UNITED STATES
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May 1, 1996

MEMORANDUM TO: AP600 Docket File

FROM: William C. Huffman, Project Manager
Standardization Project Directorate
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

SUBJECT: SUBMITTAL OF DRAFT STANDARD SAFETY ANALYSIS REPORT (SSAR) MARKUP PERTAINING TO AP600 HUMAN FACTORS ENGINEERING

Attached is a Westinghouse draft-markup of AP600 SSAR Section 18.7. This draft document was sent to the Nuclear Regulatory Commission via facsimile on April 11, 1996, by Steve Kersch of the Westinghouse Electric Corporation to facilitate resolution of open issues related to Element 5 (staffing) of the human factors engineering program review model.

Docket No. 52-003

Attachment: Draft mark-up
of AP600 SSAR 18.7

Westinghouse

FAX COVER SHEET

RECIPIENT INFORMATION		SENDER INFORMATION	
DATE:	4/11/96	NAME:	Steve Kerch
TO:	Jim Bongarra / John O'Hara	LOCATION:	ECE-457
PHONE:	301-415-1046 / ———	PHONE:	412-374-5184
COMPANY:	NRC / BNL		
LOCATION:		FAX:	(412) 374-5099

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Comments:

Jim and John,

Attached is a draft/markup of SSAR section 18.7. This draft will replace the existing 18.7 of the SSAR. Also attached is a table that provides a mapping of the Element 5 (Staffing) DSER open items to the subsection of this document that addresses the respective open item. Please review and provide any appropriate "Discussion items" for our May meeting in Rockville,

Thanks

Steve Kerch

Phone Number of Receiving Equipment: Jim 301-415-2222

John 516-282-4980

Attachment

The following table provides a mapping of Open Item issues and where they are addressed in the SSAR.

Open Item Number/Title		SSAR Section/Title	
18.6.3.1	Number and Qualification of Personnel	18.7.3	Number and Qualification of Personnel
18.6.3.2	Staffing Levels	18.7.3	Number and Qualification of Personnel
		18.7.4	Combined License Information Item
18.6.3.3	Staffing Analysis Iteration	18.7.3	Number and Qualification of Personnel
18.6.3.4	Basis for Staffing	18.7.2	Design Basis for Staffing
18.6.3.5	Industry Standards, Guidelines, and Practices	18.7.1	Industry Standards, Guidelines, and Practices

18.7 Determination of Staffing

This section describes the implementation plan for determining the staffing level of the operating crew in the main control room. Determination of the staffing levels and qualifications of all personnel (operations, maintenance, engineering, instrumentation and control technicians, radiological protection technicians, chemists, security and the like) is the responsibility of the Combined License applicant.

18.7.1 Industry Standards, Guidelines, and Practices

The following documents are used as guidance to address staffing issues:

- 10 CFR 50.54 U.S. Code of Federal Regulations Part 50. "Conditions of Licenses."
- 10 CFR 50.47 U.S. Code of Federal Regulations Part 50, "Emergency Plans."
- NUREG-0800, "Standard Review Plan," Sections 13.1.2 through 13.1.3, 1984.
- NUREG-0654, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," 1980.
- Reg Guide 1.114. "Guidance to Operators at the Controls and to Senior Operators in the Control Room of a Nuclear Power Unit," May 1989.
- Regulatory Guide 1.8, "Qualification and Training of Personnel for Nuclear Power Plants," Revision 2, April 1987.
- NUREG-0711, "Human Factors Engineering Program Review Model," USNRC, July 1994.

18.7.2 Design Basis for Staffing

The design goal for the AP600 main control room and its operating crew is to design the plant and the man-machine interface system (M-MIS) such that one reactor operator (RO) and one senior reactor operator (SRO) can safely monitor and control the plant under all conditions including emergencies. Using this design goal, initial staffing for the main control room is assumed to be composed of one shift supervisor (SS) who is qualified as senior reactor operator, one senior reactor operator, and one reactor operator. One of the shift supervisors or senior reactor operators in the main control room will take on the function of the senior technical advisor (STA) under the assumption that the individual meets the applicable engineering expertise requirements.

The following elements of the AP600 human factors engineering (HFE) design program are used as the basis to help achieve, verify, and validate the design goal stated above:

- Operating Experience Review
- Function Analysis and Allocation
- Task Analysis
- Human Reliability Assessment
- Human System Interface (HSI) Design
- Procedures
- Training
- Human Factors Engineering Verification and Validation

18.7.2.1 Operating Experience Review

An input to the human factors engineering design of the AP600 and its advanced man-machine interface system is an operating experience review. The objective of this operating experience review is to identify and analyze human factors engineering-related problems and issues encountered in previous designs that are similar to the AP600 so that they are avoided in the AP600, or to retain positive features. The results of the review are used as input to the design process so that adequate consideration is given to these issues. Refer to Section 18.3 for a description of the review of operating experience conducted for the AP600. The operational problems and strengths of the main control room staffing levels in currently operating Westinghouse pressurized water reactors are identified as part of the operating experience review. These problems and issues are addressed in the design of the AP600 man-machine interface system to help achieve the main control room operating crew design goal stated in subsection 18.7.2.

18.7.2.2 Functional Requirements Analysis and Allocation

The objective of the Functional Requirements Analysis and Allocation is to define the safety functional requirements and to assign function allocations that take advantage of human strengths and avoid allocating functions that would be negatively affected by human limitations. The function allocation process is used to help establish and support the desired main control room staffing level. This process involves determination of which functions are achieved through automation and which functions are allocated to personnel. Preliminary decisions with respect to system automation are made by plant designers based on a variety of criteria, including "lessons learned" from operating experience of current Westinghouse pressurized water reactors. The role of the man-machine interface system designers is to evaluate these function allocation decisions with respect to:

- Achieving maximized human and system performance without placing excessively burdensome demands upon the operators

- Determining the "post-conditions" that result from automating a task

When a task is automated, additional human tasks are added, and subsequently, an assessment is made of the operator's ability to accomplish these new tasks. These added human tasks usually deal with issues such as supervisory control of the automated systems including determining whether or not the automatic system made the correct decision; whether or not to switch to "Manual" control from "Automatic" control; and, in the case of automatic protection systems, whether or not the full capability of the system is needed. Refer to subsection 18.8.2 for a description of the AP600 function allocation process and its results.

18.7.2.3 Task Analysis

The AP600 Task Analysis has the following objectives:

- Provide one of the bases for man-machine interface system design decisions
- Ensure that human performance requirements do not exceed human capabilities
- Provide input to procedure development
- Provide input to staffing, training, and communications requirements of the plant

Task Analysis provides input to the main control room staffing levels by including workload analysis as part of the overall Task Analysis process. During the functional design phase of the man-machine interface system, a workload analysis (Operations Sequence Analysis [OSA-2]) is performed to establish that the man-machine interface system design adequately supports operator performance for important operator tasks. Operations Sequence Analysis employs man-in-the-loop tests of rapid prototypes of man-machine interface system systems as well as analytic techniques to establish that operators are able to accomplish important task sequences within the available time. The workload analysis is performed for a subset of the tasks used in the first operational sequence analysis, including tasks identified to be time critical and tasks identified to be critical human actions or risk important to safety. The objective of the workload analysis is to provide an early verification that the control room man-machine interface system adequately supports operator performance. In cases where the workload analysis indicates a task with high operator workload values, or insufficient time available for performance, alternative staffing assumptions or changes to the man-machine interface system design or function allocation to reduce operator workload are evaluated. For additional information regarding Task Analysis, including workload analysis, refer to subsection 18.8.2.

18.7.2.4 Human Reliability Analysis

The Human Reliability Analysis (HRA) evaluates the potential for and mechanisms of human error that may affect plant safety. The design of the man-machine interface system is an important contributor to human reliability. The goal is to design the man-machine interface system to minimize the potential for human error and to provide for error detection and recovery capability, particularly for risk-important tasks.

The AP600 design draws on lessons learned from existing plant experience and the results of past human reliability analyses and probabilistic risk assessments to reduce the potential for human error. One approach to increase human reliability in the AP600 is to simplify the plant design and reduce the number of human actions required.

Integration of human reliability analysis activities within the man-machine interface system design process is accomplished by:

- Task Analysis - Results of human reliability analyses/probabilistic risk assessments are used to identify critical human actions and risk-important tasks as input to task analysis activities. Critical actions and risk-important tasks are examined using operational sequence task analyses, including workload analysis.

- Human System Interface Design and Procedure Development - Results of man-machine interface system/human system interface design and procedure development activities will be used to confirm or refine human reliability analysis assumptions. Tasks that are identified in the human reliability analysis/probabilistic risk assessment to pose challenges to plant safety and reliability will be re-examined by task analysis, man-machine interface system design, and procedure development, to identify changes to the operator task or the control and display environment to reduce or eliminate sources of error.

- Human Factors Engineering Verification and Validation (V&V) Human reliability analysis performance assumptions (actions to be performed; time within which they are completed) will be validated as part of the human factors engineering Integrated System Validation.

The human reliability analysis/human factors engineering integration implementation plan is discussed in subsection 18.8.2.

18.7.2.5 Human System Interface Design

The man-machine interface system includes design of the man-machine interface system operations and control centers and man-machine interface system subsystems intended to support personnel performance. Activities performed as part of the functional design phase include development of rapid prototypes and mockups, man-in-the-loop testing, and development of guidelines documents.

An important element of the man-machine interface system design process is the conduct of man-in-the-loop concept tests that are used to establish the adequacy of man-machine interface system design concepts. One objective of the man-in-the-loop testing is to establish that the main control room staffing level and the man-machine interface system functional design of the main control room is adequate to support operator performance in the range of activities and situations that are anticipated to arise.

A full-scale mockup of the main control room working area including main control consoles (workstations) and the wall panel display is constructed. The mockup is constructed to the required anthropometric profiles and arranged in the floor layout intended for the AP600 plant main control room. The mockup is primarily used to verify physical layout aspects such as availability of workspace, physical access, visibility, and related anthropometric and human factors engineering issues. It is also used for walk-through exercises to examine issues such as staffing levels, task allocation, and procedure usage.

For additional information on the human systems interface/man-machine interface system design, see subsection 18.8.2.

18.7.2.6 Procedures

The Computerized Procedure System is a human system interface/man-machine interface system resource that provides the interface for the operators to execute procedures. The Computerized Procedure System helps achieve the staffing goal for the main control room by reducing the mental burden and workload of the operators. This is accomplished by reducing the number of parallel activities performed by the operators. For example, when a procedure requires the operator to execute a specific action only after the plant reaches a given state, the Computerized Procedure System monitors and alerts the operator when the plant state exists. This frees the operator of the burden of monitoring for this state in parallel with performing further steps in the procedure. For additional information on the Procedure Development and the Computerized Procedure System, refer to subsection 18.9.8.

18.7.2.7 Training

Training program development is the responsibility of the Combined License applicant as stated in Section 13.2. Refer to subsection 18.9.9 for a discussion of the Training Program Development.

18.7.2.8 Human Factors Engineering Verification and Validation

As described in subsection 18.8.2, a human factors engineering verification and validation is part of the human factors engineering design process. The Integrated System (M MIS) Validation, conducted as part of the human factors engineering verification and validation, includes the following evaluations:

- Establish the adequacy of the integrated man-machine interface system for achieving human factors engineering program goals
- Confirm allocation of function and the structure of tasks assigned to personnel
- Establish the adequacy of main control room staffing levels and the adequacy of the man-machine interface system to support the staff in accomplishing their tasks
- Validate the EOPs
- Confirm the dynamic aspects of the man-machine interface system for task accomplishment
- Evaluate and demonstrate error tolerance to human and system failures

If it is determined from the integrated validation testing that the main control staffing and man-machine interface system design goals are not achieved, a decision is made to either redesign the appropriate system (such as man-machine interface, instrumentation and control, fluid systems) or modify the proposed main control room staffing.

18.7.3 Number and Qualifications of Personnel

As stated in subsection 18.7.2, a design goal of the AP600 and its man-machine interface system is to have one reactor operator and one senior reactor operator be able to monitor and control the plant under all plant conditions, including emergencies. Using this goal, the initial staffing level for the main control room crew is assumed to be composed of one shift supervisor (senior reactor operator license), one senior reactor operator (senior reactor operator license) and one reactor operator (reactor operator license). Refer to subsections 16.1.5.1 and 16.1.5.2 for the organization and responsibilities of the unit management and staff. The elements of the human factors engineering design process, as described in subsection 18.7.2, are used to verify and validate this design goal.

Potential iterations to the staffing level occur during or following the human factors engineering program elements listed below:

- The qualitative workload analysis conducted as part of the task analysis
- The quantitative workload analyses conducted as part of the man-in-the-loop concept test phase of the human system interface design
- The integrated system validation conducted as part of the human factors engineering verification and validation

An alternative to iterating the staffing level is to modify appropriately the system design (man-machine interface system, instrumentation and control systems, or fluid systems) or the function allocation in order to achieve the staffing level initially assumed. The Combined License applicant shall address the minimum licensed operator staffing requirements of 10 CFR 50.54(m) during the Combined License process.

Refer to subsection 16.1.5.3 for the qualifications of unit staff personnel.

18.7.4 Combined License Information Item

Combined License applicants referencing the AP600 design will address the staffing levels and qualifications of plant personnel including operations, maintenance, engineering, instrumentation and control technicians, radiological protection technicians, security, and chemists.