC) and Westinghouse, the staff agreed to provide information concerning human factors engineering review topics and operating experience review issues for the AP600 design certification review. Enclosures 1 and 2 provide that information.

If you have any questions regarding this matter, you can contact me at (301) 504-1120.

Sincerely,

(Original signed by)

Thomas J. Kenyon, Project Manager
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Enclosures:
As stated

cc w/enclosures:
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Enclosure 1
HFE Review Topics and Related AP600 Documentation

This document contains a description of the AP600 human factors review with respect to (1) major review topics, (2) a brief statement of the draft objective of each review topic, and (3) the AP600 documentation supporting each topic area. It should be noted that the review objectives for each topic are considered draft since the NRC's HFE Program Review Model (PRM) is in draft form and has not been tailored to the AP600 review. The draft objectives are being provided in order to facilitate the idenitfication of relevant AP600 documentation. In addition, the listing of documents does not imply that the material provides a complete description of the information needed to conduct the review. Additional information needs are required for some review topics.

1. PRM Element 1 - Human Factors Engineering (HFE) Program

The objective of this review is to ensure that the HFE program management provides an adequate HFE program plan conducted by a qualified HFE design team. The plan should describe the technical program elements assuring that all aspects of HSI are developed, designed, and evaluated based upon a structured top-down systems analysis using accepted human factors engineering (HFE) principles based upon current HFE practices.

1. SSAR Sections:
   - 18 - HFE (All inclusive)
   - 18.1 - Overview
   - 18.2 - Introduction
   - 18.4 - M'MIS Design Team
   - 18.8 - HFE Design and Implementation Process
   - 18.12 - MMIS Integration
   - 1.0 - Introduction and General Description of the Plant (All inclusive)

2. RAI Responses:
   - 620.01 - OSC, TSC space requirements
   - 620.04 - Feedback/experience used in design
   - 620.05 - Contractor support
   - 620.06 - M-MIS definition
   - 620.13 - M-MIS team comp./org.
   - 620.14 - M-MIS team Decision Process
   - 620.15 - M-MIS team tools/etc
   - 620.16 - M-MIS team process
   - 620.30 - User behavior/decision model
   - 620.34 - License holder design change
   - 620.36 - Verification and validation
   - 620.51 - HFE request for matrix
   - 620.54 - Tracking of design issues
   - 620.55 - MMI team composition
   - 620.56 - Design review process
   - 620.57 - Modified Figure 18.4-1
   - 620.67 - Mental models for operators
   - 620.69 - Use of EOPs by operators
   - 620.80 - Issue tracking verification
   - 620.88 - Designer of EOF and TSC

3. Other Documents:
   - M-MIS Development Plan (OCS-GEH-001)
   - WCAPs 9565 and 12601 (For issues tracking and design review material)
   - WCAP 19817
   - ET-NRC-92-3781/NSRA-APSL-92-0262 (12/30/92)

2. PRM Element 2 - Operating Experience Review

The objective of this review is to assure that the applicant has identified and analyzed problems and issues encountered in previous designs which are similar to the current design under review so that they are avoided in the development of the current design or, in the case of positive features, to ensure their retention.

1. SSAR Sections:
   - 18.3 - Past Experience and Lessons Learned
   - 18.8.2.1.1.1 - Review of Past Experience in NPPs and Other Process Control Rooms
   - 1.0 - Introduction and General Description of the Plant (All inclusive)

2. RAI Responses:
   - 100.08 - GSI/USI treatment
   - 620.04 - Feedback/experience used in design
   - 620.08 - Sources of M-MIS information
   - 620.09 - Lessons learned (M-MIS)
   - 620.10 - M-MIS team/lessons learned
   - 620.11 - M-MIS general literature
   - 620.12 - M-MIS interviews
   - 620.15 - M-MIS team tools/etc
   - 620.24 - Lessons learned (sources and doc.)
   - 620.35 - Review of past experience
   - 620.41 - Major evaluation issues
   - 620.45 - Review of operating conditions
   - 620.52 - OER Review/documentation
   - 620.53 - Doc. on interface problems
   - 620.54 - Tracking of design issues
   - 620.89 - Low-pressure reference plant

3. Other Documents:
   - ALWR URD Compliance Matrix
   - WCAP 13559
   - Low power and shutdown report
   - Operator interview summaries (?)
   - Comparison of AP600 Plant and a standard 2-loop, low-pressure reference plant

3. PRM Element 3 - Functional Requirements Analysis

The objective of this review is to assure that the applicant has defined the plant's safety functional requirements. Functional requirements should be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. Function analysis should: (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.

1. SSAR Sections:
   - 18.6 - User Behavior/Decision-Making Model
   - 18.8.2.1.1.2 - Operation and Control Centers Mission and Major Tasks
   - 18.9.1.3 - FBTA
   - 1.0 - Introduction and General Description of the Plant

2. RAI Responses:
   - 620.26 - Decision set model status
   - 620.31 - Modelling process definition
   - 620.32 - Task analysis models
   - 620.33 - Rem Shut. workstation TA
   - 620.62 - Explain near-real time
   - 620.63 - Model & type of decision maker
   - 620.64 - Functional decomp. & decision sets
   - 620.65 - Numbers Figures 18.6-1 to 18.6-8
   - 620.66 - Decision-sets and behavior interface
   - 620.72 - Allocation decisions
   - 620.73 - Allocation process
   - 620.74 - Allocation process
   - 620.78 - V&V passive plant issues

3. Other Documents:
   - WCAP 1260
   - WCAP 9817
   - Draft FBTA Report

4. PRM Element 4 - Allocation of Function

The objective of this review is to assure that the applicant's function allocations take advantage of human strengths and avoid allocating functions which would be negatively impacted by human limitations. Functions should be allocated to personnel, system elements, and personnel-system combinations according to accepted HFE principles using a structured and well-documented methodology and should not be based on technology considerations alone. The crew should be left with a logical, coherent, function in the plant rather that an ad hoc set of activities that results for allocation to the crew of anything not well handled by the automated systems.

1. SSAR Sections:
   - 18.8.2.1.2.4 - Allocation of Tasks Between Man and Machine
   - 7.0 - Instrumentation and Controls (for identification of initial allocations)

2. RAI Responses:
   - See Element 3 list

3. Other Documents:
   - WCAP 9817
   - ET-NRC-92-3748 (9/17/92) - Role of operator

5. PRM Element 5 - Task Analysis

The objective of this review is to assure that the applicant's task analysis identifies the behavioral requirements of the tasks the personnel subsystem is required to perform in order to achieve the functions allocated to them. Task analysis is a very important activity in the design of an HSI since it represents the definition of what will be needed at the interface in order for the crew to accomplish the tasks they need to perform (and by exclusion, what is not needed in the HSI).

1. SSAR Sections:
   - 18.6.5 - The User Behavior/Decision-Making Model
   - 18.6.6 - Role of the Operators in the AP600 Main Control Room
   - 18.6.7 - Summary
   - 18.7 - Allocation and Determination of Staffing
   - 18.8.2.1.1.2 - Operation and Control Centers Mission and Major Tasks
   - 18.8.2.1.1.3 - Plant-Specific Design Inputs
   - 18.8.2.1.1.4 - Model of Human Decision-Making
   - 18.8.2.1.2 - Function-Based Task Analysis
   - 18.9.1.3 - Function-Based Task Analysis
   - 7.0 - Instrumentation and Control (input/outputs for human actions)

2. RAI Responses:
   - 620.26 - Decision set model status
   - 620.28 - Task analysis (cog. vs. trad.)
   - 620.29 - Task analysis scope
   - 620.31 - Modelling process definition
   - 620.32 - Task analysis models
   - 620.33 - Rem Shut. workstation TA
   - 620.37 - TA (results and audit)
   - 620.38 - TA (task descriptions)
   - 620.39 - TA (guidelines for)
   - 620.42 - TA scope
   - 620.46 - Staffing level requirements
   - 620.47 - Control (operator actions)
   - 620.62 - Explain near-real time
   - 620.63 - Model & type of decision maker
   - 620.64 - Functional decomp. & decision sets
   - 620.65 - Numbers Figures 18.6-1 to 18.6-8
   - 620.66 - Decision-sets and behavior interface
   - 620.68 - Operator qualification
   - 620.70 - Traditional approach to TA
   - 620.71 - Model/example task description
   - 620.75 - TA implementation guidance
   - 620.82 - V&V and LCS
   - 720.66 - Sequence summaries
   - 720.117 - HRA insights
   - 720.119 - Inadvertant IRWST draining
   - 720.122 - Diverse instrumentation readings
   - 720.123 - CMT and ADS acturation
   - 720.124 - Vessel level indication
   - 720.127 - Multiple steam generator tube ruptures
   - 720.128 - CVS actuation
   - 720.133 - Importance of human actions

3. Other Documents:

- Draft FBTA Report
- AP600 PRA (Revised 2/94??)
- AP600 High-level Operator Action Strategies as a Precursor to the FRGs

6. PRM Element 6 - Human-System Interface Design

The objective of this review is to evaluate the process by which HSI design requirements are developed and HSI designs are selected and refined. The review should assure that the applicant has appropriately translated function and task requirements to the displays and controls that are available to the crew. The applicant should have systematically applied HFE principles and criteria (along with all other function/system/task design requirements) to the identification of HSI requirements, the selection and design of HSIs, and the resolution of HFE/HSI design problems and issues. The process and the rationale for the HSI design (including the results of trade-off studies, other types of analyses/evaluations, and the rationale for selection of design/evaluation tools) should be documented and be available for review.

1. SSAR Sections:
   - 18.5 - HFE Acceptance Criteria
   - Table 18.5-1 - Design Acceptance Testing: Verification Tests
   - 18.8.2.1.3 - M-MIS Design Implementation
   - 18.8.2.3 - M-MIS Design Verification and Validation Process
   - 18.9 - Design Process Results for Main Control Room
   - 18.10 - Design Process Results for Other Areas Within the MCR Envelope
   - 18.11 - Design Process Results for Other Operations and Control Centers
   - 18.12 - M-MIS Integration
   - 18.13 - HF Design for Non-MMI Systems Portion of the Plant
   - 7.0 - Instrumentation and Control (for design-related aspects of human actions)

2. RAI Responses:
   - 620.20 - Guidelines, Process ITAAC
   - 620.34 - License holder design change
   - 620.40 - M-MIS guidelines documents
   - 620.41 - Major evaluation issues
   - 620.48 - SPDS
   - 620.49 - Alarm system
   - 620.59 - HSI specification
   - 620.72 - Allocation decisions
   - 620.74 - Allocation process
   - 620.76 - Availability/ guidance docs
   - 620.82 - V&V and LCS
   - 620.83 - Concept test requirements
   - 620.84 - V&V performance measures
   - 620.85 - Comm. - CR & plant personnel
   - 620.86 - Display response time
   - 620.90 - Plant labeling
   - 720.122 - Diverse instrumentation readings

3. Other Documents:
   - WCAP 13383, Rev.0

- Guidance documents
  - AP600 Alarm Design Guidelines
  - AP600 Alarm System Functional Requirements
  - Draft AP600 Display Design Guidebook
  - Computerized Procedures Functional Requirements
  - QDPS (PAMS) Functional Requriements

7. PRM Element 7 - Procedures

The objective of this review is to assure that the applicant's procedure development program will result in procedures that support and guide human interaction with plant systems and control plant-related events and activities. Human engineering principles and criteria should be applied along with all other design requirements to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated.

1. SSAR Sections:
   - 13.5 - Plant Procedures
   - 18.9.8 - Design of Plant Procedures

2. RAI Responses:
   - 620.41 - Major evaluation issues
   - 620.50 - Display/control/alarm matrix
   - 620.69 - Use of EOPs by operators
   - 620.87 - High-level operator actions
   - 620.89 - Low-pressure reference plant
   - 720.122 - Diverse instrumentation readings

3. Other Documents:
   - ERGs

8. PRM Element 8 - Verification & Validation

The objective of this review is to assure that the applicant has thoroughly evaluated the HSI as an integrated system using HFE evaluation procedures, guidelines, standards, and principles. Four separate review activities are considered:

Human Factors Issue Resolution Verification - All issues documented in the Human Factors Issue Tracking System of Element 1 should be verified as adequately addressed.

HSI Task Support Verification - All aspects of the HSI (e.g., controls, displays, procedures, and data processing) that are required to accomplish human safety-related tasks and actions [as defined by the task analysis, EOP analysis, and probabilistic risk assessment/human reliability analysis (PRA/HRA)] should be verified as available through the HSI and that HSI aspects which do not support operator tasks are not present.

HFE Verification - All aspects of the HSI (e.g., controls, displays, procedures, and data processing) should be verified as designed to be appropriate to crew task requirements and consistent with accepted HFE guidelines, standards, and principles. If HFE issues were identified during the review conducted as part of Element 6, resolution of those issues should also be verified as part of the HFE Verification.

Integrated System Validation - The integration of HSI elements with each other and with personnel should be evaluated and validated through dynamic task performance evaluation using evaluation tools which are appropriate to the accomplishment of this objective (preferably a fully functional HSI prototype and plant simulator) under a range of operational conditions, including normal and upset conditions.

1. SSAR Sections:
   - Table 18.5-1 - Eval. 16 - HFE Guidelines Evaluation
   - Table 18.5-2 - Eval. 17 - Validation of Integrated M-MIS
   - 18.8.2.3.5.4 - Evaluation for Conformance to HFE Design Guidelines
   - 18.8.2.3.5.5 - Evaluation for Validation of Integrated M-MIS

2. RAI Responses:
   - 620.17 - MCR simulator
   - 620.18 - Near full-scope, hi fi. simulator
   - 620.20 - Guidelines, Process ITAAC
   - 620.33 - Rem Shut. workstation TA
   - 620.36 - Verification and validation
   - 620.40 - M-MIS guidelines documents
   - 620.41 - Major evaluation issues
   - 620.56 - Design review process
   - 620.59 - HSI specification
   - 620.60 - Evaluations in Table 18.5-2
   - 620.61 - Obj. criteria for per. ITAAC
   - 620.77 - V&V vs. unexpected issues
   - 620.78 - V&V passive plant issues
   - 620.79 - Validation Imp. Plan
   - 620.80 - Issue tracking verification
   - 620.81 - Availability analysis
   - 620.82 - V&V and LCS
   - 620.83 - Concept test requirements
   - 620.84 - V&V performance measures

3. Other Documents:
   - WCAP 13383

9. Training

A training program shall be developed in accordance with 10 CFR 55 and other relevant requirements to ensure that operations personnel have the knowledge, skills, and abilities to perform their duties. Training should address:

- The full range of positions of operational personnel including licensed operators and non-licensed persons whose actions may affect the safety of the plant.
- The full range of plant safety functions and systems including those that may be different from predecessor plants (e.g., passive systems and functions).
- The full range of relevant HSI components (e.g., MCR, RSP, local control stations) including characteristics that may be different from predecessor plants (e.g., display space navigation, operation of "soft" controls.
- The full range of plant conditions.

1. SSAR Sections:
   - 13.2 - Training
   - 15.9.9 - AP600 Training Program

10. Inventory

The objective of this review is to assure that an initial set of controls, displays, and alarms for transient and accident mitigation has been identified before design certification based upon the AP600 ERGs and the important operator actions specified as a result of the PRA analysis.

1. SSAR Sections:
   - Not addressed

2. RAI Responses:
   - 620.50 - Display/control/alarm matrix

11. CDD/ITAAC/DAC

The objective of this review is to evaluate the AP600 HFE ITAAC against the requirements of 10 CFR Part 52.47(a)(1)(vi) by ensuring that significant features of the design certification application contained in the SSAR are captured by the CDD and that the ITAAC and DAC are consistent with the criteria described in the HFE PRM.

1. SSAR Sections:
   - 18.8.2.4 - Inspections, Tests, Analyses, and Acceptance Criteria

2. RAI Responses:
   - 620.19 - Design ITAAC development
   - 620.21 - Design ITAAC (V&V)
   - 620.22 - Acc. criteria for construction
   - 620.23 - Acc. criteria and perf. meas.
   - 620.44 - Design ITAAC (completeness)
   - 620.58 - MMIS process ITAAC (see 620.20 & 59)
   - 620.61 - Obj. criteria for per. ITAAC

Enclosure 2
Oper Experience Review Issues

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 applicant during the design and implementation process. Thus for each issue identified below, a brief explanation of the HFE aspects of the issue is 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 applicant in the design specific treatment of the issue). Each of the issues listed below should be addressed in the Operating Experience Review as part of the applicant's design and implementation process.

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

1. USI/GSI Issues
2. TMI Issues
3. NRC Generic Letters
4. AEOD Studies
5. Low Power and Shutdown Issues
6. INPO Reports

1. USI/GSI 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 Actions - involves the development of a time criterion for safety-related operator actions including a determination of whether automatic actuation is required. This issue also concerns some current PWR designs requiring manual operations to accomplish the switchover from the injection mode to the recirculation mode following a LOCA.

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-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.

7. 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.

8. 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."

9. 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.

10. 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.

11. 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.

12. 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.)

13. 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.

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

15. 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.

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

17. GI-125.1.3, Safety Parameter Display System Availability - addresses SPDS availability and the reliability of the information it displays.

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.

20. HF1.1, Shift Staffing - This issue is similar to Item I.A.1.4. above.

21. HF4.4, Guidelines for Upgrading Other Procedures - addresses normal and abnormal procedures in the same manner as emergency procedures.

22. HF4.5, MMI - Automation and Artificial Intelligence - See HF 5.2.

23. HF5.1, Local Control Stations - addresses the MMI of local control stations and auxiliary operator interfaces.

24. HF5.2, Review Criteria for Human Factors Aspects of Advanced Controls and Instrumentation - This concern is a combination of HF 4.5 Automation and Artificial Intelligence, the original HF5.2 on Annunciators, HF 5.3 Operational Aids, and HF5.4 Computers and computer displays.

25. HF5.3, Man-Machine Interface, (MMI) Evaluation of Operational Aids - involves guidance for MMI for new display and control technologies.

26. HF5.4, MMI - Computers and Computer Displays - See HF5.2.

2. TMI ISSUES

The following issues come from two sources. Items 1-18 are from 10 CFR 50.34 and are identified by the item numbers from that source. The rest of the items are from NUREG-0933 (and its predecessor NUREG-0737) and are identified by the item numbers from the NUREG. It should be noted that there is duplication in the content of some items; i.e., a single OER item may address several of the TMI issues described below. The items are listed by number and not the technical issue which is addressed.

1. 1vi, Reduction of challenges to SRVs: the design should consider control room alarm and indication of SRV status and important parameters.

2. 1vii, 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 backup if required.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.

9. 2xii, AFW indication and initiation.

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

16. 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.

17. 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.

18. 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.

19. I.A.1.4, Long-Term Upgrading of Operating Personnel and Staffing - concerns shift staffing with licensed operators, and working hours of licensed operators. Updates to 10 CFR 50.54 were approved.

20. I.A.4.2, Simulator Capabilities - involves the improvement of the use of simulators in the training of operators.

21. I.C.1, Guidance for Evaluation and Development of Procedures - addresses normal, transient, and accident conditions. This is to ensure that procedures are technically correct, explicit, and easily understood.

22. I.C.9, Long-Term Program for Upgrading Procedures - includes emergency operating procedures with particular emphasis on diagnostic aids for off-normal conditions.

23. I.D.1 - Addresses general CR design issues.

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26. I.D.5.1, Control Room Design - Improved Instrumentation Research Alarms and Displays - involves the man-machine interface in the control room with regard to the use of lights, alarms, and annunciators to reduce the potential for operator error, information overload, unwanted distractions, and insufficient information organization.

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Operating Experience Review Issues

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 applicant during the design and implementation process. Thus for each issue identified below, a brief explanation of the HFE aspects of the issue is 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 applicant in the design specific treatment of the issue). Each of the issues listed below should be addressed in the Operating Experience Review as part of the applicant's design and implementation process.

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

1. USI/GSI Issues
2. TMI Issues
3. NRC Generic Letters
4. AEOD Studies
5. Low Power and Shutdown Issues
6. INPO Reports

1. USI/GSI 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 Actions - involves the development of a time criterion for safety-related operator actions including a determination of whether automatic actuation is required. This issue also concerns some current PWR designs requiring manual operations to accomplish the switchover from the injection mode to the recirculation mode following a LOCA.

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-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.

7. 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.

8. 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."

9. 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.

10. 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.

11. 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.

12. 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.)

13. 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.

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

15. 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.

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

17. GI-125.I.3, Safety Parameter Display System Availability - addresses SPDS availability and the reliability of the information it displays.

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.

20. HF1.1, Shift Staffing - This issue is similar to Item I.A.1.4. above.

21. HF4.4, Guidelines for Upgrading Other Procedures - addresses normal and abnormal procedures in the same manner as emergency procedures.

22. HF4.5, MMI - Automation and Artificial Intelligence - See HF 5.2.

23. HF5.1, Local Control Stations - addresses the MMI of local control stations and auxiliary operator interfaces.

24. HF5.2, Review Criteria for Human Factors Aspects of Advanced Controls and Instrumentation - This concern is a combination of HF 4.5 Automation and Artificial Intelligence, the original HF5.2 on Annunciators, HF 5.3 Operational Aids, and HF5.4 Computers and computer displays.

25. HF5.3, Man-Machine Interface, (MMI) Evaluation of Operational Aids - involves guidance for MMI for new display and control technologies.

26. HF5.4, MMI - Computers and Computer Displays - See HF5.2.

2. TMI ISSUES

The following issues come from two sources. Items 1-18 are from 10 CFR 50.34 and are identified by the item numbers from that source. The rest of the items are from NUREG-0933 (and its predecessor NUREG-0737) and are identified by the item numbers from the NUREG. It should be noted that there is duplication in the content of some items; i.e., a single OER item may address several of the TMI issues described below. The items are listed by number and not the technical issue which is addressed.

1. 1vi, Reduction of challenges to SRVs: the design should consider control room alarm and indication of SRV status and important parameters.

2. 1vii, 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.

3. 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.

4. 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.

5. 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.

6. 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.

7. 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.

8. 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.

9. 2xii, AFW indication and initiation.

10. 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.

11. 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.

12. 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.

13. 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.

14. 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.

15. 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.

16. 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.

17. 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.

18. 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.

19. I.A.1.4, Long-Term Upgrading of Operating Personnel and Staffing - concerns shift staffing with licensed operators, and working hours of licensed operators. Updates to 10 CFR 50.54 were approved.

20. I.A.4.2, Simulator Capabilities - involves the improvement of the use of simulators in the training of operators.

21. I.C.1, Guidance for Evaluation and Development of Procedures - addresses normal, transient, and accident conditions. This is to ensure that procedures are technically correct, explicit, and easily understood.

22. I.C.9, Long-Term Program for Upgrading Procedures - includes emergency operating procedures with particular emphasis on diagnostic aids for off-normal conditions.

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