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WESTINGHOUSE NON-PROPRIETARY CLASS 3

WCAP-14690

Revision 1

Designer's Input to Procedure Development for the AP600

OCS-GEH-023

Revision 1

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PREFACE

WCAP-14690 is revised from Revision 0 to Revision 1 for the sole purpose of adding this preface to address the concern raised in Reference 19.

Although the AP600 human system interface resources include a computerized procedure system, evaluation of the acceptability of such a system is not part of the NRC staff AP600 Human Factors Engineering Program review for Design Certification. At the time of AP600 design certification, the NRC staff does not endorse or reject using a computerized procedure system as a means for providing instruction to plant personnel in a nuclear plant environment. The acceptability of such a system for application to the NRC design would be determined during the implementation of the AP600 verification and validation program and reviewed as part of an application for a Combined License.

LIST OF ACRONYMS AND ABBREVIATIONS

COL	Combined License
CPS	Computerized Procedure System
EOP	Emergency Operating Procedure
ERG	Emergency Response Guidelines
HFE	Human Factors Engineering
HRA	Human Reliability Analysis
LOCA	Loss-of-Coolant-Accident
MCR	Main Control Room
MMI	Man-Machine Interface
PRA	Probabilistic Risk Assessment
PWR	Pressurized Water Reactor
SSAR	Standard Safety Analysis Report
SSC	Structures, Systems, and Components

1.0 INTRODUCTION

Plant procedures are developed and used by the plant staff so that startup, routine, nonroutine, and emergency activities are conducted in a safe manner. Activities affecting safety-related structures, systems, and components (SSCs) are performed by following detailed and approved plant procedures.

As stated in the AP600 Standard Safety Analysis Report (SSAR) subsection 13.5, procedure development is a Combined License (COL) applicant responsibility. COL applicants referencing the AP600 certified design, will address plant procedures including normal operation, abnormal operation, emergency operation, alarm response, maintenance, inspection, test, surveillance, and administrative procedures. This document provides input from the designer to the AP600 COL applicant on the development of plant procedures. Also included in this document is information on the development and design of the AP600 emergency response guidelines (ERGs), and information on the computerized procedure system (CPS). The CPS is the human system interface that allows operators to execute the plant procedures.

2.0 PROCEDURE DEVELOPMENT

An implementation plan for the development of plant operating procedures should be developed and executed by the COL applicant. This plan should be created to guide the development of the plant operating procedures and to specify the process by which the plant operating procedures will be verified, validated, and maintained. The scope of the plan should include the applicable operating procedures specified in the previous section. The plan should specify that plant operating procedures follow standard formats implemented through a writer's guide. The plan should also include the need to document the plant operating procedures' technical bases. The implementation plan should do the following:

- Specify the process by which plant operating procedures are developed, verified, validated, and maintained

- Include the applicable operating procedures listed in Section 1.0

- State that plant operating procedures follow guidance provided by the writer's guide

- Specify that the plant operating procedures' technical bases be documented and shall be consistent with plant design basis material, task analysis, Probabilistic Risk Assessment (PRA), and output from the human reliability analysis (HRA)/human factors engineering (HFE) integration plan

- Specify that the plant operating procedures be developed using the accepted industry standards, guidelines, and practices. A list of documents to be used as guidance is provided in Section 6.0 as References 1 through 12.

3.0 COMPUTERIZED PLANT PROCEDURES

The AP600 man-machine interface (MMI) (human system interface) is designed to provide a CPS for the presentation of plant procedures to the operating staff. The CPS is one of the human system interface systems of the AP600 main control room (MCR). The AP600 SSAR subsection 18.8 lists the interface systems and describes the design implementation plan for them. The human system interface design implementation plan includes functional design documentation, HFE design guidelines, Man-in-the-Loop concept testing, design specifications, full-scale mockup of the MCR, design reviews, and the implementation of the hardware and associated software designs.

The CPS is accessible from each operator workstation in the MCR. Design options, including a paper backup, are being explored to determine the operator's course of action in the unlikely event of a loss of the CPS on the workstations.

A procedure writer's guide is developed as part of the human system interface design implementation plan for the CPS. SSAR subsection 18.8 describes the design implementation plan for the AP600 human system interface. The writer's guide establishes the process for developing procedures. The guide is used for procedures within the scope of this design element so that the procedures developed are consistent in organization, style, and content. The writer's guide provides instructions for procedural content and format, including the specification of acceptable acronym lists and acceptable terms to be used. The content of the procedures incorporates the following elements:

- Title
- Statement of purpose and applicability
- References
- Prerequisites
- Precautions (including warnings, cautions, and notes)
- Limitations and actions
- Required human actions
- Acceptance criteria
- Checkoff lists

The procedure development guidelines include:

- Determination of the parallel information to be monitored by the CPS

- Guidance on actions that may be initiated, but need not be completed prior to leaving the step, or may be completed at a later time.

- Determination of the priority of parallel information (for example, cautions, notes, foldout page items, and critical safety functions).

- Determination of the parameters that need to be continuously monitored.

- Determination of the frequency at which each parallel information item should be checked by the computer.

Laydown areas are available in the control room and outside the control room for paper documents to be used.

The COL applicant is responsible for developing the administrative procedures to ensure that the computer-based procedure database is available only to authorized personnel.

4.0 DEVELOPMENT OF THE EMERGENCY OPERATING PROCEDURES

The emergency operating procedures (EOPs) for the AP600 define the actions to be taken by the plant operating staff for the prevention or mitigation of the consequences of emergency conditions. These procedures include automatic actions that occur in the event of an emergency, operator actions to help prevent or mitigate the consequences of an emergency, and operator actions to stabilize the plant condition. EOPs provide a conservative course of action for the operator and are flexible enough to accommodate variations.

The use of EOPs that encompass both optimal recovery and function restoration guidance enhances human reliability and decreases adverse results for a broad range of initiating events and subsequent multiple failures or operator errors. These EOPs are developed from a set of ERGs. The EOP development process for the AP600 is based on the same accepted and established process used by utilities with Westinghouse pressurized water reactors (PWRs).

For the AP600, the Westinghouse Owners Group generic ERGs are modified and adapted to the specific plant configuration of the AP600 (Ref. 13, AP600 Document No. GW-GJR-100 provides the AP600-specific ERGs). Plant-specific EOPs should be written using the criteria and process described below:

- The AP600 EOPs should meet the guidelines of NUREGs 0899 (Ref. 14), 0737 Supplement 1 (Ref. 15), and 1358 (Ref. 16).

- The AP600 EOPs should be based on two primary elements. The technical content, should be developed from the AP600 ERGs, along with additional sources of information such as design characteristics, transient and accident analysis, engineering judgment, task analysis, and operating experience. The AP600 ERGs should be a translation of engineering data derived from operating experience and transient and accident analysis into information presented in such a way that it can be used to write EOPs.

- The EOPs should follow the principles defined in the AP600 procedure writer's guide. The procedure writer's guide provides confidence in consistent production of high-quality EOPs. The use of a procedure writer's guide provides for the integration of human factors principles when converting technical guidelines into an acceptable EOP format.

  The procedure writer's guide contains the necessary information and guidance for translating the AP600 ERGs into AP600 EOPs. Using a procedure writer's guide

provides confidence that the EOPs are usable, accurate, complete, readable, convenient to use, and acceptable to MCR personnel.

Emergency operating circumstances involve some degree of stress and/or degraded environmental conditions unique to that situation. The AP600 procedure writer's guide addresses the goals, requirements, and recommendations identified in the writer's guide section of NUREG-0899 (Ref. 14).

- The process of translating the AP600 ERGs into action steps that make up the EOPs is the responsibility of the procedure writer. The AP600 ERGs identify the plant objectives to be met, the systems and subsystems required, the situations requiring operator action, and the order in which the actions should be carried out. It is the task of the procedure writer to extract the relevant information, and to carry out any additional function, task, or technical analysis required to provide the EOPs.

- Operating experience and information contained in the procedure writer's guide should be used throughout this process so that the EOPs are written in a form that optimizes operator performance. As the sequence and relationships among action steps are developed, the technical guidelines are followed by the EOP writers. The AP600 EOP development process should be iterative and should usually begin at a system level, and become more specific at the subsystem and the component levels. During this iterative process, the specific operator tasks are identified and written in the form of action steps.

- The orientation of the AP600 EOPs parallels that of the AP600 ERGs and are symptom-based, with provisions for specific event-based actions (optimal recovery procedures such as loss-of-coolant-accident (LOCA), steam generator tube rupture, secondary break). Symptom-based EOPs, encompassing both optimal recovery and function restoration guidance, provide the operator with guidance on how to verify the adequacy of safety functions and how to restore and maintain those functions when they are degraded.

- The analysis of functions and tasks used in the development of AP600 EOPs is provided by the AP600 ERGs. This information provides the initial cut at identifying functions, their associated hardware systems, the actions that are taken (by man and machine), and the circumstances under which they are taken.

The AP600 EOPs are verified and validated on the AP600 simulator as part of the integrated system validation activity of the AP600 HFE verification and validation (Ref. 17,

WCAP-14401, "Programmatic Level Description of the Human Factors Engineering Verification and Validation"). This process addresses the following objectives:

1. The EOPs are written in accordance with the respective AP600 writer's guide.

2. The EOPs are usable. (They can be understood and followed without confusion, delays, errors.)

3. There is a correspondence between the EOPs and the MCR/plant hardware (controls, equipment, indications) that becomes a reference for use both inside and outside of the MCR. EOPs use the same designations, the same units of measurement, and operate consistently with the plant hardware.

4. The language and level of information presented in the EOPs are compatible with the number, qualifications, training, and experience of the operating staff.

5. There is a high level of confidence that the EOPs guide the operator in mitigating transients and accidents.

EOP discrepancies found during the verification/validation process are corrected.

Reference 17, WCAP-14401 provides a programmatic level description of the AP600 HFE verification and validation, which includes EOP verification and validation as part of the integrated system validation activity.

5.0 FUNCTIONAL DESIGN OF THE COMPUTERIZED PLANT PROCEDURES

The functional design of the CPS uses a systems engineering approach wherein high-level requirements for the system are first defined. This is followed by successively more detailed requirements. Engineering expertise in plant procedures and MMI design is employed. The design of the system is enhanced by a Design Review and by discussions with plant operating personnel.

SSAR subsection 18.8 describes the design implementation plan for the AP600 human system interfaces. Man-in-the-Loop concept tests are planned as part of the human system interface design implementation plan. At least two tests are planned for the CPS. Concept tests six and seven of WCAP-14396, "Man-in-the-Loop Test Plan Description" (Ref. 18), test the CPS and the coordination of computerized procedures with workstation displays and soft controls. One of the objectives of these tests is to determine how effectively computerized procedures handle difficult situations and determine whether computer-based procedures adequately support operator performance. Another objective is to determine whether computerized procedures introduce new difficulties not found in current paper-based procedures. Difficulties discovered are evaluated and resolved as part of the iterative design process.

Design options are being explored to determine the operator's course of action in the unlikely event of a loss of the CPS on all workstations. These options include the use of a paper backup system. The maintenance and control of the backup system is developed as part of the human system interface design process. The acceptability of the backup is evaluated through concept testing or by executing a walk-through, using the full-scale mockup of the AP600 MCR. The backup is also evaluated as part of the integrated system validation by including test scenarios that examine the use of the backup following the simulated loss of the CPS (Ref. 17, WCAP-14401, "Programmatic Level Description of the AP600 Human Factors Verification and Validation Plan").

The ERGs and the procedure writer's guide identify the content and format of the EOPs. This content and format is the basis for the type of information presented in the computer-based representation of the EOPs.

5.1 COMPUTERIZED PROCEDURES SYSTEM INTRODUCTION/ BACKGROUND

In most complex situations, active human response is guided by individual experience, training, and procedures. The individual's response is knowledge-based when the response is directed by applying knowledge obtained through formal training and derived from the

individual's own experience. The individual's response is rule-based when the response follows an established set of procedures, and is supported by training in applying and using those procedures.

The relative proportions of knowledge-based responses and rule-based responses varies from one situation to the next, and from individual to individual.

Normal and emergency plant procedures are developed by experienced specialists. The procedures guide the user along a recommended course of action, aid in the detection of anomalous conditions, and recommend changes in the normal course of action in dealing with these anomalies.

The functions involved in generating rule-based responses consist of the following:

- Collecting specified data
- Processing that data through a prespecified train of logic
- Recognizing the action recommended by the course taken
- Executing that action

The functions involved in generating responses are as amenable to computer application as to human application. Rule-based responses (but not necessarily execution of the resultant recommended actions) generated by a programmed computer may actually be preferable to responses generated by a human operator for the following reasons:

First, the likelihood of error in computer-generated responses is significantly smaller than in human-generated responses, provided the basic procedures are well formulated.

Second, the operator confronted with the situation can be freed from the noncognitive component of the response-generating activity. The individual can concentrate on applying his knowledge to comprehending the situation, detecting anomalous conditions, and determining appropriate courses of action.

Lastly, the computer can provide an independent verification of the course of action chosen by the human operator before executing action steps.

The goal of the CPS is to transfer to the computer the rule-based functions at which it excels.

5.2 MISSION OF COMPUTERIZED PROCEDURES

The mission of the CPS is to assist power plant operators in monitoring and controlling the execution of plant procedures.

The CPS is a software system. It runs on the hardware selected for the operations control centers. As long as memory, disk, and processing requirements are satisfactory, the system does not dictate specific hardware requirements.

The CPS includes an off-line tool that is used to modify, update, or edit the procedures. This is accomplished by using a database management system that stores the procedural steps. The off-line tool allows access only to the CPS database. The administrative procedures controlling the security of the off-line tool and the procedural database are the responsibility of the COL applicant.

The physical means by which operators access and use the CPS and its backup is evaluated as part of the human system interface design process. SSAR subsection 18.8 presents a description of the implementation plan for the human system interface design. This plan includes Man-in-the-Loop concept testing (Ref. 18, WCAP-14396), design reviews, and construction of a full-scale mockup. The concept tests for the CPS test the usability of the system and the coordination of computerized procedures with workstation displays and soft controls. The MCR mockup is used to verify physical layout aspects such as availability and adequacy of workspace and laydown areas, physical access, visibility, and related anthropometric and human factors issues. The mockup is also used for walk-through exercises to examine issues such as staffing levels, task allocation, and the use of computerized procedures and their backup.

5.3 COMPUTERIZED PROCEDURES SYSTEM VERIFICATION AND VALIDATION

The verification and validation of the operating procedures on the AP600 simulator as a part of the validation of the integrated human system interface provides confidence that the CPS meets its design goals and that unresolved human engineering issues are addressed. Ref. 17, WCAP-14401, provides a programmatic level description of the AP600 HFE verification and validation which includes computerized plant procedures.

6.0 REFERENCES

1. NUREG-0800, "Standard Review Plan," Rev. 1, 1984

2. NUREG-0899, "Guidelines For The Preparation of Emergency Operating Procedures," 1982

3. NUREG-1358, "Lessons Learned From The Special Inspection Program For Emergency Operating Procedures," 1989

4. NUREG-1358, "Lessons Learned From The Special Inspection Program For Emergency Operating Procedures," Supplement 1, 1989

5. NUREG/CR-5228, "Techniques For Preparing Flowchart Format Emergency Operating Procedures," Volumes 1 and 2, 1989

6. NRC Regulatory Guide 1.33 (Rev. 2), "Quality Assurance Program Requirements," 1978

7. ANS 3.2-1988, "Administrative Controls and QA For The Operational Phase of NPPs," 1988

8. Code of Federal Regulations, Energy, 10 CFR 50.34 (F) (2) (ii), 1993

9. NUREG-0737, "Clarification of TMI Action Plan Requirements," 1980

10. NUREG-0737, Supplement 1, "Requirements For Emergency Response Capability," 1982

11. WCAP-14401, "Programmatic Level Description of the AP600 Human Factors Verification and Validation Plan," April 1996

12. NUREG-0933, "A Prioritization of Generic Safety Issues," 1983

13. AP600 Emergency Response Guidelines, GW-GJR-100, Rev. 0, May 31, 1995

14. U.S. Nuclear Regulatory Commission 1982A, "Guidelines for the Preparation of Emergency Operating Procedures," NUREG-0899 (Washington, DC, United States Nuclear Regulatory Commission)

15. U.S. Nuclear Regulatory Commission 1980, "Clarification of TMI Action Plan Requirements," NUREG-0737 (Washington, DC, United States Nuclear Regulatory Commission)

16. U.S. Nuclear Regulatory Commission 1989B, "Lessons Learned from the Special Inspection Program for Emergency Operating Procedures," NUREG-1358 (Washington, DC, United States Nuclear Regulatory Commission)

17. Programmatic Level Description of the AP600 Human Factors Engineering Verification and Validation Plan, WCAP-14401, April 13, 1995

18. Man-in-the-Loop Test Plan Description, WCAP-14396, April 1996

19. Letter from the NRC to Westinghouse, "AP600 Use of a Computerized Procedure System," June 13, 1997.

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