ENCLOSURE 4

APP-OCS-GEH-322 Revision D,

"Human Factors Engineering Integrated System Validation Plan"

(Non-Proprietary)

Westinghouse

AP1000™

Human Factors Engineering Integrated System Validation Plan (Non-Proprietary)

APP-OCS-GEH-322,
Rev. D

May 2010

APPROVALS

Function	Name and Signature
Author	Julie I. Reed* Fellow Engineer, Human Factors and Operations
Reviewer	Zhonghai Li* Senior Engineer, Human Factors and Operations
	Santiago A. Alvarez* Program Manager, Operation and Control Centers
Approver	Michael C. Shaffer* Manager, Human System Interface Design

*Electronically approved records are authenticated in the electronic document management system.

LIST OF CONTRIBUTORS

Revision	Name and Title
A	Santiago A. Alvarez Project Manager, Human System Interface Design
A	Sarah J. Barczyk Technical Editor, Technical Writing and Editing Group
B	Todd W. Van Meter Senior Engineer, Simulations and Applications Engineering
B	Mark A. Caskey Principal Engineer, Human Factors and Operations
B	Megan L. Holland Editorial Specialist, Technical Communications
B, C, D	Zhonghai Li Senior Engineer, Human Factors and Operations
B, C	Ruiqi Ma Principal Engineer, Human Factors and Operations
B	Julie I. Reed Principal Engineer, Human Factors and Operations
B	Zachary T. Casella Project Engineer, Control Room Design
C, D	Daniel Zinzow Engineer, Human Factors and Operations
C	Robert B. Fuld Principal Engineer, Human Factors and Operations
C	Mark G. Williams Supervisor, AP1000 Operations
C, D	Sarah E. Gasbarrini Technical Editor, Technical Communications
D	Donald W. Briggs Principal Engineer, Human Factors and Operations

Template Version 2.0

REVISION HISTORY

RECORD OF CHANGES

Revision	Author	Description	Completed
A	Robert B. Fuld	Preliminary Issue	06/08
B	Robert B. Fuld Zachary T. Casella	Added scenario specifications and other details across sections. Added proprietary markings.	05/09
C	Julie I. Reed	Tracked changes are not shown in this document due to extensive revision. These are summarized below: Deleted Appendices A, E, and F (which are now part of APP-OCS-GEH-321). Provided cross-references to this document. Deleted Appendices B and D. Replaced with the new Appendices A, B, C, and D. Rev. B of Appendix B is now Appendix E, and Appendix G is now Appendix F. Updated document to provide more detailed information in the following sections: Section 1.2 to include detailed objectives. Section 1.3 to address the Technical Support Center. Section 2.1 to describe the Engineering Development Facility. Combined Section 3.2 into Section 3.1 to include information on trial replications, the requirements to run a fourth trial and the limitations to making changes part way through ISV. Section 4.1 revised to describe the qualifications of the test subjects. Section 4.1.2 to describe the minimum and maximum staffing levels. Section 4.3 to include test staff training information. Section 5.2.1 to delete information on procedures that is now included in APP-OCS-GEH-321. Section 6.2.1 to include a description of the questionnaires and observer guides. Section 6.2.2 to include a description of the situation awareness measurement technique.	02/10

REVISION HISTORY (cont.)

Revision	Author	Description	Completed
C (cont.)	Julie I. Reed	Section 7.3 to provide a detailed description of the re-test criteria and to add Figure 7.3-1.	02/10
D	Julie I. Reed	The first issue of this document (APP-OCS-GEH-322) is non-proprietary and is being issued at revision D to correspond to the revision of the proprietary document (APP-OCS-GEH-320). Added Section 1.5, "List of Exceptions from WCAP-15860." Added a description of the Remote Shutdown Workstation mock-up to Section 2.1. Combined Section 3.3 into Section 3.2, "Trial Assignments and Scheduling." Information added on the assignment of crews to the scenarios. Expanded Section 4.1.1 to include guidance on the selection of the participant personnel. Updated Section 5.2, "ISV Procedures" to include additional information. Completely revised Section 6, "Data." Added information to Section 7.3 to describe the rationale for re-running a trial in the event of a small number of Priority 1 and/or Priority 2 human error discrepancies (HEDs) based on diagnostic criteria. Added proprietary markings.	See EDMS

DOCUMENT TRACEABILITY & COMPLIANCE

Created to Support the Following Document(s)	Document Number	Revision
Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan	WCAP-15860	2

OPEN ITEMS

Item	Description	Status
None.		

TABLE OF CONTENTS

TABLE OF CONTENTS (cont.)

TABLE OF CONTENTS (cont.)

LIST OF TABLES

LIST OF FIGURES

ACRONYMS AND TRADEMARKS

Acronyms used in the document are defined in WNA-PS-00016-GEN, "Standard Acronyms and Definitions" (Reference 1), or included below to ensure unambiguous understanding of their use within this document.

Acronyms	Definition
ADS	Automatic Depressurization System
APS	Alarm Presentation System
CPS	Computerized Procedure System
DAS	Diverse Actuation System
EDS	Engineering Development Simulator
HED	Human Error Discrepancy
HEP	Human Error Probability
ISV	Integrated System Validation
LBLOCA	Large-break Loss of Coolant Accident
MTIS	Maintenance, Test, Inspections and Surveillance
NASA	National Aeronautics and Space Administration
PDSP	Primary Dedicated Safety Panels
PMS	Protection and Safety Monitoring System
Q&A	Question and Answer
SART	Situation Awareness Rating Technique
SBLOCA	Small-break Loss of Coolant Accident
SDSP	Secondary Dedicated Safety Panels
TDS	Training Development Simulator
TLX	Task Load Index

AP1000™ is a trademark of Westinghouse Electric Company LLC.

Morae™ is a trademark of TechSmith Corporation.

All other product and corporate names used in this document may be trademarks or registered trademarks of other companies, and are used only for explanation and to the owners' benefit, without intent to infringe.

GLOSSARY OF TERMS

Standard terms used in the document are defined in WNA-PS-00016-GEN, "Standard Acronyms and Definitions" (Reference 1), or included below to ensure unambiguous understanding of their use within this document.

Term	Definitions
Exception	A justified (i.e., documented and approved) departure from specified guidance or requirements.
Human Engineering Discrepancy	A departure of the AP1000™ Human Factors Engineering (HFE) design from guidance and criteria identified during the execution of HFE verification and validation activities.

REFERENCES

Following is a list of references used throughout this document.

1.　WNA-PS-00016-GEN (Proprietary), Rev. 4, "Standard Acronyms and Definitions," Westinghouse Electric Company LLC.

2.　APP-OCS-GBH-001 (Proprietary), Rev. 1, "AP1000 Human Factors Engineering Program Plan," Westinghouse Electric Company LLC.

3.　WCAP-15860, Rev. 2, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan," Westinghouse Electric Company LLC.

4.　WCAP-14655, Rev. 1, "Designer's Input for the Training of the Human Factors Engineering Verification and Validation Personnel," Westinghouse Electric Corporation.

5.　NUREG-0711, Rev. 2, "Human Factors Engineering Program Review Model," U.S. Nuclear Regulatory Commission, February 2004.

6.　APP-OCS-GEH-321 (Proprietary), Rev. B, "AP1000 Human Factors Engineering Integrated System Validation Scenario Information," Westinghouse Electric Company LLC.

7.　APP-OCS-GEH-120 (Proprietary), Rev. B, "AP1000 Human Factors Engineering Design Verification Plan," Westinghouse Electric Company LLC.

8.　APP-OCS-GGR-110 (Proprietary), Rev. 1, "AP1000 Technical Support Center and Emergency Operations Facility Workshop," Westinghouse Electric Company LLC.

9.　ANSI/ANS-3.5-1998, "Nuclear Power Plant Simulators for Use in Operator Training and Examination," American National Standards Institute/American Nuclear Society.

10.　WCAP-16096-NP-A, Rev. 1, "Software Program Manual for Common Q Systems," Westinghouse Electric Company LLC.

11.　WNA-SQ-00047-GEN (Proprietary), Rev. 0, Standard Integrated I&C Validation Test Strategy," Westinghouse Electric Company LLC.

12.　APP-OCS-GEH-420 (Proprietary), Rev. B, "AP1000 Human Engineering Discrepancy Resolution Process," Westinghouse Electric Company LLC.

13.　APP-OCS-GEH-220 (Proprietary), Rev. B, "AP1000 Human Factors Engineering Task Support Verification Plan," Westinghouse Electric Company LLC.

14.　APP-OCS-GJR-003 (Proprietary), Rev. 1, "AP1000 Main Control Room Staffing Roles and Responsibilities," Westinghouse Electric Company LLC.

REFERENCES (cont.)

15. APP-GW-GL-011 (WCAP-16555), Rev. 0, "AP1000 Identification of Critical Human Actions and Risk Important Tasks Form 36 AP1000 NRC," Westinghouse Electric Company LLC.

16. APP-GW-GLR-040, Rev. 1, "Plant Operations, Surveillance, and Maintenance Procedures," Westinghouse Electric Company LLC.

17. NUREG-1021, Rev. 9, "Operator Licensing Examination Standards For Power Reactors," U.S. Nuclear Regulatory Commission, July 2004.

18. Taylor, R. M., "Situational awareness rating technique (SART): The Development of a Tool for Aircrew Systems Design." In "Situational Awareness in Aerospace Operations (AGARD-CP-478)," Neuilly-sur-Seine, France: NATO-AGARD, 3/1-3/17, 1990.

19. Taylor, R. M., and S. J. Selcon, "Situation in Mind: Theory, Application and Measurement of Situational Awareness." In R. D. Gilson, D. J. Garland, & J. M. Koonce (Eds.), "Situational Awareness in Complex Settings," Daytona Beach, FL: Embry-Riddle Aeronautical University Press, 69-78, 1994.

20. APP-GW-GAP-100 (Proprietary), Rev. 20, "Inter-Business Unit Policies and Procedures Manual," Westinghouse Electric Company LLC.

21. APP-OCS-GEH-520 (Proprietary), Rev. B, "AP1000 Plant Startup Human Factors Engineering Design Verification Plan," Westinghouse Electric Company LLC.

22. APP-OCS-J1R-220 (Proprietary), Rev. B, "Operational Sequence Analysis (OSA-2) Summary Report," Westinghouse Electric Company LLC.

23. APP-OCS-GJR-001 (Proprietary), Rev. 0, "Human Factors Engineering Operating Experience Review Report for the AP1000 Nuclear Power Plant," Westinghouse Electric Company LLC.

BIBLIOGRAPHY

Following is a list of sources that were considered in preparing this document, or that provide additional information.

1.   APP-GW-GL-700 (Proprietary), Rev. 17, "AP1000 Design Control Document," Westinghouse Electric Company LLC.

(Last Page of Front Matter)

SECTION 1
INTRODUCTION

1.1   BACKGROUND

The Integrated System Validation (ISV) provides a comprehensive human performance-based assessment of the final design of the AP1000™ Human-System Interface (HSI) resources, based on their realistic operation within a simulator-driven Main Control Room (MCR). [

]a,c,e

a,c,e

[

]a,c,e

[

]a,c,e

[

]^{a,c,e}

1.2   PURPOSE

This document describes the ISV implementation plan for AP1000 as directed by APP-OCS-GBH-001, "Human Factors Engineering Program Plan" (Reference 2), WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan" (Reference 3), WCAP-14655, "Designer's Input for the Training of the Human Factors Engineering Verification and Validation Personnel" (Reference 4), and NUREG-0711, "Human Factors Engineering Program Review Model" (Reference 5).

[

]^{a,c}

[

]^{a,c}

The main body of this document includes the scope, methodology, description of the ISV facility, test design, participants, scenario selection process, test criteria, and the processing and documentation of the results. The Appendices comprise details on the workload rating forms, post-trial questionnaires, and the debriefing protocol.

A 'sister' document APP-OCS-GEH-321, "AP1000 Human Factors Engineering Integrated System Validation Scenario Information" (Reference 6) provides the detailed information on the scenario descriptions, scenario-specific objectives, scenario observer guides, plus detailed information on the scope of simulation and simulation testing. This information was placed in a separate document for two main reasons. Firstly, this will assist in restricting access to the scenario information from the ISV participants, and secondly, it is envisioned that details of the scenario information are likely to be updated and further developed prior to the implementation of ISV (in comparison, it is anticipated that the information contained in this document will not be subject to change).

1.3   SCOPE

The following are utilized to represent the final MCR and HSI design:

- HSI hardware (consoles, visual display units, workstations, keyboards, mice, trackballs, panels, printers, tables, bookcases, etc.)

- HSI software (non-safety control system, safety control system, alarms, displays, soft controls, computerized procedures, local area network displays, etc.)

- Communications facilities

- Plant emergency, operations, surveillance, and maintenance procedures

- Realistic work environment, including the room dimensions and general arrangement

- Operating crews

[

]^{a,c}

[

$]^{a,c}$

1.4   SCOPE OF ISV ISSUES

WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan," (Reference 3) Section 4.1 lists the issues to be addressed by the ISV implementation plan. These issues are listed below and mapped to the sections of the present document that addresses them:

- Objectives – Section 1.1, "Background"

- Personnel performance issues – Section 4, "Participants"

- Test methodology and procedures – Section 3, "Test Design"

- Test participants – Section 4, "Participants"

- Test conditions (including plant conditions, operating sequences, and accident scenarios) – Section 5, "Scenario Test Set"

- HSI description – Section 2, "ISV Facility"

- Performance measures – Section 6, "Data"

- Data analysis – Section 6, "Data"

- Acceptance criteria – Section 6, "Data"

- Processing of results – Section 7, "Processing of Results"

1.5   LIST OF EXCEPTIONS FROM WCAP-15860

[

$]^{a,c}$

[

]^{a,c}

(Last Page of Section 1)

SECTION 2
THE ISV FACILITY

The ISV will be performed at a dedicated, purpose-built facility. The facility will employ a high fidelity, near full-scope simulator to represent the AP1000 systems and the MCR. This simulator will satisfy the requirements of Sections 3 and 4 of ANSI/ANS-3.5-1998, "Nuclear Power Plant Simulators for Use in Operator Training and Examination" (Reference 9). The ISV facility will be provided at the EDS based at the Westinghouse Headquarters Building in Cranberry, Pennsylvania, USA.

2.1   PHYSICAL SCOPE AND FIDELITY

To the extent practical, the HSI resources provided by the EDS will be identical to those to be delivered for the actual AP1000 MCR. These resources will include full hardware representation for the following:
[

]a,c

[

]^{a,c}

2.2   FUNCTIONAL SCOPE AND FIDELITY

The simulation capability of the EDS will be adequate for the procedures, scenarios, and HSI to be exercised in the ISV. Sufficient simulation scope and systems modeling is determined by the scenarios selected for ISV (see Section 5). Features of the simulation that are not relevant to ISV may be of lesser fidelity or omitted. The development of the required simulator models and software are coordinated with the Simulator Design and Development group. Details of the scope of simulation by individual plant systems can be found in APP-OCS-GEH-321, Appendix D (Reference 6).

2.3   SIMULATOR TESTING

The EDS and simulator readiness is demonstrated by the following test activities (also see Section 3.4 for further information):
[

$]^{a,c}$

(Last Page of Section 2)

SECTION 3
TEST DESIGN

This section addresses the number of individual trials, requirements for trial replications, and their assignment to crews. The minimum number of trials is a function of the number of scenarios and the number of replications of each scenario.

3.1   NUMBER OF TRIAL REPLICATIONS

[

]ᵃ,ᶜ

[

]^{a,c}

3.2   TRIAL ASSIGNMENTS AND SCHEDULING

[

]^{a,c}

[

]^{a,c}

[

]a,c
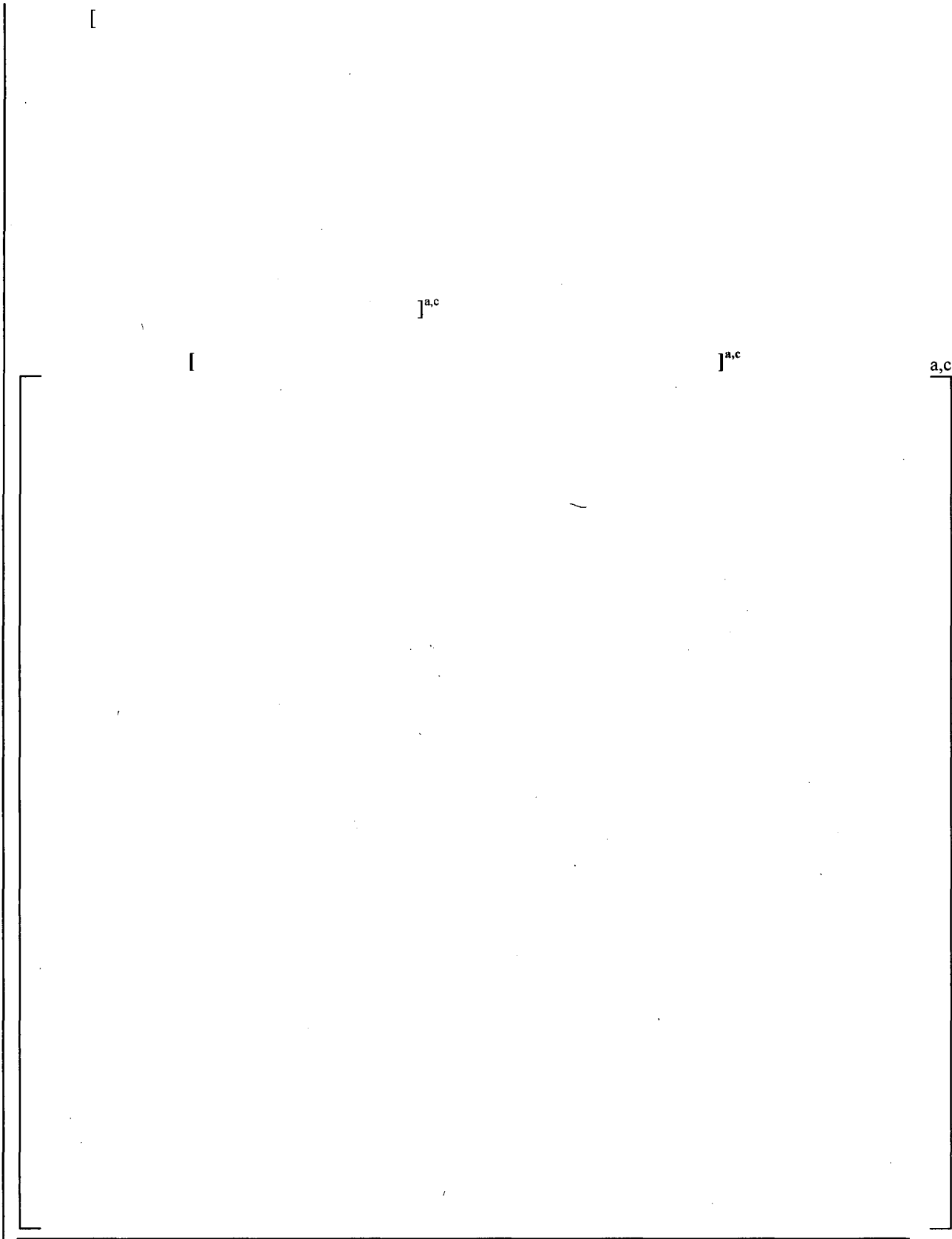
[   ]a,c   a,c

a,c

[

]^{a,c}

3.3　PILOT TESTING

The objective of simulator pilot testing in preparation for ISV is to demonstrate that the simulator responds in a manner similar to the reference unit while utilizing the plant operating procedures. [

]^{a,c}

[

]^{a,c}

(Last Page of Section 3)

SECTION 4
PARTICIPANTS

This section describes the personnel involved in ISV. The ISV participants include the test subjects, observers, and the EDS staff.

4.1   SUBJECTS

[

]^{a,c}

[

      ]^{a,c}

4.1.1   Selection

[

                                                                              ]^{a,c}

[

]^{a,c}

4.1.2   Crew Size and Number

[

]^{a,c}

[

]^{a,c}

4.1.3   Training

[

]^{a,c}

4.2   OBSERVERS

Project-independent ISV observers will be assigned to evaluate performance and generate results data in each trial. These observers will include one of each of the following specialists:
[

]^{a,c}

4.3   ISV STAFF

For each trial, the ISV staff will include at least one of each of the following specialists:
[

|

]^{a,c}

SECTION 5
SCENARIO SET

A scenario comprises the simulated events, anticipated procedure usage, and added complications. A set of scenarios has been developed for ISV. Each scenario will be performed in multiple (i.e., replicate) trials. This section describes the selection and development of the representative set of validation scenarios for ISV. Full details of the scenarios can be found in APP-OCS-GEH-321 (Reference 6), Appendix A.

The ISV scenarios are developed by a multi-disciplinary team. This team includes human factors specialists, procedure writers, operator training developers, and personnel from the simulation group. A number of the team members possess previous operating experience, thereby also contributing to the actual credibility and realism of the ISV scenarios.

5.1   SCENARIO REQUIREMENTS

[

]^{a,c}

5.1.1   Events

Events are identified for ISV in WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan" (Reference 3) Section 4.6 ("Criteria for Selection of Test Scenarios for Dynamic Evaluations"). [

]^{a,c}

[

]a,c

[

]^{a,c}

5.1.2   Procedures

The procedures to be addressed by ISV are outlined in a number of sections in WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan" (Reference 3).

[

]^{a,c}

[

]^{a,c}

5.1.3   Complications

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

5.2   ISV PROCEDURES

5.2.1   General Procedure and Documentation

The ISV procedures for each scenario (i.e., the "scenario package") will be prepared prior to ISV and maintained under the ISV Coordinator's control in order to prevent the ISV participants from obtaining prior knowledge of the scenarios. The scenario-packages include the following:

[

]^{a,c}

[

]^{a,c}

5.2.2   Communications with ISV Personnel

[

]^{a,c}

[

]^{a,c}

5.2.3   Unforeseen Events

[

]^{a,c}

[

          ]^{a,c}

5.2.4   Storage of Data

The ISV Coordinator will be responsible for the ISV documentation and data. In addition to maintaining and controlling the 'scenario packages,' the ISV Coordinator will collect the ISV results data and will be in charge of ensuring that this data is not 'lost.'

[

          ]$^{a.c}$

(Last Page of Section 5)

SECTION 6
DATA

The techniques used to collect the ISV results data are described in this section. This data serves as the basis for determining whether the task goals and performance requirements are achieved, per WCAP-15860, "Programmatic Level Description of the AP1000 Human Factors Verification and Validation Plan" (Reference 3) Section 4.8.

6.1   MEASURES

A set of performance measures are identified and selected to collect data on operator performance, as follows:

[

]^{a,c}

[

]^{a,c}

6.2   METHODS

Data collection will use a variety of paper-and-pencil techniques, structured discussions, and digital recording methods, as follows:

[

]^{a,c,e}

[

]^{a,c,e}

[

]^{a,c,e}

[

]ᵃ,ᶜ,ᵉ

[

]a,c,e

6.3   CRITERIA

This subsection describes how the measurement results are applied to the determination of the success of the ISV trials in respect to the pass/fail criteria and the diagnostic criteria. A set of performance measures, as described in Section 6.1, will be used which includes measures of the performance of the plant and personnel.

6.3.1   Pass/Fail Criteria

[

]^{a,c,e}

[   ]^{a,c,e}

a,c,e

[

]^{a,c,e}

[

]^{a,c,e}

6.3.2   Diagnostic Criteria
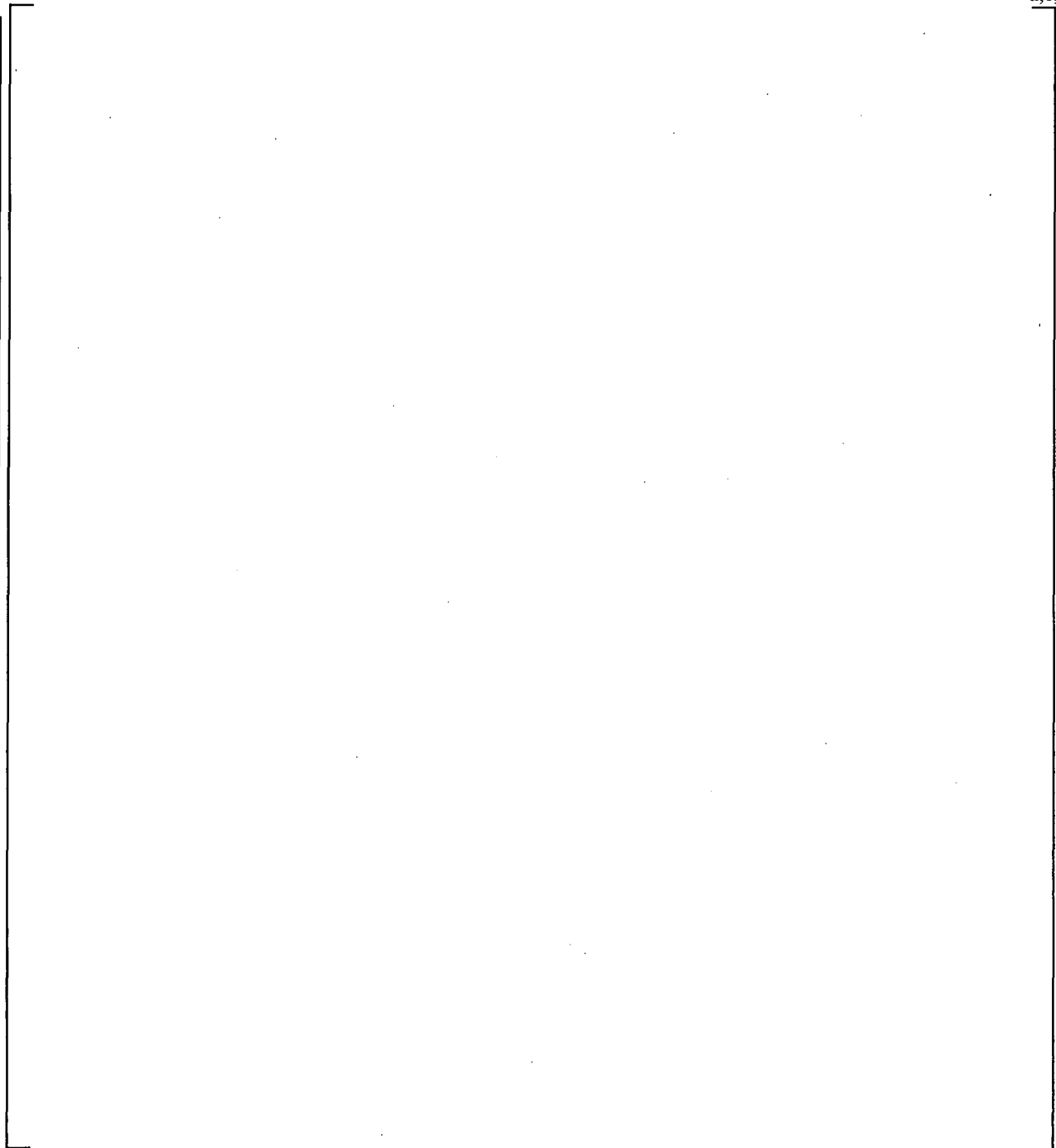
[

]^{a,c,e}

[   ]^{a,c,e} a,c,e

a,c,e

a,c,e

a,c,e

(Last Page of Section 6)

SECTION 7
PROCESSING OF RESULTS

The final results of the ISV trials will be processed to promptly to determine the overall results and conclusions, identify HEDs and to assign HED priorities, and to assess the need for added trial replications.

7.1   RAW DATA PROCESSING

[

$]^{a,c}$

7.2   ANALYSIS AND INTERPRETATION

[

$]^{a,c}$

[

]^{a,c}

7.3   ADDRESSING HEDS AND RE-TEST REQUIREMENTS

[

]^{a,c}

[

]^{a,c}

a,c

[

[   ]^{a,c}

[

]^{a,c}

[

]^{a,c}

7.4   RESULTS REPORT

The final ISV report will document the results and detailed findings from the analysis, including any HEDs. Any limitations of the ISV plan, implementation, and execution will also be addressed. The basis for concluding that the AP1000 MCR, HSI resources, procedures, and operator training are adequate (or not) will be described (i.e., that the integrated system performed acceptably during testing and can be expected to support safe operation in actual use).

The final results report will be communicated to the Training Group, Procedures Group, and the PRA Group. This will enable the results of ISV to be incorporated into the development/updates of the training programs, revisions to procedures, and any updates to the PRA in terms of the assumptions claimed on operator performance.

(Last Page of Section 7)

APPENDIX A
POST-TRIAL QUESTIONNAIRE FOR SUBJECTS

A.1　　PROTOCOL

[

]^{a,c}

[

]a,c

[

]^{a,c}

A.2   POST-TRIAL QUESTIONNAIRE FOR SUBJECTS

[

]^{a,c}

[

]a,c

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

[

]a,c

[

]^{a,c}

[

]a,c

[

]a,c

[

]^{a,c}

[

[

$]^{a,c}$

[

$]^{a,c}$

(Last Page of Appendix A)

APPENDIX B
FINAL QUESTIONNAIRE FOR SUBJECTS

Note, additional line spaces for the participants to provide comments have been removed in this report. However, the printed version used in ISV will contain adequate space for the participants to provide written comments.

Name: _____ Position: _____ Crew: _____ Date: _____

Circle your level of agreement with the statements below based on your experience in all of the preceding trials.

[

]ᵃ,ᶜ

[

]^{a,c}

[

]^{a,c}

[

]a,c

[

]^{a,c}

[

]^{a,c}

[

]a,c

[

]a,c

[

]^{a,c}

[

]^{a,c}

(Last Page of Appendix B)

APPENDIX C
POST-TRIAL QUESTIONNAIRE FOR OBSERVERS

Note, additional line spaces for the participants to provide comments have been removed in this report. However, the printed version used in ISV will contain adequate space for the participants to provide written comments.

Name: _____   Scenario: _____

Trial: _____   Date: _____

[

]ᵃ'ᶜ

[

]a,c

[

]^{a,c}

[

]^{a,c}

[

]a,c

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

[

]^{a,c}

[

]a,c

(Last Page of Appendix C)

APPENDIX D
FINAL QUESTIONNAIRE FOR OBSERVERS

Note, additional line spaces for the participants to provide comments have been removed in this report. However, the printed version used in ISV will contain adequate space for the participants to provide written comments.

Name: _____   Date: _____

Circle your level of agreement with the statements below based on your experience in all of the preceding trials.

[

]^{a,c}

[

]^{a,c}

[

$]^{a,c}$

[

]^{a,c}

[

]a,c

[

]a,c

[

]^{a,c}

[

]a,c

[

]a,c

[

]^{a,c}

[

]^{a,c}

(Last Page of Appendix D)

APPENDIX E
TRIAL PROTOCOL

This Appendix provides the protocol and general sequence of events for running the ISV trials.

PRETRIAL PREPARATIONS

[

]ᵃ,ᶜ

START TRIAL RUN

[

]ᵃ,ᶜ

END TRIAL RUN

[

]^{a,c}

BREAK

(Last Page of Appendix E)

APPENDIX F
DEBRIEFING PROTOCOL

An informal debriefing of the test participants will be performed after each separate trial run. A formal debriefing will be held after each major period (typically one week) of testing. Guidance for the formal debriefing process is provided as follows:

PREPARATION
[

]^{a,c}

START
[

]^{a,c}

DISCUSSION
[

]^{a,c}

[

]^{a,c}

CLOSE

1. Thank participants for their support.