From: Seelman, Robert J. [seelmarj@westinghouse.com]
Sent: Monday, May 10, 2010 1:42 PM
To: Donnelly, Patrick
Subject: Chapter 18 At Risk RAI Responses
Attachments: RAI-SRP18-COLP-34 Rev 1.pdf; RAI-SRP18-COLP-35 Rev 2.pdf; RAI-SRP18-COLP-36 Rev 1.pdf

Importance: High

Patrick,

Per our discussion, here are the three RAI responses at risk (34-35-36) for additional comment from the Staff.

Westinghouse is available to discuss these further as necessary.

Note:

1. I will also submit the supporting (low risk) RAI responses later today. The responses are interrelated. Therefore, in order for the reviewers to have a total understanding of our response, we believe it best to submit all responses.
2. I may be in Rockville all day Thursday (5/13) to meet the Staff on Chapters 6 and 7. If you would like to meet on Chapter 18, please let me know.

Regards.
Bob

From: Donnelly, Patrick [mailto:Patrick.Donnelly@nrc.gov]
Sent: Friday, April 16, 2010 4:16 PM
To: Pieringer, Paul; Higgins, James C; O'Hara, John M; Seelman, Robert J.; Reed, Julie I.
Cc: McKenna, Eileen; Junge, Michael
Subject:

The following is a summary of the phone call on the closure plan for Chapter 18. Action items are in red.

RAI-SRP18-COLP-22

WEC response states the following: "WEC agrees that any discrepancies between the commitments stated in WCAP-15860 (Reference 1) and the ISV Plan need to be addressed. It should be noted that WCAP 15860 was issued in 2003, and since that time the OCS and HFE design has progressed. Therefore, some minor adjustments may be justifiable or inevitable, although it is confirmed that the AP1000 HFE V&V will conform to the intent of WCAP 15860, and any discrepancies will be resolved." This is an acceptable approach. The deviations will need to be documented by WEC and evaluated by NRC.

BNL has reviewed exceptions that were specifically noted in the ISV Plan (320) and found them acceptable. There still is not a general statement of compliance with the programmatic ISV Plan (WCAP-15860) and a listing of exceptions. We understand that WEC is considering putting that in DCD Chapter 18. That would be acceptable. It could also be in the ISV Plan itself. RAI-22 is Open pending documentation of conformance and a listing of the exceptions.

Westinghouse to include a subsection to the -320 document that specifies the exceptions taken to WCAP-15860.

RAI-SRP18-COLP-23

Evaluation based on W response letter dated 2/2/10 – WEC states that closure of ITAAC #4 will be justified in DCD Rev. 17/18. This is an acceptable approach but the draft DCD markup did not fully address the wording of ITAAC #4. This should be done and further since exceptions are being taken, the DCD should reference where the exceptions are justified.

Westinghouse to revise the DCD to specify the Implementation Plans were developed IAW the Programmatic Plans as required by ITAAC#4.

RAI-SRP18-COLP-26

Evaluation based on W response letter dated 2/2/10: The response to the RAI and 320, Rev. C, Section 4.1.2, both define the min and max crew size. Validation scenarios will be run for both of these cases as specified in ISV documents 320 and 321. This is acceptable and this portion of the RAI is closed. The response also commits to updating TR-52 (and a related document) to make them consistent with these new values. This is acceptable and confirmatory.

Westinghouse to revise the reference in the DCD from TR-52 to APP-OCS-GJR-003. The documents contain nearly identical information, however TR-52 contains DCD changes from Rev 16 that are no longer applicable. It is cumbersome to update both reports with the min and max crew sizes, therefore APP-OCS-GJR-003 will replace TR-52 indefinitely.

RAI-SRP18-COLP-28

Evaluation Based on W response in letter dated 1/2/2010 and APP-OCS-GEH-320, Rev. C (Feb 2010)
W's response in the letter indicates that if a scenario fails a P/F criterion, it will be rerun a minimum of three times with new crews. So will some of the failures on diagnostic measures based on the results of their HED analysis. Overall the approach looks pretty good.

Remaining follow-up questions:

1. For diagnostic measures, why is it necessary to see the same issue on multiple measures and multiple trails, especially if they are Priority 1 HEDs?

Westinghouse to update diagnostic measures in the -320 document.

2. Treatment of HEDs is based on APP-OCS-GEH-420, "AP1000 Human Factors Engineering Discrepancy Resolution Process." Rev. B seems limited to Priority 1 and Priority 2 HEDs identified during V&V. Where are the HEDs being tracked that are identified:

- prior to V&V from other aspects of the HFE program - **Westinghouse to address in the RAI response**
- from the final Verification at Plant Startup (document 520) – **Westinghouse to address in the -520 document (roll over to the COL?)**
- as Priority 3 HEDs – **Westinghouse to address in the -420 document. Need to clarify process, to specify that the P3 HED's will all be addressed in the Results Report. Needs to be clear that these are improvements and not corrective actions.**

RAI-SRP18-COLP-34

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010)
Follow up questions:

1. In general, we found it difficult to see a clear relationship between objectives, performance measures, and performance criteria. We think it is important to easily see what performance measures are used to address specific objectives, what criteria are used to determine acceptable performance on each measure, and how

overall scenario acceptability is determined. Some of this information is presented, but a crystal clear picture does not emerge as the following RAIs indicate.

2. Diagnostic criteria are not consistently mentioned in the scenario measures. Diagnostic criteria are not actually presented, only high-level goals generally for task support, situation awareness (SA), and training. For example, in one scenario the task support bullet says “Indications, alarms and other monitoring aids are sufficient to support timely recognition of IRWST leak, feedwater heater dump valve malfunction, and failure of source range instrument.” What specific measures will address this goal and what are their criteria? Workload (NASA TLX) is not mentioned as a diagnostic measure. The SA item that follows task support states “Crew recognizes IRWST leak and need for makeup to the tank.” Again, what specific measures will address this goal and what are their criteria? How is the task support item different from the SA item? Are they both assessed using the single Observer Guide item 2a Malfunction – When detected <IRWST leak>, crew takes steps to locate the leak and make-up to the tank as needed. Observer guides are not referenced in the scenario descriptions.

3. Another diagnostic measure is “perceived time. What does this mean, how is it determined, and what criteria are used to judge its acceptability?

Westinghouse to update the -320 document to clarify the objectives of each scenario, the performance measures for each objective, and the performance criteria for each measurement. Scenarios 1, 2 & 12 are to be updated to the level of detail required to demonstrate the process. These scenarios will be presented at the next phone call/net meeting.

RAI-SRP18-COLP-35

Evaluation Based on W response in letter dated 1/2/2010 and APP-OCS-GEH-320, Rev. C (Feb 2010)
W’s response does not address all the measures. It provides measurement information for workload, SA, teamwork, goal achievement, and usability (**not** plant level measures, task performance measures).

The actual measurement characteristics are really not addressed. For example, after discussing that the SART measure will be used for workload, they simply state that: “SART is a good approach to measure SA in terms of construct validity, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity.” No explanation as to why it’s good is identified. We are not sure the SART is a good measure of situation awareness. The SART questions do not pertain to any specific scenario details. Further, the measure is collected at the end of scenarios that, in many cases, are several hours long. Thus its sensitivity to changing SA across a scenario may not be too good. Please explain the use of the SART measure of SA.

The ISV plan does not include all the info in the RAI response. The logical organization of the ISV plan data section is unclear. The first measure discussed is workload (NASA TLX rating scales). This is followed by a discussion of questionnaires. That discussion includes situation awareness which is a rating scale like the TLX. This questionnaire discussion addresses many individual performance measures that are not individually discussed – a least not to the degree the TLX is discussed. The measurement characteristics of individual performance measures are really are not mentioned, except for workload and SA. A more detailed discussion of the SART measure that addresses construct validity appears later in the document with respect to diagnostic criteria.

Westinghouse to revise Section 6 of the -320 document accordingly:
6.1 – Describe Measures
6.2 – Describe Methods
6.3 – Describe Criteria
    1. Pass/Fail
    2. Diagnostic

Westinghouse will also include a more detailed discussion of the SART method. May include in the -320 document or just in the RAI response.

RAI-SRP18-COLP-36

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010) and 321
Follow-up questions:

1. With respect to P/F measures, how is failure to performance a RIHA on time per PRA assessed?

2. With respect to criteria for diagnostic measures, some are precisely defined while other are not. For example, a criterion stating "less that 75% expected operator responses per the observer guide" is a clearly stated criterion that identified how it's measured and precisely what is acceptable. This is not typically the case. In some cases the diagnostic measures are identified with reference to a criterion (e.g., extreme workload), while other diagnostic measures are not (e.g., SA). Please identify the criteria for each measure, the basis for the criterion (e.g., engineering analysis, expert judgment, etc.), and how will these measures will be used to trigger an HED?

3. Why are some diagnostic measure mentioned for specific scenarios while others are not, e.g., workload is not mentioned for any scenarios.

4. Additional specific questions:

- Error of Omission – how measured?
- Error of Commission – how measured?
- Extreme workload... leading to an operator error. Why does workload have to lead to an error to be a diagnostic criterion? The RAI response acknowledged error was not necessary – see RAI response to this RAI in the 11/02/09 letter - "In addition, Westinghouse acknowledges that if workload is considered to be extreme relative to the situation, then a HED will be generated.") How is extreme workload defined?
- Implementation error or substantial deficiency of the design of HSI, procedures and training - how assessed?
- any other specific concern with a plausible negative impact on acceptable ops (how measured?)
- SA – a lot of detail is provided that would seem more appropriate for Section 6.1. But no criterion is provided.

Westinghouse to revise the -320 document to better describe Pass/Fail measures, Diagnostic Measures and to explain how to develop acceptance criteria for more subjective performance measures like "workload".

RAI-SRP18-COLP-39

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010)
A minimum of three crews will be user per scenario (see RAI 27). Section 3.1, Number of Trial Replications, states that Each scenario will be run a minimum of three times. This is good.

Two follow-up questions remain:

1. W's response above stated that guidance for the utilities will be presented in ISV Plan C, but we cannot find it. Section 4.1.1 still states that "Guidance will be provided ...."

2. Counter balancing – Rev C provides little additional information than was available in the prior version of the plan. It states that the "trial assignment will provide a balance order, so as to prevent result bias due to the effects of trial order." But no actual order or sample of what this precisely means is presented.

Westinghouse to address the two issues above in the -320 document.

RAI-SRP18-COLP-42

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010)

This RAI asked for the information needed to evaluate the ISV plan with respect to NUREG-0711 11.4.3.2.6.2, Test Procedures. To be more specific, the aspects of these criteria that do not seem to be fully addressed are listed below.

Detailed, clear, and objective procedures should be available to govern the conduct of the tests. These procedures should include:

· The identification of which crews receive which scenarios and the order that the scenarios should be presented. **<This information is not currently presented, except via high-level description.>**

· Detailed and standardized instructions for briefing the participants. The type of instructions given to participants can affect their performance on a task. This source of bias can be minimized by developing standard instructions. **<The detailed instruction for briefing operators is not presented in the scenario descriptions>**

· Specific criteria for the conduct of specific scenarios, such as when to start and stop scenarios, when events such as faults are introduced, and other information discussed in Section 11.4.3.2.4, Scenario Definition. **<Most of this information is included – see subbullets from 11.4.3.2.4 below>.**

- description of the scenario and any pertinent "prior history" necessary for personnel to understand the state of the plant upon scenario start-up **<This info is included>**
- specific initial conditions (precise definition provided for plant functions, processes, systems, component conditions and performance parameters, e.g., similar to plant shift turnover) **<This info is included>**
- events (e.g., failures) to occur and their initiating conditions, e.g., time, parameter values, or events This info is included
- precise definition of workplace factors, such as environmental conditions <see RAI 49 – now closed>
- task support needs (e.g., procedures and technical specifications) **<This info is included>**
- staffing objectives **<This info is included>**
- communication requirements with remote personnel (e.g., load dispatcher via telephone) **<This info is included>**
- the precise specification of what, when and how data are to be collected and stored (including videotaping requirements, questionnaire and rating scale administrations) **<This info is included>**
- specific criteria for terminating the scenario.> **<This info is included>**
- Scenarios should have appropriate task fidelity so that realistic task performance will be observed in the tests and so that test results can be generalized to actual operation of the real plant. **<The scenarios as describes should provide appropriate task fidelity>**
- When evaluating performance associated with operations remote from the main control room, the effects on crew performance due to potentially harsh environments (i.e., high radiation) should be realistically simulated (i.e., additional time to don protective clothing and access radiologically controlled areas). **<This info is included>**

· Scripted responses for test personnel who will be acting as plant personnel during test scenarios. To the greatest extent possible, responses to communications from operator participants to test personnel (serving as surrogate for personnel outside the control room personnel) should be prepared. There are limits to the ability to preplan communications since personnel may ask questions or make requests that were not anticipated. However, efforts should be made to detail what information personnel outside the control room can provide, and script the responses to likely questions. **<This info is not presented, although 320 does commit to providing that info "ISV staff will fulfill the AO's responsibilities by scripted role play">**

· Guidance on when and how to interact with participants when simulator or testing difficulties occur. Even when a high-fidelity simulator is used, the participants may encounter artifacts of the test environment that detract from the performance for tasks that are the focus of the evaluation. Guidance should be available to the test conductors to help resolve such conditions. **<This info is not addressed>**

· Instructions regarding when and how to collect and store data. These instructions should identify which data are to be recorded by:

- simulation computers
- special purpose data collection devices (such as situation awareness data collection, workload measurement, or physiological measures)
- video recorders (locations and views)
- test personnel (such as observation checklists)

- subjective rating scales and questionnaires.

<This info is presented in that the same info is used for all scenarios and instructions for collecting the data are provided>

· Procedures for documentation, i.e., identifying and maintaining test record files including crew and scenario details, data collected, and test conductor logs. These instructions should detail the types of information that should be logged (e.g., when tests were performed, deviations from test procedures, and any unusual events that may be of importance to understanding how a test was run or interpreting test results) and when it should be recorded. **<This info is not addressed>**

In summary, many of the individual items in the review criterion are not addressed. Therefore this is open and a follow up is needed.

Where information has been flagged as missing above, Westinghouse has committed to providing more information where appropriate in the -320 & -321 documents.

RAI-SRP18-COLP-46

Evaluation based on review of 320 Rev. C, and 321: The wording of the response was acceptably added to 320 Rev. C, Section 6.2.1. Review of 321, including the observer guide for Scenario 12, noted that for RIHAs, the document is not completely clear on how the actual times to complete a RIHA would be measured/determined. Also there didn't seem to be a specified place for recording this information. The observer guide only has a SAT/UNSAT column. WEC needs to clearly specify the events that start and stop the time clock. This didn't seem consistent between the scenario description (Table A12-1) and the observer guide. The Scenario 12 guide seems to start on red path announcement rather than a physical parameter such as CET ≥ 1200 °F. Please clarify and update documents as necessary. Open

Westinghouse to revise the scenario descriptions and the observer guides to clearly identify when timing begins and ends with respect to P/F criteria. Where appropriate, the timing of these actions will be recorded automatically by the simulator.

RAI-SRP18-COLP-52

Evaluation based on W response letter dated 2/2/10 and review of 320, Rev. C: The response acceptably explained the reason for this approach. However, it is still not fully clear in the documents, what will be done to reconfigure the MCR to represent the RSW. This could be described in either 320 or 321. Open

Westinghouse will include a description in the -320 document of the as-yet built room near the simulator that will replicate the remote shutdown station. Will also include a transfer of control switch in the MCR simulator room.

RAI-SRP18-COLP-53

Evaluation based on review of 320 Rev. C and 321: The RIHA to close the hatches is addressed in Scenario 19 of 321. The actual verification of acceptability of planned local actions associated with the hatches will need to be deferred until the plant is built. Therefore the RAI response proposes adding this to the HFE Design Verification at Plant Startup, APP-OCS-GEH-520. This is acceptable and this RAI is confirmatory until that change is made.

Westinghouse will revise the -520 document accordingly.

Westinghouse will alert the NRC when they would like to hold a net meeting to update the staff on their latest revisions. The meeting is tentatively scheduled for early May, with an anticipated submittal date of late May. This will push the Chapter 18 review schedule out several weeks.

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Hearing Identifier: AP1000_DCD_Review
Email Number: 359

Mail Envelope Properties (A782B66116EBEA469D1D4B69402CBE592A92A880)

Subject: Chapter 18 At Risk RAI Responses
Sent Date: 5/10/2010 1:41:37 PM
Received Date: 5/10/2010 1:41:45 PM
From: Seelman, Robert J.

Created By: seelmarj@westinghouse.com

Recipients:
"Donnelly, Patrick" <Patrick.Donnelly@nrc.gov>
Tracking Status: None

Post Office: SWEC9980.w-intra.net

Files	**Size**	**Date & Time**
MESSAGE	21156	5/10/2010 1:41:45 PM
RAI-SRP18-COLP-34 Rev 1.pdf	312628	
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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP18-COLP-34
Revision: 1

Question:

The plan generally indicates that plant measures will be obtained, but the specific measures for each scenario are not identified. For example, the plant measures section in the scenarios is generic and repeated for all 29 scenarios. This should be made scenario specific and identify parameters of particular interest. Since the ISV Plan is using the tech specs (TS) as key criteria, the scenario description should identify which TS are expected to automatically be violated as a result of the scenario imposed failures. Then all the remaining TS should be required to be met; otherwise the scenario should fail to meet the acceptance criteria. The scenario should identify those TS particularly important and at risk during the scenario. Please provide this added information.

Westinghouse Response:

A standard wide range of events and plant measures will be collected for all the scenarios using the recording features of the simulator. Specific plant measures of particular interest, which will be a subset of the previously mentioned range of events and plant measures, will be specified for each scenario.

Each scenario description will reference the Technical Specifications of particular interest and importance. This will include the identification of any Technical Specifications that are expected to be violated as a result of any complications or failures that are an integral part of the scenario. The Technical Specifications are a highly interrelated, and include the measured variables, applicable limits (i.e., criteria) and the required responses when the limits are exceeded. Therefore, they provide a very useful means to assist in measuring performance.

In the detailed scenario descriptions, Westinghouse will identify the scenario-specific Technical Specifications which are required in order for the individual scenarios to meet the associated acceptance criteria. This will be provided in the ISV Plan, Rev C, to be issued by 31st January 2010.

Question Rev 1:

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010)

Follow up questions:

1. In general, we found it difficult to see a clear relationship between objectives, performance measures, and performance criteria. We think it is important to easily see what performance

measures are used to address specific objectives, what criteria are used to determine acceptable performance on each measure, and how overall scenario acceptability is determined. Some of this information is presented, but a crystal clear picture does not emerge as the following RAIs indicate.

2. Diagnostic criteria are not consistently mentioned in the scenario measures. Diagnostic criteria are not actually presented, only high-level goals generally for task support, situation awareness (SA), and training. For example, in one scenario the task support bullet says "Indications, alarms and other monitoring aids are sufficient to support timely recognition of IRWST leak, feedwater heater dump valve malfunction, and failure of source range instrument." What specific measures will address this goal and what are their criteria? Workload (NASA TLX) is not mentioned as a diagnostic measure. The SA item that follows task support states "Crew recognizes IRWST leak and need for makeup to the tank." Again, what specific measures will address this goal and what are their criteria? How is the task support item different from the SA item? Are they both assessed using the single Observer Guide item 2a Malfunction – When detected <IRWST leak>, crew takes steps to locate the leak and make-up to the tank as needed. Observer guides are not referenced in the scenario descriptions.

3. Another diagnostic measure is "perceived time. What does this mean, how is it determined, and what criteria are used to judge its acceptability?

Westinghouse Response Rev 1:

The response to each of the three questions is provided below. In addition, to facilitate the review of this RAI Response, the revised Scenario Descriptions and Observer Guides for Scenarios 1, 2 and 12 are inserted.

1. The sections on 'Pass/Fail Criteria' and 'Diagnostic Criteria' for Scenarios 1, 2 and 12 in APP-OCS-GEH-321 have been rewritten in to clearly illustrate what criteria are used to determine acceptable performance on each measure. This will be included in APP-OCS-GEH-321, Rev B. The remaining scenarios will be updated accordingly in a later revision of the document.

The overall scenario acceptability and the resolution of HEDs generated by the pass/fail criteria and diagnostic criteria will follow the process described in Section 7.3, Addressing HEDs and Re-Test Requirements, ISV Plan (APP-OCS-GEH-320).

2. As described above, the revised scenario descriptions will include the diagnostic criteria for each performance measure.

3. The term "perceived time" was used in the Scenario Description for Scenario 12 in the ISV Scenario Description document (APP-OCS-GEH-320). The purpose was to represent the time between when red path condition occurs and when the crew recognizes red path condition exists. Westinghouse acknowledges that the term 'perceived time' causes confusion, and

therefore it will no longer be used in the scenario descriptions. Instead, the time when red path condition occurs and the time when the crew recognizes that the red path condition exists will be clearly specified in the observer guides. If the difference between the two recorded times exceeds two minutes, a corresponding HED will be generated for further resolution as one of the diagnostic criteria for situation awareness.

The example Scenario Descriptions and associated Observer Guides for Scenarios 1, 2, and 12 are inserted below. The Scenario Descriptions demonstrate the modified "Detailed Scenario Description" sections and "Diagnostic Criteria" sections. The corresponding modified Observer Guides have also been inserted for comparison and reference for the associated Scenario Descriptions.

A.1 SCENARIO 1 – PLANT SHUTDOWN FROM MODE 1 TO MODE 3

A.1.1 Scenario Description

The plant is initially in Mode 1 at 100 percent power. A normal plant shutdown to Mode 3 will be performed as part of a continuous shutdown and cooldown evolution from Mode 1 through Mode 5 over two operating shifts (i.e., Scenario 1 followed by Scenario 2). At the end of the first shift, a complete shift turnover between operating crews will occur.

A small IRWST leak will be initiated after shutdown commences. When the leak is recognized, the crew is expected to align Chemical and Volume Control System (CVS) makeup water to the tank, and to communicate with plant management to set a strategy for repairing the leak.

The following scenario complications are included to represent real-world and/or beyond-design basis conditions, to increase cognitive demands on the operators:

1. At approximately 45 percent power, Feedwater Heater 6A level decreases below the low level alarm setpoint, due to the onset of a leaking dump valve, which excessively lowers heater level.

2. At approximately 8 percent power, one of the source range instruments fails.

3. Lower mode conditions provide a less familiar and more challenging situation in which to cope with plant casualties. Responses are more situation-specific and reliant on knowledge-based reasoning, and are thus more prone to error.

A.1.2 Scenario Objectives

The objectives include the validation of plant procedures as follows:

- GOP-102 as directions for normal plant shutdown to Mode 3.
- CDS-101 for stopping condensate pump(s).
- CVS-101 for borating as required by reactivity plan for plant shutdown.
- ECS-101 for transferring station loads to Offsite Power.
- FWS-101 for stopping main feedwater (MFW) pump(s).
- HDS-101 for shutting down the Heater Drain System to coincide with plant power reduction.
- ASS-101 for placing the auxiliary boiler in service and aligning steam loads to the Auxiliary Steam Supply System.
- LOS-101 for monitoring automatic operation of the Turbine Lube Oil System.
- AOP-328 to address lowering level in Feedwater Heater 6A.

A.1.3 Scenario Participants

- Operating Crew: 4 members (1 Senior Reactor Operator {SRO}, 2 Reactor Operators {ROs}, 1 Shift Technical Advisor {STA}
- Scenario Coordinator
- Simulator Work Instruction Station Operator
- Simulated Local Operator
- Observers (Utility, Designers, Procedure Writers, Human Factors Specialists, Quality Assurance {QA} Personnel)

A.1.4 Risk-Important Human Actions and MTIS Activities

There are no RIHAs evaluated in this scenario.

Table A.1-1. Risk-Important Human Actions

Basic Event ID	Event Description	Time Window Trigger	Procedures	Time Window
None	N/A	N/A	N/A	N/A

Table A.1-2. Representative Maintenance, Test, Inspection, and Surveillance Activities

Activity	Event Description	Time Window Trigger	Procedures	Time Window
Source Range Reactor Trip Channel Operability Test (RTCOT)	Surveillance performance	N/A	[LATER]	N/A
Power Range RTCOT	Surveillance performance	Within 4 hours after reducing power below 10%	[LATER]	N/A
Intermediate Range RTCOT	Surveillance performance	Within 4 hours after reducing power below 10%	[LATER]	N/A

A.1.5 Initial Conditions

The Initial Condition (IC) sets available on the Instructor Station will be used to establish the initial operating conditions. At the start of the scenario, the ICs presented to the crew in shift turnover will be:

1. The plant is at 100 percent power
2. IRWST level is 100 percent
3. The Passive Containment Cooling Water Storage Tank (PCCWST) level is 101 percent.

A.1.6 Sequence of Events

Table A.1-3. Sequence of Events

Events	Malfunctions/Local Actions	Estimated Timing Sequence
Small IRWST Leak (e.g., between the root isolation valves for PXS-LT045 and 046)	Component malfunction. When detected and reported, plant management will direct for containment entry to occur as soon as possible on the next shift.	Pre-existing fault

Feedwater Heater 6A level low due to dump valve leaking	Component malfunction	When power reaches 45%
Source Range Instrument Failure (RXS-NE-001B)	Component malfunction	When power reaches 8%

A.1.7 Detailed Scenario Description

Simulator is setup with scenario (computer) program established in cue with plant conditions stable and with the simulator in "freeze" mode.

Operating crew will be given a turnover briefing sheet which outlines the current plant status and goal for the shift. Staff verbally briefs the operating crew with initial conditions as follows:

> *The plant is operating at 100 percent power near the end of core life. It is a weekday, dayshift and the weather is partly cloudy with temperature near 71 degrees Fahrenheit. Wind is relatively calm at 3.0 miles per hour from the southwest (at compass point: 234 degrees). All plant equipment is operational with no major maintenance activities in progress. Goal for the shift is to shutdown the plant to Mode 3, in accordance with GOP-102. Power reduction rate should proceed at ½ % per minute. Initial conditions of GOP-102 are complete.*

After the briefing, the operating crew is allowed time to familiarize themselves with the plant conditions. This should be limited to ten minutes at which time the crew should assume their respective stations and the simulator scenario is set in operation (running mode).

The SRO briefs the operating crew concerning the plan for power reduction including concerns related to projected reactivity changes, precautions, and contingencies related to the down-power maneuver. A crew member notifies the System Operator of the expected power change and ultimate separation from the grid. Staff should respond as the System Operator to acknowledge the communication, "I understand that your plant is reducing power to 0% and will be separating from the grid."

Crew obtains reactivity plan for the expected power change and profile from BEACON™.

Crew begins the power reduction while monitoring power, borating per the reactivity plan in accordance with CVS-101. Operator energizes all Pressurizer Backup Heaters.

Simulator operator inserts a malfunction which initiates a small IRWST leak. When detected, crew takes steps to locate the leak and establish makeup to the tank as needed. SRO reviews technical specifications (T.S. 3.5.6.B).

After a power change of 15% thermal power or more within a 1-hour period, crew notifies Chemistry to perform an isotopic analysis of reactor coolant for dose equivalent I-131 in order to comply with

Technical Specification Surveillance 3.4.10.2. Staff will respond as the Chemist, "I understand that power has changed more than 15% within one hour and I need to perform an isotopic analysis of the RCS for dose equivalent I-131."

When plant power is between 63% and 65%, the crew takes steps to stop one of the three running feedwater pumps per FWS-101.

When plant power is between 60% and 65%, crew takes steps to transfer station loads to Offsite Auxiliary Transformers per ECS-101.

When plant power is between 48% and 50%, the crew takes steps to stop one of two running condensate pumps per CDS-101.

Simulator operator inserts a malfunction which initiates a leaking feedwater heater dump valve. The crew acknowledges the low level alarm on Feedwater Heater 6A, and responds per AOP-328. Performance of this AOP is not expected to solve the level alarm on the Feedwater Heater. The item should be placed on the list of items to be repaired at the soonest opportunity. Crew should proceed with the plant shutdown.

When plant power is between 33% and 35%, the crew takes steps to a) stop one of the remaining two running feedwater pumps per FWS-101, b) shut down the heater drain system per HDS-101.

When plant power is approximately 30%, the crew takes steps to starts auxiliary boiler and aligns it to supply steam loads per ASS-101. If requested, staff may respond as a local operator, "I understand that you want me to start the auxiliary boiler to supply steam loads." Staff will report back 30 minutes later that the auxiliary boiler is operating.

When plant power is less than 20%, the crew places rod control in MANUAL.

When plant power is between 12% and 15%, the crew takes steps to a) place steam dumps in Steam Pressure Mode, b) remove Main Generator from service, and c) trip turbine.

Simulator operator inserts a malfunction which initiates a source range power channel failure (RXS-NE-001B). The crew identifies the affected instrument and its relationship with Technical Specifications 3.3.1 Condition I, that will apply once the plant is below P-6.

When plant power is less than 2%, crew shuts down the reactor and announces plant in Mode 3. The SRO denotes entry into Technical Specification 3.3.1 Condition I.

The crew confirms plant is stable in Mode 3 and concludes GOP-102.

Simulator staff terminates the scenario.

A.1.8 Key Variables

The values of the following key variables and their changes over time will be collected to represent key aspects of scenario performance. A record of the alarm list for the scenario will also be retained.

1. Containment Sump Level
2. Departure from Nuclear Boiling Ratio
3. Feedwater Heater 6A Level
4. IRWST Injection Isolation and Squib Valve Positions
5. IRWST Level
6. Reactor Coolant System (RCS) Leak Rate
7. RCS Hot Leg Levels
8. Peak Centerline Fuel Temperature
9. Pressurizer (PZR) Level
10. RCS Pressure
11. RCS Subcooling
12. RCS Temperature
13. Reactor Power
14. Source Range Power
15. Main Turbine Power
16. Main Generator Output

A.1.9 Termination Criteria

The scenario is terminated when the plant is stable in Mode 3, with GOP-102 completed and prerequisites for GOP-103 met.

A.1.10 Pass/Fail Criteria

Successful performance of this scenario requires the following Pass/Fail Criteria to be met per the AP1000 design basis. Pass/fail criteria will be evaluated using the Observer Guide and results will be verified by Plant Performance Recording and/or video and audio recordings.

A.1.10.1 General Safety Limits

No violation of the following safety limits of Technical Specifications due to operator error shall occur:

1. The combination of reactor thermal power, highest RCS loop cold leg temperature, and PZR pressure shall not exceed the limits specified in the Core Operating Limits Report (COLR).

2. The departure from nucleate boiling (DNB) ratio shall be maintained ≥1.14 for the WRB-2M DNB correlation.

3. The peak fuel centerline temperature shall be maintained <5080°F, decreasing by 58°F per 10,000 units of burnup.

4. RCS pressure shall be maintained ≤2733.5 psig.

A.1.10.2 Risk-Important Human Actions

None.

A.1.10.3 Technical Specifications

Applicable Limiting Condition(s) for Operation (LCOs) and surveillance requirements of the technical specifications shall be met, and required actions for the associated conditions shall be performed within the specified limits and time criteria.

Table A.1-4. Key Technical Specifications (Design Criteria Document {DCD}, Chapter 16)

Items	Ref	Notes
3.0 LCO Applicability		
3.1 Reactivity Control Systems		
3.2 Power Distribution Limits		
On-Line Power Distribution Monitoring System (OPDMS) Monitored Parameters	LCO 3.2.5	Verify Parameters within limits.
3.3 Instrumentation		
Reactor Trip System Instrumentation	LCO 3.3.1	One or two Source Range Neutron Flux channels inoperable.
3.4 Reactor Coolant System		
RCS Pressure/Temperature Limits	LCO 3.4.3	Verify Parameters and Rate-of-Change within limits.

Table A.1-4. Key Technical Specifications (Design Criteria Document {DCD}, Chapter 16)

Items	Ref	Notes
3.5 Passive Core Cooling System		
IRWST – operating	LCO 3.5.6	The IRWST, with two injection flow paths and two containment flow paths, shall be operable.
3.6 Containment Systems		
3.7 Plant Systems		
Main Feedwater Isolation Valves (MFIVs) and Main Feedwater Control Valves (MFCVs)	LCO 3.7.3	The MFIV and MFCV for each Steam Generator shall be operable.
3.8 Electrical Power Systems		
3.9 Refueling Operations		
INVESTMENT PROTECTION/SHORT-TERM AVAILABILITY		
1.0 Instrumentation Systems		
2.0 Plant Systems		
3.0 Electrical Power Systems		

A.1.11 Diagnostic Criteria

The following scenario-specific criteria should be considered by observers and discussed during the trial debriefings. Results will be addressed in the Human Engineering Discrepancy (HED) resolution process described in APP-OCS-GEH-420, "AP1000 Human Engineering Discrepancy Resolution Process" .

1. Plant Performance Data

   - Axial offset is maintained in the appropriate band in accordance with the COLR during the downpower manuever. Results are verified by Plant Performance Recording and/or video and audio recordings.

2. Personnel Task Performance

   - Operator successfully performs boration in accordance with procedure (CVS-101), as noted in the Observer Guide.

- Operator successfully establishes makeup to the IRWST in accordance with procedure (PXS-101), as noted in the Observer Guide.

- Operator successfully stops one of the three running feedwater pumps in accordance with procedure (FWS-101), as noted in the Observer Guide.

- Operator successfully transfers station loads to Offsite Auxiliary Transformers in accordance with procedure (ECS-101), as noted in the Observer Guide.

- Operator successfully stops one of the two running condensate pumps in accordance with procedure (CDS-101), as noted in the Observer Guide.

- Operator successfully stops one of the two remaining running feedwater pumps in accordance with procedure (FWS-101) and shuts down the heater drain system in accordance with procedure (HDS-101), as noted in the Observer Guide.

- Operator successfully starts auxiliary boiler and aligns it to supply steam loads in accordance with procedure (ASS-101), as noted in the Observer Guide.

- Operator places rod control to Manual when required by procedure GOP-102.

- Operator successfully places steam dumps in Steam Pressure Mode, removes Main Generator from service, and trips turbine in accordance with procedure GOP-102, as noted in the Observer Guide.

- Operator successfully shuts down the reactor in accordance with procedure GOP-102, as noted in the Observer Guide.

3. Situation Awareness

- SART score across all subjects > 50 per the participant questionnaires, and no significant situation awareness issue is identified by either the participant questionnaires or by direct observation.

- SRO is aware of plant conditions (IRWST leak) and affected Technical Specifications (3.5.6.B), as noted on the Observer Guide.

- All crew members are aware of the power reduction status and affected operators' balances reactor power with turbine loading to maintain the Tavg and Tref within a 3-degree temperature band, as noted on the Observer Guide.

- Crew is aware of power change within a 1-hour period and notifies Chemistry whenever power changes by 15% or more during a 1-hour period. SRO is aware of the affected Technical Specification surveillance requirement (SR 3.4.10.2). This is noted on the Observer Guide under Evaluation Item 1.

- Crew is aware of the Source Range instrument failure. SRO is aware of the affected Technical Specification related to the Source Range instrument when reactor power goes below P-6.

4. Workload

- TLX score based on questionnaires < 85.

- Crew was able to maintain the planned down power rate while completing branching procedures. This is noted on the Observer Guide under Evaluation Item 2.

5. Anthropometric and Physiological Factors

- Average rating across subjects and observers from questionnaire shall be > 3 for any positive statement or < 3 for any negative statement.

6. Team Performance

- At least one member of the crew recognizes and communicates with the crew or SRO the appropriate indications and/or alarms associated with the IRWST leak, 15% power change within a 1-hour period, Feedwater Heater level alarm, and Source Range instrument channel failure. This is noted on the Observer Guide under Evaluation Item 3.

- SRO conducts crew briefs appropriately as noted on the Observer Guide.

7. Goal Achievement

- All average rating across subjects and observers > 2 and no significant usability issues identified from the questionnaires or Observer Guides.

- All average ratings for individual HSI features across subjects and observers are > 3 as identified from the questionnaires or Observer Guide.

- Crew reached appropriate procedure branch points as specified in the Observer Guide.

8. Usability

- BEACON™ functioned properly and CPS functioned properly for abnormal procedure AOP-328. This is noted on the Observer Guide under Evaluation Item 2.

- Average rating across subjects and observers > 3 and no significant usability issues identified from the questionnaires or Observer Guide.

A.2 SCENARIO 2 – PLANT COOLDOWN FROM MODE 3 TO COLD SHUTDOWN

A.2.1 Scenario Description

The plant is initially shutdown in Mode 3 as part of an overall continuous evolution to conduct a plant shutdown and cooldown from Mode 1 through Mode 5 (i.e., Scenarios 1 and 2). Shift turnover from the preceding crew will reflect that a small leak from the IRWST has been detected and that containment entry is to be performed as soon as possible to inspect the problem and make repairs. The oncoming crew is expected to continue the cooldown to Mode 5 and make plans to enter containment and repair the leak. The following scenario complications are included to represent real-world and/or beyond-design basis conditions, to increase the cognitive demands on the operators:

1. PZR spray valves will fail closed (RCS-V110A and RCS-V110B). This will complicate RCS pressure control. However, alternate spray methods may be available after proper consideration given to possible thermal stresses. Operators must be cognizant of consequences of allowing RCS pressure to exceed 1970 psig at this point in the procedure for plant cooldown and depressurization.

2. After commencing cooldown of steam generators (SGs) via blowdown, CDS-V035 fails closed due to a localized instrument air tubing problem. This fault will make cooldown of SGs using Steam Generator Blowdown System (BDS) ineffective. After operators have had an opportunity to troubleshoot cause of ineffective cooling, repairs can be completed by technicians.

3. Lower mode conditions provide a less familiar and more challenging situation in which to cope with plant casualties. Responses are more situation-specific and reliant on knowledge-based reasoning, and are thus more prone to error.

A.2.2 Scenario Objectives

The objectives include the validation of:

1. The sufficiency of plant procedures as follows:

    - GOP-103 as directions for plant cooldown to Mode 5
    - BDS-101 for system alignment to cool SGs
    - CDS-101 for stopping condensate pump(s)
    - CVS-101 for borating per reactivity plan for plant cooldown and for degassing the RCS
    - CWS-101 for shutting down condenser Circulating Water System (CWS) pumps
    - FWS-101 for maintaining SG levels between 40 percent and 60 percent and shutting down Startup Feedwater (SFW) and Main Feedwater (MFW) pumps
    - MSS-101 for system shutdown and to facilitate condensation removal during cooldown
    - RCS-101 for placing RCP Variable Speed Drives in service and for ensuring continuous PZR spray flow during boration
    - PXS-101 for isolating Passive Core Cooling System (PXS) Accumulators
    - RNS-101 for placing RNS in service
    - SGS-101 for placing SGs in wet layup

2. The adequacy of the human-system interface (HSI) for supporting abnormal operations in a degraded operating environment.

3. The ability of the crew to assess the situation and implement appropriate response plans.

A.2.3 Scenario Participants

- Operating Crew: 4 members (1 SRO, 2 ROs, 1 STA)
- Scenario Coordinator
- Simulator Work Instruction Station Operator
- Simulated Local Operator
- Observers (Utility, Designers, Procedure Writers, Human Factors Specialists, QA Personnel)

A.2.4 Risk-Important Human Actions and MTIS Activities

There are no RIHAs evaluated in this scenario.

Table A.2-1. Risk-Important Human Actions

Basic Event ID	Event Description	Time Window Trigger	Procedures	Time Window
None	N/A	N/A	N/A	N/A

Table A.2-2. Representative Maintenance, Test, Inspection, and Surveillance Activities

Activity	Event Description	Time Window Trigger	Procedures	Time Window
None	N/A	N/A	N/A	N/A

A.2.5 Initial Conditions

The IC sets available on the Instructor Station will be used to establish the initial operating conditions. At the start of the scenario, the ICs presented to the crew in shift turnover will be:

1. The plant is at shutdown in Mode 3.
2. IRWST level is [<100%] with a small leak in need of inspection and repair. Level is being maintained by intermittent charging.
3. The PCCWST level is [101%].
4. The Source Range instrument (RXS-NE-001B) is out of service for repairs.

A.2.6 Sequence of Events

Table A.2-3. Sequence of Events

Events	Malfunctions/Local Actions	Estimated Timing Sequence
Small IRWST leak (e.g., between PXS-LT045 and 046)	Component malfunction (retain conditions from Scenario 1)	Pre-existing fault
Pressurizer Spray valves fail closed	Component malfunction	30 minutes
Failure of CDS-V035	Component malfunction	30 minutes

A.2.7 Detailed Scenario Description

The simulator is setup with scenario (computer) program established in cue with plant conditions stable and with the simulator in "freeze" mode.

Operating crew will be given a turnover briefing sheet which outlines the current plant status and goal for the shift. Staff verbally briefs the operating crew with initial conditions as follows:

> *The plant is shutdown and in Mode 3, near the end of core life. It is a weekday, evening shift and the weather is partly cloudy with temperature near 68 degrees Fahrenheit. Wind is relatively calm at 2.0 miles per hour from the southwest (at compass point: 230 degrees). All plant equipment is operational with no major maintenance activities in progress, except for a small IRWST leak which was previously determined to be located between root isolation valves for PXS-LT045 and -046. Goal for the shift is to cooldown the plant to Mode 5, in accordance with GOP-103.*

After the briefing, the operating crew is allowed time to familiarize themselves with the plant conditions. This should be limited to ten minutes at which time the crew should assume their respective stations and the simulator scenario is set in operation (running mode).

The SRO briefs the operating crew concerning the plan for plant cooldown, including concerns related to projected reactivity changes and maintaining shutdown margin (SDM), precautions, and contingencies related to the plant cooldown and containment entry.

Crew should verify that initial conditions for GOP-103 have been satisfied in preparation for plant cooldown.

Crew obtains reactivity plan for the expected plant cooldown to Mode 5 from BEACON™.

The simulator operator inserts a malfunction which causes the pressurizer spray valves (RCS-V110A/B) to fail closed. When detected the crew considers alternate means for pressure control. Once RCS pressure is reduced to below 1970 psig it should not be allowed to increase to avoid exceeding 1970 psig (safeguards actuation will be unblocked and an inadvertent actuation could occur if Tavg is less than 482 °F).

SRO reviews the Technical Specifications for Mode 4 transition with the crew.

Crew begins the plant cooldown while monitoring power, borating per the reactivity plan in accordance with CVS-101. Operator energizes all Pressurizer Backup Heaters.

Crew places the RCP Variable Speed Drives in service per RCS-101.

Crew continues the cooldown, borating and degassing the RCS per CVS-101. When RCS pressure < 1000 psig, the crew isolates PXS accumulators per PXS-101.

When RCS pressure < 700 psig, the crew blocks Hot Leg Pressure Low, CVS/Passive Residual Heat Removal Safeguards on PMS divisions.

When RCS pressure reaches 400 psig, the crew announces plant is in Mode 4, and reviews technical specifications for Mode 5 transition.

When RCS pressure <440 psig and RCS temperature <340 °F, crew places RNS in service per RNS-101.

Before RCS <275 °F, crew ensures at least one LTOP system is operable.

When RCS <220 °F, crew initiates action to cooldown SGs per BDS-101, announces plant in Mode 5.

The simulator operator inserts a malfunction which causes CDS-V035 (condensate supply isolation to BDS HXs) to fail closed. Crew detects ineffective SG cooling by the BDS. Crew identifies failed valve and advises technicians to troubleshoot and repair CDS V035. If requested, staff will respond as technician or field operator, “I understand you would like me to troubleshoot (or examine BD system for possible problems) the cause for ineffective SG cooling.”

When RCS <180 °F, crew collapses PZR steam bubble and secures PZR heaters.

Continuing with the cooldown, the crew continues shutdown alignments of systems and equipment.

Crew coordinates a simulated containment entry by simulated team for IRWST inspection. Staff responds as simulated containment entry team to acknowledge any communication from crew.

Crew confirms plant is stable in Mode 5 with the pressurizer solid and concludes GOP-103. The IRWST leak is identified by the simulated containment entry team and (with time compression) repair is in progress.

Simulator staff terminates the scenario.

A.2.8 Key Variables

The values of the following key variables and their changes over time will be collected to represent key aspects of scenario performance. A record of the alarm list for the scenario will also be retained.

1. Containment Sump Level
2. CDS-V035 Position
3. IRWST Injection Isolation and Squib Valve Positions
4. IRWST Level
5. RCS Hot Leg Levels
6. RCS-V110A and RCS-V110B Positions
7. PZR Level
8. PZR Pressure
9. Source Range Power
10. RNS Flow
11. RNS Pressure

A.2.9 Termination Criteria

The scenario is terminated after GOP-103 is completed with plant stable in Mode 5 and the PZR is solid. Containment entry has been performed and the IRWST leak is being temporarily repaired.

A.2.10 Pass/Fail Criteria

Successful performance of this scenario requires the following Pass/Fail Criteria to be met per the AP1000 design basis. Pass/fail criteria will be evaluated using the Observer Guide and results will be verified by Plant Performance Recording and/or video and audio recordings.

A.2.10.1 General Safety Limits

No violation of the following criteria safety limits of Technical Specifications due to operator error shall occur:

- The core remains covered by reactor coolant throughout the scenario.
- RCS pressure shall be maintained $\leq$2733.5 psig

- The reactor remains subcritical.

A.2.10.2 Risk-Important Human Actions

None.

A.2.10.3 Technical Specifications

Applicable LCOs and surveillance requirements of the technical specifications shall be met, and required actions for the associated conditions shall be performed within the specified limits and time criteria.

Table A.2-4. Key Technical Specifications (DCD, Chapter 16)

Items	Ref	Notes
3.0 LCO Applicability		
3.1 Reactivity Control Systems		
3.2 Power Distribution Limits		
3.3 Instrumentation		
Engineered Safety Feature Actuation System (ESFAS) Instrumentation	LCO 3.3.2	ESFAS Instrumentation for each function in Table 3.3.2-1 shall be operable.
3.4 Reactor Coolant System		
Low Temperature Overpressure Protection (LTOP) System	LCO 3.4.14	At least one Overpressure Protection System must be operable with the accumulators isolated.
RCS Pressure/Temperature Limits	LCO 3.4.3	Verify Parameters and Rate-of-Change within limits.
3.5 Passive Core Cooling System		
IRWST – operating	LCO 3.5.6	The IRWST, with two injection flow paths and two containment flow paths, shall be operable.
3.6 Containment Systems		
Containment Air Locks	LCO 3.6.2	Two containment air locks shall be operable.
3.7 Plant Systems		

Table A.2-4. Key Technical Specifications (DCD, Chapter 16)

Items	Ref	Notes
3.8 Electrical Power Systems		
3.9 Refueling Operations		
INVESTMENT PROTECTION/SHORT-TERM AVAILABILITY		
1.0 Instrumentation Systems		
2.0 Plant Systems		
3.0 Electrical Power Systems		

A.2.11 Diagnostic Criteria

The following scenario-specific criteria should be considered by observers and discussed during applicable trial debriefings. Results will be addressed in the HED resolution process.

1. Plant Performance Data

   - RCS pressure is maintained below 1970 psig after safeguards actuation has been blocked and Tavg is less than 482 °F. Results are verified by Plant Performance Recording and/or video and audio recordings.

2. Personnel Task Performance

   - Crew detects failure of pressurizer spray valves and determines an alternate means for RCS pressure control and implements necessary actions, as noted in the Observer Guide.

   - Operator successfully performs boration in accordance with procedure (CVS-101), as noted in the Observer Guide.

   - Operator successfully places RCP Variable Speed Drives in service in accordance with procedure (RCS-101), as noted in the Observer Guide.

   - Operator successfully continues with plant cooldown and degassing the RCS in accordance with procedure (CVS-101), as noted in the Observer Guide.

- Operator successfully isolates PXS accumulators in accordance with procedure (PXS-101), as noted in the Observer Guide.

- Operator successfully blocks Hot Leg Pressure Low, CVS/Passive Residual Heat Removal Safeguards on PMS divisions in accordance with procedure (GOP-103), as noted in the Observer Guide.

- Operator successfully places RNS in service in accordance with procedure (RNS-101), as noted in the Observer Guide.

- Operator successfully initiates action to cooldown SGs in accordance with procedure (BDS-101), as noted in the Observer Guide.

- Operator successfully collapses pressurizer bubble and secures pressurizer heaters in accordance with procedure GOP-103, as noted in the Observer Guide.

3. Situation Awareness

- SART score across all subjects > 50 per the participant questionnaires and no significant situation awareness issue is identified by either the participant questionnaires or by direct observation.

- SRO is aware of plant conditions related to the failed pressurizer spray valves and ensures that crew understands the precautions and limitations associated with alternate means of pressure control, as noted on the Observer Guide.

- All crew members are aware of the plant cooldown status and ensure that Shutdown Margin is met at all times, as noted on the Observer Guide.

- The crew ensures at least one LTOP system is operable before the RCS temperature is reduced below 275 °F, as noted on the Observer Guide.

4. Workload

- TLX score based on questionnaires < 85.

- Crew was able to maintain the planned cooldown rate while completing branching procedures. This is noted on the Observer Guide under Evaluation Item 2.

5. Anthropometric and Physiological Factors

   - Average rating across subjects and observers from questionnaire shall be > 3 for any positive statement or < 3 for any negative statement.

6. Team Performance

   - At least one member of the crew recognizes and communicates with the crew or SRO the appropriate indications and/or alarms associated with the pressurizer spray valves, and ineffective SG cooling due to failed Condensate Supply Isolation valve (CDS-V035). This is noted on the Observer Guide under Evaluation Item 3.
   - SRO conducts crew briefs appropriately as noted on the Observer Guide.

7. Goal Achievement

   - All average rating across subjects and observers > 2 and no significant usability issues identified from the questionnaires or Observer Guides.
   - All average ratings for individual HSI features across subjects and observers are ≥ 3 as identified from the questionnaires or Observer Guide.
   - Crew reached appropriate procedure branch points as specified in the Observer Guide.

8. Usability

   - BEACON™ functioned properly. This is noted on the Observer Guide under Evaluation Item 2.
   - Average rating across subjects and observers > 3 and no significant usability issues identified from the questionnaires or Observer Guide.

A.12 SCENARIO 12 – LARGE BREAK LOCA WITH INADEQUATE CORE COOLING

A.12.1 Scenario Description

With the plant operating at 100 percent power, a large break LOCA will be initiated in RCS Cold Leg 1A sufficient to depressurize the RCS and to allow IRWST gravity injection. Reactor trip and safeguards actuation will occur, after which the crew is expected to respond using the E-0 , F-0, and FR-C.1 emergency operating procedures. High incore temperatures (>1200 °F) on five or more Core Exit Thermocouples (CETs) will be simulated, followed by fuel element failure and high containment radiation [>100 Rad/hr]. A resulting red condition for the core cooling critical safety function (F-0, Att. 2) will require the crew to enter the FR-C.1 emergency operating procedure.

Responses within FR-C.1 must occur within the time windows assumed in the Human Reliability Analysis (HRA).

The following scenario complications are included to represent real-world and beyond-design basis conditions, to increase cognitive demands on the operators:

1. At the onset of the LOCA, operators will be performing the quarterly in-service stroke testing of CMT discharge valves per PXS-801.

2. Following reactor trip, the running Central Chilled Water System (VWS) water chiller pump will trip, but the standby pump will fail to pick up, requiring detection and correction by the crew in E-0.

3. Containment radiation >100 Rad/hr will preclude low pressure RCS makeup using RNS.

4. High CET readings will not respond to appropriate actions.

A.12.2 Scenario Objectives

The objectives of this scenario are to validate the following:

1. The sufficiency of plant procedures

   - E-0 to stabilize the plant following reactor trip and safeguards actuation
   - E-1 to address the loss of primary coolant
   - F-0 to monitor critical safety functions

- FR-C.1 to address inadequate core cooling conditions

2. The usability of the HSI for routine and abnormal operations, including routine alarm response.

3. The ability of the crew to perform REN-MAN03 and VLN-MAN01, RIHAs in the PRA.

4. The ability of the crew to assess the situation and to plan and implement appropriate response strategies in a beyond design basis event.

5. The ability of the crew to perform the CMT discharge valve stroke tests, a representative MTIS activity on a risk-significant component, per PXS-801.

A.12.3 Scenario Participants

- Operating Crew: 4 members (1 SRO, 2 ROs, 1 STA)
- Scenario Coordinator
- Simulator Work Instruction Station Operator
- Simulated Local Operator
- Observers (Utility, Designers, Procedure Writers, Human Factors Specialists, QA Personnel)

A.12.4 Risk-Important Human Actions and MTIS Activities

Table A.12-1. Risk-Important Human Actions

Basic Event ID	Event Description	Time Window Trigger	Procedures	Time Window
REN-MAN03	Failure to recognize the need and failure to open recirculation valves to flood reactor cavity after core damage	Simulation of high incore temperatures (>1200 °F) with high containment radiation levels	F-0 FR-C.1	20 minutes [following red condition on core cooling]
VLN-MAN01	Failure to recognize the need and failure to actuate the hydrogen control system, given core damage following a LOCA	Simulation of high incore temperatures (>1200 °F) with high containment radiation levels	F-0 FR-C.1	15 minutes following containment recirculation actuation

Table A.12-2. Representative Maintenance, Test, Inspection, and Surveillance Activities

Activity	Event Description	Time Window Trigger	Procedures	Time Window
CMT Discharge Valve Stroke Testing	Routine surveillance of risk-significant system	N/A	PXS-801 Section 5.2	N/A
Hydrogen Igniters	Actions from MCR in FR-C.1 [Step 2] are representative of activities for designated surveillance activity	N/A	VLS-801 Sections 5.2, 5.3	N/A

A.12.5 Initial Conditions

The IC sets available on the Instructor Station will be used to establish the initial operating conditions. At the start of the scenario, the ICs presented to the crew in shift turnover will be:

- Normal steady state operating conditions at 100 percent power (Mode 1)
- Quarterly surveillance test of CMT discharge valve stroke time, per Section 5.2 of PXS-801, is scheduled to be performed.

A.12.6 Sequence of Events

Table A.12-3. Sequence of Events

Event	Malfunctions/Local Actions	Estimated Timing Sequence
Turnover at steady state 100% power	N/A	Start of Scenario
Initiate RCS line break when 3rd CMT discharge valve is test stroking OPEN.	Simulator malfunction RCS07	[+20 minutes]
Water Chiller Pump VWS-MP-01A trips and standby pump does not start	Component malfunction	[+20 minutes]

Simulate fuel element failure by setting selected incore thermocouples to >1200 deg	Component malfunction	[+21 minutes]
RCS fuel leak malfunctions initiated (leading to high containment radiation levels)	Simulator malfunction RXS01	[+23 minutes]

A.12.7 Detailed Scenario Description

Simulator is setup with scenario (computer) program established in cue with plant conditions stable and with the simulator in "freeze" mode.

Operating crew will be given a turnover briefing sheet which outlines the current plant status. A calibrated stopwatch should be available for operating crew. (Calibration of stopwatch can be simulated, if necessary.) Staff verbally briefs the operating crew with initial plant conditions as follows:

> *The plant is operating at 100 percent power near the end of core life. It is a weekday, dayshift and the weather is partly cloudy with temperature near 78 degrees Fahrenheit. Wind is relatively calm at 2.3 miles per hour from the west (at compass point: 272 degrees). Thunderstorms are expected to develop later in the day. All plant equipment is operational with no major maintenance activities in progress. The surveillance schedule requires the performance of PXS-801, CMT Valve Surveillance and IST Testing, Section 5.2, in order to comply with Technical Specification SR 3.5.2.6. PXS-801, Initial Conditions 4.1 and 4.4 are signed off as complete and 4.2 and 4.3 are not applicable (N/A). Remote position verification is not required for this quarter. Maintain the plant in a safe condition and at 100% power in accordance with Technical Specifications.*

After the briefing, the operating crew is allowed time to familiarize themselves with the plant conditions. This should be limited to ten minutes at which time the crew should assume their respective stations and the simulator scenario is set in operation (running mode).

The Supervising Reactor Operator (SRO) directs the Reactor Operator (RO) to commence the surveillance test (PXS-801) and provides a copy of the procedure (which has been verified as the current revision). SRO makes a note of entering Technical Specification Limiting Condition for Operation (LCO) T.S. 5.5.2. Action A, during surveillance testing.

RO should navigate to Display 12701, announce an expected alarm due to closing PXS valve, use the soft control for PXS-V002A and stroke the valve closed (in accordance with step 5.2.1.b). RO uses stopwatch to time opening of valve and uses soft control for PXS-V014A and strokes the valve OPEN. This process is repeated for subsequent valves in the surveillance testing up to and including step 5.2.2.d. Operator should have navigated to Display 12702 for step 5.2.2.

When the operator opens PXS-V014B in step 5.2.2.d.1, the RCS malfunction (RCS07), which is to be used to simulate a maximum LOCA on Cold Leg 2B, should be initiated. Also, the running Central Chill Water System (VWS) Water Chiller Pump will trip (component malfunction) and the standby pump will fail to start automatically, but remains capable of manual start (component malfunction).

Alarm Presentation System (APS) should indicate the resulting abnormal plant conditions including the Reactor Trip condition. Operators should recognize the alarming condition and announce the Reactor Trip. SRO should direct entry in to Emergency Operating Procedure E-0 (APP-GW-GJP-201).

If STA is also an SRO, then this person may act in the role of Shift Manager and determine the Emergency Plan status and implement the plan, as necessary.

At E-0, Step 5, RO should pay particular attention to valves PXS-V002B and PXS-014B to ensure both valves are OPEN (as they were closed for the surveillance testing). Valves should be manually repositioned to OPEN if they do not automatically open.

At E-0, Step 29, RO should determine that at least one Water Chiller Pump is NOT running and should attempt to start each pump until one is operating. For this function, RO should navigate to Display 17401 and use soft controls for VWS-MP-01A and/or VWS-MP-01B.

At E-0, Step 30, Critical Safety Function Status Trees (CSFSTs) monitoring should commence in accordance with F-0. SRO should direct the STA to perform F-0 and continue to monitor CSFSTs as a continuous action. The remainder of the crew continues on in E-0, but at Step 33, should transition to E-1, Step 1, based on some or all of the indications listed in E-0, Step 33. (Note: Simulator operator should delay Core Exit Temperature overrides until this transition occurs and crew reaches E-1, Step 6.)

Six Core Exit Thermocouples (CETs) temperature outputs will need to be overridden to read greater than 1200 degrees Fahrenheit and these temperatures should ramp up very quickly within about 5 seconds. (Note: While this effect may lack some basis in realism, it is necessary in order to drive the test in the desired direction for the ISV testing.) When the 5^{th} Highest CET indicates greater than 1200 degrees Fahrenheit, observers should determine how long operators take to recognize the existence of this Red Path condition. Associated alarms via the APS and displays should reflect the Red Path for CSFST for Core Cooling. Operators should be able to recognize the Red Path condition within one minute from when the time indications become available in the MCR via APS and/or PMS displays. SRO should direct immediate transition to FR-C.1, based on CET readings, without delay or crew brief.

Fuel leakage initiated (RXS01) by simulation and/or Containment Radiation indications are overridden to cause inread greater than 100 rad/hour. (Note: While this effect may lack some basis in realism, it is necessary in order to drive the test in the desired direction for the ISV testing.)

Operating crew must initiate FR-C.1, Step 1, Reactor Cavity Flooding, within 20 minutes of the criteria being met for Red Path on Core Cooling. (Note: this is a Risk-Important Human Action (RIHA).)

Operating crew must energize both groups of hydrogen igniters within 15 minutes of completing FR-C.1, Step 1. (Note: this is a RIHA.) RO should navigate to Display 18200 to energize hydrogen igniters.

At FR-C.1, Step 8, crew should go to Step 11.

Operating crew continues in FR-C.1 and at Step 11.e recognize that low pressure RCS makeup from RNS is unavailable due to high containment radiation.

At FR-C.1, Step 15, crew should go to Step 18.

At FR-C.1, Step 23, crew should go to Step 26.

When crew gets to FR-C.1, Step 28, CET indications can be reduced below 1200 degrees Fahrenheit.

Crew completes FR-C.1 through Step 30.

Simulator Staff announces termination of scenario.

A.12.8 Key Variables

Values of the following key variables and their changes over time will be collected to represent key aspects of scenario performance. A record of the alarm list for the scenario will also be retained.

6. ADS Stage 1, 2, 3, 4 Valve Positions
7. CMT Discharge Valve Positions
8. Containment Radiation
9. Containment Recirculation Isolation and Squib Valve Positions
10. Containment Water Level
11. Core Exit Thermocouple Temperature
12. Departure from Nucleate Boiling Ratio
13. Hydrogen Igniter Status
14. IRWST Injection Isolation and Squib Valve Positions
15. Peak Centerline Fuel Temperature
16. RCS Hot Leg Levels
17. RCS Pressure
18. Reactor Power
19. PZR Level
20. VWS Water Chiller Pump Breaker Positions

A.12.9 Termination Criteria

The scenario is terminated when [Step 30] of FR-C.1 is reached.

A.12.10 Pass/Fail Criteria

Successful performance of this scenario requires the following pass/fail criteria to be met per the AP1000 design basis. Pass/fail criteria will be evaluated using the Observer Guide and results will be verified by Plant Performance Recording and/or video and audio recordings.

A.12.10.1 General Safety Limits

No violation of the following safety limits of Technical Specifications due to operator error shall occur:

21. The combination of reactor thermal power, highest RCS loop cold leg temperature, and PZR pressure shall not exceed the limits specified in the COLR.

22. The departure from nucleate boiling ratio shall be maintained ≥1.14 for the WRB-2M DNB correlation.

23. The peak fuel centerline temperature shall be maintained <5080°F, decreasing by 58°F per 10,000 units of burnup.

24. RCS pressure shall be maintained ≤2733.5 psig.

A.12.10.2 Risk-Important Human Actions

Following the initiation of the red condition on the core cooling critical safety function, the manual actuation of containment recirculation (REN-MAN03) and Hydrogen Igniters (VLN-MAN01) both shall be successfully performed within the specified time windows of Table A.12-1.

A.12.10.3 Technical Specifications

Applicable LCOs and surveillance requirements of the technical specifications shall be met, and required actions for the associated conditions shall be performed within the specified limits and time criteria.

Table A.12-4. Key Technical Specifications (DCD, Chapter 16)

Items	Ref	Notes
3.0 LCO Applicability		
3.1 Reactivity Control Systems		
3.2 Power Distribution Limits		

Table A.12-4. Key Technical Specifications (DCD, Chapter 16)

Items	Ref	Notes
OPDMS Monitored Parameters	LCO 3.2.5	Verify Parameters within limits.
3.3 Instrumentation		
3.4 Reactor Coolant System		
3.5 Passive Core Cooling System		
PXS Core Makeup Tanks	LCO 3.5.2	CMT Discharge Valve Quarterly Stroke testing.
3.6 Containment Systems		
Containment	LCO 3.6.4	Verify Containment Pressure is within limits.
3.7 Plant Systems		
3.8 Electrical Power Systems		
3.9 Refueling Operations		
INVESTMENT PROTECTION/SHORT-TERM AVAILABILITY		
1.0 Instrumentation Systems		
2.0 Plant Systems		
3.0 Electrical Power Systems		

A.12.11 Diagnostic Criteria

The following scenario-specific criteria should be considered by observers and discussed during applicable trial debriefings. Results will be addressed in the HED resolution process.

1. Plant Performance Data

   - Flow to each Steam Generator must be maintained greater than 200 gpm whenever narrow range level is less than or equal to 26% [42%]. Results are verified by Plant Performance Recording and/or video and audio recordings.

2. Personnel Task Performance

- Successful performance of surveillance procedure (PXS-801) up to the point of simulated malfunction, as noted in the Observer Guide.

- Operator successfully takes manual action to start the standby chiller pump when it is noted that it did not start automatically, as noted in the Observer Guide.

- Operator successfully initiates depressurization of RCS for low pressure injection per FR-C.1, Step 11 as noted in the Observer Guide.

3. Situation Awareness

- SART score across all subjects > 50 per the participant questionnaires and no significant situation awareness issue is identified by either the participant questionnaires or by direct observation.

- SRO is aware of plant conditions and affected Technical Specifications during the performance of surveillance PXS-801 as noted on the Observer Guide.

- All crew members are aware of the reactor trip as noted by individual behaviors in response to SRO instructions in accordance with E-0, as noted on the Observer Guide.

- Successful detection of tripped Chiller Pump and the auto-start failure of the standby pump, as noted on the Observer Guide.

- Crew detects red path for Core Cooling in a timely manner as specified and is noted on the Observer Guide.

- Operator recognizes that low pressure RCS makeup from RNS is unavailable due to high containment radiation as noted in the Observer Guide.

4. Workload

- TLS score based on questionnaires < 85.

- During the period immediately following entry into E-0 procedure, crew is able to respond to 80% of all high level alarms. This is noted on the Observer Guide under Evaluation Item 3.

5. Anthropometric and Physiological Factors

- Average rating across subjects and observers from questionnaire shall be > 3 for any positive statement or < 3 for any negative statement.

6. Team Performance

- At least one member of the crew recognizes and communicates with the crew or SRO the appropriate indications and/or alarms associated with the LOCA, VWS Chiller Pump trip, High CET Temperatures, and High Containment Radiation. This is noted on the Observer Guide under Evaluation Item 4.

- SRO conducts crew briefs appropriately as noted on the Observer Guide.

7. Goal Achievement

- All average rating across subjects and observers > 2 and no significant usability issues identified from the questionnaires or Observer Guide.

- All average ratings for individual HSI features across subjects and observers are > 3 as identified from the questionnaires or Observer Guide.

- Crew reached appropriate procedure transition points as specified in the Observer Guide.

8. Usability

- CPS functioned properly for affected emergency procedures, including E-0, E-1, F-0, and FR.C.1. This is noted on the Observer Guide under Evaluation Item 3.

- Average rating across subjects and observers > 3 and no significant usability issues identified from the questionnaires or Observer Guide.

A.13 SCENARIO 1 OBSERVER GUIDE

INITIAL CONDITIONS: Normal, steady-state operation at 100% power. Operators are making preparations to lower power and shutdown to hot standby in accordance with GOP-102.

Scenario 1 – Plant Shutdown from Mode 1 to Mode 3		
SEQUENCE OF EVENTS	**EXPECTED RESPONSE**	**SAT/UNSAT**
1. START SCENARIO Time _______________		
1a. Turnover	Operators receive and review plant conditions.	
1b. Normal plant operation.	SRO briefs the crew on conducting the shutdown evolution	
1c. Prepare for power change.	Crew notifies grid control operator of the intended power change.	
1d. Prepare for power change.	Crew obtains reactivity plan for the expected power change and profile from BEACON™.	
2. PLANT SHUTDOWN 2a. Commence power reduction.	Crew begins power reduction. Crew monitors power and borates using procedure CVS-101, per the reactivity plan.	
MALFUNCTION: Small IRWST leak	When detected, crew takes steps to locate the leak and makeup to the tank, as needed, using procedure PXS-101. SRO reviews technical specifications (T.S. 3.5.6.B).	
	SRO makes a note about the LCO related to Tech Spec 3.5.6 Action B.	
	Crew makes a note of a 15% power change within a 1-hour period and notifies Chemistry to take samples to comply with S.R. 3.4.10.2	
2b. Plant power 63% to 65%	Crew stops one of the three running feedwater pumps per FWS-101.	

Scenario 1 – Plant Shutdown from Mode 1 to Mode 3		
SEQUENCE OF EVENTS	**EXPECTED RESPONSE**	**SAT/UNSAT**
2c. Turbine load 60% to 65%	Crew transfers station loads to Offsite Auxiliary Transformers per ECS-101.	
2d. Plant power 48% to 50%	Crew stops one of two running condensate pumps per CDS-101.	
MALFUNCTION: At 45% power, leaking feedwater heater dump valve	Crew acknowledges low level alarm on Feedwater Heater 6A and responds per AOP-328.	
2e. Plant power 33% to 35%	Crew a) stops one of the remaining two running feedwater pumps per FWS-101, b) shuts down the heater drain system per HDS-101.	
2f. Plant power ~30%	Crew starts auxiliary boiler and aligns it to supply steam loads per ASS-101.	
2g. Reactor power <20%.	Crew places rod control in MANUAL.	
2h. Plant power 12% to 15%	Crew a) places steam dumps in Steam Pressure Mode, b) removes Main Generator from service, and c) trips turbine.	
MALFUNCTION: At 8% power source range power channel fails	Crew identifies and bypasses the affected instrument per technical specifications.	
2i. Reactor power <2%	Crew shuts down the reactor and announces plant in Mode 3.	
3. END SCENARIO Time ____________	Crew confirms plant is stable in Mode 3 and concludes GOP-102.	

EVALUATION ITEMS

1. Safety Limits, applicable LCOs and surveillance requirements of the Technical Specifications were met, and required actions for the associated conditions were performed within the specified limits and associated time criteria:

2. System resources and staffing levels were sufficient to support the plant shutdown operation at the planned rate and in a controlled manner, while keeping up with the tasks related to branching procedures. Shutdown schedule (rate) was not delayed by more than 25% due to inadequate staffing or system resources. BEACON and CPS functioned properly:

3. Crew recognized malfunctions in a timely fashion (typically within 2 minutes of when indications became available), and were able to provide appropriate responses:

_____ IRWST Leak

_____ Feedwater Heater Level Control Valve Failure

_____ Source Range NI Failure

_____ Other

4. Emergency Plan classification and reporting was properly performed, if supported by operating crew staffing levels:

5. Other deficiencies noted, such as an operator action which caused a potential safety concern or an adverse consequence:

A.14 SCENARIO 2 OBSERVER GUIDE

INITIAL CONDITIONS: Plant is shutdown in Mode 3. Preparations are underway to perform cooldown and depressurization to Mode 5 in accordance with GOP-103. A small IRWST leak was detected last shift; containment entry for inspection and repair will be performed as soon as possible.

Scenario 2 – Plant Cooldown from Mode 3 to Cold Shutdown

SEQUENCE OF EVENTS	EXPECTED RESPONSE	SAT/UNSAT
1. START SCENARIO Time _______________		
1a. Turnover	Operators receive and review plant conditions.	
1b. Normal plant operation.	SRO briefs the crew on conducting the cooldown evolution and plans for containment entry.	
1c. Prepare for cooldown	Crew establishes or confirms initial conditions.	
MALFUNCTION: PZR Spray Valves RCS-V110A/B fail closed	When detected, crew considers and determines alternate means for pressure control. RCS pressure is not allowed to exceed 1970 psig. SRO should review technical specifications for impact.	
1d. Prepare for cooldown	Crew reviews technical specifications for Mode 4 transition. Crew maintains adequate Shutdown Margin throughout the plant cooldown.	
2. COOLDOWN TO MODE 4		
2a. Commence cooldown	Crew monitors power and borates per the reactivity plan.	
2b. Continue cooldown	Crew places RCP Variable Speed Drives in service per RCS-101.	
2c. Continue cooldown	Crew borates and degasses the RCS per CVS-101.	

Scenario 2 – Plant Cooldown from Mode 3 to Cold Shutdown		
SEQUENCE OF EVENTS	**EXPECTED RESPONSE**	**SAT/UNSAT**
2d. When RCS pressure <1000 psig	Crew isolates PXS accumulators per PXS-101.	
2e. When RCS pressure <700 psig	Crew blocks Hot Leg Pressure Low, CVS/Passive Residual Heat Removal Safeguards on PMS divisions.	
2f. When RCS reaches 440 psig	Crew announces plant in Mode 4, reviews technical specifications for Mode 5 transition.	
2. COOLDOWN TO MODE 5		
3a. When RCS pressure <440 psig and RCS temperature <340 °F	Crew places RNS in service per RNS-101.	
3b. Before RCS <275 °F	Crew ensures at least one LTOP system is operable.	
3c. When RCS <220 °F	Crew initiates action to cooldown SGs per BDS-101, announces plant in Mode 5.	
MALFUNCTION: CDS-V035 (condensate supply isolation to BDS HXs) fails closed.	Crew detects ineffective SG cooling by the BDS. Crew identifies failed valve and advises technicians to troubleshoot and repair CDS-V035.	
3d. When RCS <180 °F	Crew collapses PZR steam bubble and secures PZR heaters.	
3e. Continue cooldown	Crew continues shutdown alignments of systems and equipment.	
4. CONTAINMENT ENTRY		
4.1 Enter containment	Crew coordinates containment entry for IRWST inspection.	

Scenario 2 – Plant Cooldown from Mode 3 to Cold Shutdown		
SEQUENCE OF EVENTS	**EXPECTED RESPONSE**	**SAT/UNSAT**
4. END SCENARIO Time ____________	Crew confirms plant is stable in Mode 5 with PZR solid and GOP-103 complete. IRWST leak is identified and repair is in-progress.	

EVALUATION ITEMS

1. Safety Limits, applicable LCOs and surveillance requirements of the Technical Specifications were met, and required actions for the associated conditions were performed within the specified limits and associated time criteria.

2. System resources and staffing levels were sufficient to support cooldown operations at the planned rate and in a controlled manner, while keeping up with the tasks related to branching procedures. Cooldown schedule (rate) was not delayed by more than 25% due to inadequate staffing or system resources. BEACON and functioned properly:

3. Crew recognized malfunctions in a timely fashion (typically within 2 minutes of when indications became available), and were able to provide appropriate responses:

_____ PZR Spray Valve Failure

_____ CDS-V035 Failure (Condensate Supply Isolation to BDS HXs)

_____ Other

4. Emergency Plan classification and reporting was properly performed, if supported by operating crew staffing levels.

5. Other deficiencies noted, such as an operator action which caused a potential safety concern or an adverse consequence:

A.15 SCENARIO 12 OBSERVER GUIDE

INITIAL CONDITIONS: Normal, steady-state operation at 100% power. Quarterly surveillance test of CMT discharge valve stroke time is scheduled to be performed per Section 5.2 of PXS-801.

Scenario 12 – Large Break LOCA with Inadequate Core Cooling

SEQUENCE OF EVENTS	EXPECTED RESPONSE	SAT/UNSAT
1. START SCENARIO Time ______________		
1a. Turnover	Operators receive and review plant conditions.	
1b. Prepare for test	SRO briefs the crew on conducting the CMT discharge valve stroke test.	
	SRO makes a note about the LCO related to Tech Spec 5.5.2 Action A.	
1c. Surveillance test	Operators perform stroke testing of CMT discharge valves per PXS-801.	
MALFUNCTION: LOCA on Cold Leg 1A	Crew enters E-0 to respond to reactor trip and safeguards actuation.	
	SRO ensures that all crew members (and plant personnel) are aware of the reactor trip. SRO directs crew to enter E-0.	
	Crew maintains proper feedwater flow to each S/G (440 gpm total) until narrow range level is greater than 26% [42%] in at least one S/G.	
MALFUNCTION: VWS Water Chiller Pump Trips; standby pump fails to start	Crew manually starts VWS water chiller pump per E-0.	
	At E-0, Step 33, SRO directs transition to E-1, Step 1, providing a quick brief with crew to explain expected plan of major actions to be accomplished in E-1.	

Scenario 12 – Large Break LOCA with Inadequate Core Cooling		
SEQUENCE OF EVENTS	**EXPECTED RESPONSE**	**SAT/UNSAT**
MALFUNCTION: CET readings >1200 °F Time when red path conditions present: ____________	Crew detects red path for core cooling and transitions to FR-C.1 based on CET readings.	
Time when crew ascertains red path conditions exist: ____________	Two minutes or less from time indications of red path conditions become available in MCR until crew recognizes these conditions	
MALFUNCTION: Containment >100 rad/hr (RXS01) Fuel leakage	Crew initiates and completes actions for Reactor Cavity Flooding per FR-C.1, Step 1, within 20 min. of red path indications available. (RIHA*)	
Time when Step 1 completed: ___________	Crew completes FR-C.1, Step 1.	
	Crew energizes both groups of hydrogen igniters per FR-C1, Step 2 within 15 min. of prior step (RIHA*).	
Time when Step 2 completed: ___________	Crew completes FR-C.1 Step 2 within 15 minutes of the completion of Step 1.	
	Operator initiates depressurization of RCS for low pressure injection per FR-C.1, Step 11.	
	At FR-C.1, Step 11.e, operator recognizes that low pressure RCS makeup from RNS is unavailable due to high containment radiation.	
CET readings are reduced to below 1200 degrees F when crew reaches Step 28.		
2. END SCENARIO Time ____________	Crew completes FR-C.1 through Step 30	

EVALUATION ITEMS

1. *RIHAs were completed successfully within required time windows.

2. Safety Limits, applicable LCOs and surveillance requirements of the Technical Specifications were met, and required actions for the associated conditions were performed within the specified limits and associated time criteria.

3. System resources and staffing levels were sufficient to support LOCA response (e.g., CPS functioned properly for affected emergency procedures, crew was able to respond to 80% of all high level alarms).

4. Crew recognized malfunctions in a timely fashion (typically within 2 minutes of when indications became available), and were able to provide appropriate responses:

_____ LOCA

_____ VWS Water Chiller Pump Trip

_____ High CET Temperatures (Inadequate Core Cooling/Critical Safety Function Red Path)

_____ High Containment Radiation

_____ Other (specify)

5. Emergency Plan classification and reporting was properly performed, if supported by operating crew staffing levels.

6. Other deficiencies noted such as an operator action which caused a potential safety concern or an adverse consequence.

References:

None.

Design Control Document (DCD) Revision:

None.

PRA Revision:

None.

Technical Report (TR) Revision:

None.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP18-COLP-35
Revision: 1

Question:

The ISV Plan does not address measurement characteristics. It is recognized that most of the measurement characteristics identified in Review Criterion 1 in NUREG-0711, Section 11.4.3.2.5.1 will not be applicable to many of the measures, but the plan should at least address the characteristics identified in Section 11.4.3.2.5.1 that are applicable. For example, the plan can explain how the questionnaire in Appendix D measures those variables listed on page 6-1 (workload, situation awareness, teamwork, usability, and goal achievement) and why their approach to measuring these variable in this way is a good one. The plan also indicates that the questionnaire will be filled out by both participating operators and observers. But, it is not clear how observers can answer many of the questions presented, e.g., “Was there anything about the PMS, PDSP, or SDSP surprising, misleading, or unclear?” Please update the Plan to address these issues.

Westinghouse Response:

The measurement characteristics used in the ISV are described in Section 6.1 of the ISV Plan, Rev B. These are described below along with the corresponding measurement characteristics identified in Section 11.4.3.2.5.1 of NUREG-0711, which are noted at the applicable points in italics:

1. Workload Rating Scales - The Task Load Index (TLX) is a widely used measure of subjective mental workload and has been subject to many years of research and application by NASA (*construct validity*). After each scenario is completed, the TLX is administered to the test subjects (*unintrusiveness*), and the data is relatively straightforward to process (*simplicity*). The TLX ratings capture both high and low levels of workload (*sensitivity/scale*), although whether the workload levels are acceptable or appropriate is determined in respect to the situation and scenario. In addition, separate TLX subscales for different components of subjective workload (*resolution*) will provide useful information as to the sources of workload (*diagnosticity*).

2. Questionnaires (Appendix D) – Likert scale ratings are general tools of subjective measurement. In ISV, a post-test questionnaire will be given to the operators and observers in order to investigate specific areas of interest and to assess workload, situation awareness, team work, and goal achievement (*construct validity*). The questionnaires will administered to the test participants after the trail is completed (*unintrusiveness*) and the data is straightforward to process (*simplicity*). Likert scales are developed to give a full and uniform rating range for each answer (*sensitivity*), reflecting

both good and bad results (*impartiality*). In addition, multiple questions for each of the areas of interest (*resolution*) will provide an insight into observed operator performance (*diagnosticity*).

The questionnaire (Appendix D) will be modified to take into account that certain questions cannot be readily answered by both the operators and the observers alike. Two versions of the questionnaire will be provided – one for operators and one for observers.

3. Observer Checklists (Appendix F) – These checklists will assist observers in focusing on and identifying the key instances of task performance that correspond to successful operator performance, as planned for each scenario (*objectivity*). The observer checklists use the operating procedures as a basis, and therefore, the checklists are highly valid in terms of content (*construct validity*). The use of the observer checklists does not interfere with the test performance by the subjects/operators. The results obtained from the checklists are straightforward to process (*simplicity*).

   It is noted that the observer checklist entries are most helpful when the events and behavior follow the anticipated course of the scenario (*sensitivity*), as they are prepared in terms of 'good' performance (*impartiality*). Also, note that the level of detail is relatively less than contained in the actual procedures, due to the real-time needs and limitations of observation (*resolution*). The repeatability of the checklist results is anticipated to be relatively high, because there is redundancy across observers; plus the results can be subsequently confirmed by the event and plant performance recordings (*reliability*).

4. Debriefing (Appendix G) – Debriefing supports the clarification of the other more structured results (*diagnosticity*), and allows for both good and bad results to be reported (*impartiality*). The debriefing process consisting of a guided but open discussion on the participants' test experiences, perceptions and concerns (*simplicity*). While individual and group dynamics may affect the course and results of any discussion, the repeatability of the process and results will be supported by provision of a debriefing protocol and the use of meeting recorders (*reliability*).

5. Discrete Event Recording – Computer-generated records of time-stamped actions, status changes of equipment, and other discrete events are used to evaluate time margins and will assist in confirming the results of the subjective observations (*objectivity*). The event records provide a factual history, the event recording does not interfere with test performance by the subjects (*unintrusiveness*), and because the event records are generated in computer form, these results will be relatively easy to process (*simplicity*). Furthermore, the event records are not influenced by any subjective judgments of performance quality (*impartiality*). The level of detail is defined intrinsically by the events themselves and the I&C database structure (*resolution*). Finally, the event

records are particularly useful for understanding the overall course of events and operator responses (diagnosticity) and provide a repeatable measure (*reliability*).

6. Plant Performance Recording – The continuous recording of plant parameter values over time has much in common with discrete event recording as previously described in terms of measurement characteristics (*objectivity, construct validity, unintrusiveness, simplicity, impartiality, resolution* and *diagnosticity*). A major difference is that the sampling intervals for plant performance recordings are taken at fixed 1 second intervals. This interval is imposed to help make the relatively large amount of data more manageable. However, it is sufficient for the identification and subsequent assessment of operator actions and the plant response (*sensitivity*). As a result of the fixed sampling intervals, the repeatability of plant performance recording is high *(reliability)*.

7. Video and Audio Recording - The use of video and audio recording supports the capturing of events and will assist in the use of the other measurement characteristics described above (*diagnosticity*). This data will record both good and bad results (*impartiality*). Also, it is relatively straightforward, consisting of the application of familiar equipment and technologies (*simplicity*).

Westinghouse will include the information described above, and the modified Appendix D (Post-Test Questionnaire), in the ISV Plan, Rev C, to be issued by 31st January 2010.

Question Rev 1:

The response clarified the last part of the RAI concerning use of the same questionnaires for both operators and observers by indicating that the questionnaire will contain only those questions appropriate to the person filling it out. The response did not completely address the staff's question about measurement characteristics. The response mixes measuring approaches, such as questionnaires and debriefing, and the performance measures themselves: such as workload. For example, how does the statement: "In ISV, a post-test questionnaire will be given to the operators and observers in order to investigate specific areas of interest and to assess workload, situation awareness, team work, and goal achievement" constitute construct validity for any of the performance measures listed? The staff expects the discussion of measurement characteristics to focus on the aspects of performance being measured: e.g., plant performance, task performance, situation awareness, etc. We recognize that the means of collecting data on the performance measures, such as by way of a questionnaire, is applicable to some of the specific characteristics, such as intrusiveness.

Please provide information pertaining to applicable measurement characteristics for the aspect of performance being measured.

Westinghouse Response Rev 1:

The following lists the performance measures and explains the approaches that will be used to measure them and why these approaches are appropriate in terms of assessing the corresponding measurements characteristics.

1. Workload – Workload will be measured by the Task Load Index (TLX) in the format of a questionnaire to be completed by test subjects (i.e. operators). TLX is a widely used measure of subjective mental workload and has been subject to many years of research and application by NASA. After each scenario is completed, the TLX is administered to the test subjects. The data is relatively straightforward to process. The TLX ratings capture both high and low levels of workload, although whether the workload levels are acceptable or appropriate is determined in respect to the situation and scenario. In addition, separate TLX subscales for different components of subjective workload will provide useful information as to the sources of workload. In summary, TLX is a well established good approach to measure workload in terms of construct validity, unintrusiveness, simplicity, sensitivity/scale, resolution and diagnosticity.

2. Situation Awareness – Situation awareness (SA) will be measured by the Situation Awareness Rating Technique (SART) in the format of a questionnaire to be completed by the test subjects. SART is a widely used subjective measure of SA which directly assesses SA by asking individuals to rate their own SA. After each scenario is completed, the SART is administered to the test subjects. The SART evaluates the SA using ten subscales for ten factors or constructs of SA. Operators are asked to indicate on each scale (low to high) what most accurately reflects the level of their experience for that factor. This data is relatively straightfoward to process. SART is a good approach to measure SA in terms of construct validity, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity. Further details on SART will be included in the ISV Plan, Rev C.

3. Team Work – Team work will be assessed utilizing a questionnaire to be completed by both test subjects and observers. Based on an extensive literature review, five dimensions (or aspects) of team performance are selected and evaluated individually. After each scenario is completed, the team performance questionnaire is administered to the test subjects and observers. The test subjects and observers are asked to rate the team by indicating the skill level (hardly any skill to complete skill) which most represents the skill presented by the team in each of the five dimensions. The data is relatively straightfward to process. The approach to measure the team performance is good in terms of construct validity, impartiality, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity.

4. Goal Achievement – Goal achievement will be assessed in the format of a questionnaire to be completed by both test subjects and observers. The first three questions in the

questionnaire address overall performance in achieving the goal (e.g., poor to excellent) and the remaining questions address how useful or counteractive the individual HSI features are to achieving the goal, i.e. Wall Panel Information System (WPIS), Alarm Presentation System (APS), Computerized Procedure System (CPS), Distributed Control and Information System (DCIS), Protection and Monitoring System (PMS), soft controls, Primary Dedicated Safety Panels (PDSP), Secondary Dedicated Safety Panels (SDSP), Diverse Actuation System (DAS) and the control room. In addition to an overall evaluation on usefulness of individual HSI features (very counteractive to very helpful), test subjects and observers are also given opportunity to elaborate what and how specific design features were helpful or counteractive to achieving the goal. The approach to measure the goal achievement is good in terms of construct validity, impartiality, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity.

5. Usability – Usability will be assessed in the format of questionnaires by both test subjects and observers both after each scenario is completed and after the whole test is completed. The test subjects and observers are asked to indicate their level of agreement (strongly disagree to strongly agree) on statements about the control room and HSI features. The questions are based on usability and human factors requirements on control room design and HSI features. Test subjects and observers are also given the opportunity to provide additional comments on every HSI feature and the overall control room design in terms of usability. The approach to measure goal achievement is a good one in terms of construct validity, impartiality, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity.

Note that the questionnaires described above will be provided in the ISV Plan, Rev C.

Also note that while the questionnaires can directly and systematically measure the above performance characteristics, other approaches will also be used to gain information on these performance measures. The other approaches include observer checklists, debriefing, discrete event recording, plant performance recording, audio and video recording. For example, the observer checklists and debriefing can provide confirmation or detailed information regarding the information obtained from the completed questionnaires. Also, discrete event recording, plant performance recording, video and audio recording are not influenced by any subjective judgments of performance quality and therefore will provide objective confirmation of the results of the subjective observations.

Question Rev 2:

Evaluation Based on W response in letter dated 1/2/2010 and APP-OCS-GEH-320, Rev. C (Feb 2010).

W's response does not address all the measures. It provides measurement information for workload, SA, teamwork, goal achievement, and usability (**not** plant level measures, task performance measures).

The actual measurement characteristics are really not addressed. For example, after discussing that the SART measure will be used for workload, they simply state that: "SART is a good approach to measure SA in terms of construct validity, unintrusiveness, simplicity, sensitivity/scale, resolution, and diagnosticity." No explanation as to why it's good is identified. We are not sure the SART is a good measure of situation awareness. The SART questions do not pertain to any specific scenario details. Further, the measure is collected at the end of scenarios that, in many cases, are several hours long. Thus its sensitivity to changing SA across a scenario may not be too good. Please explain the use of the SART measure of SA.

The ISV plan does not include all the info in the RAI response. The logical organization of the ISV plan data section is unclear. The first measure discussed is workload (NASA TLX rating scales). This is followed by a discussion of questionnaires. That discussion includes situation awareness which is a rating scale like the TLX. This questionnaire discussion addresses many individual performance measures that are not individually discussed – a least not to the degree the TLX is discussed. The measurement characteristics of individual performance measures are really are not mentioned, except for workload and SA. A more detailed discussion of the SART measure that addresses construct validity appears later in the document with respect to diagnostic criteria.

Westinghouse Response Rev 2:

The ISV Plan, Rev C, Section 6.1 Methods will be revised/re-organized in the ISV Plan, Rev D, into Sections 6.1 Measures and Section 6.2 Methods. Section 6.1 Measures addresses performance measures, including plant performance measurements, personnel task measurements, situation awareness, workload, anthropometric and physiological factors, team performance, goal achievement and usability. Section 6.2 Methods addresses measuring approaches, including questionnaires, observer guides, debriefing, digital simulator recording, video and audio recording. Section 6.1 describes what is being measured and Section 6.2 describes how it is being measured and why this is an appropriate method (i.e. measurement characteristics). (Note, Section 6.3 Criteria is addressed in the response to RAI-SRP18-COLP-36, Rev 1)

The following are the new Section 6.1 Measures and Section 6.2 Methods, which will be included in the ISV Plan, Rev D. (Note, the references to Appendices refer to the Appendices in the ISV Plan, APP-OCS-GEH-320).

6.1 MEASURES

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

- Plant Performance Measurement – Two types of plant performance measures representing functions, systems, components, and HSI use will be obtained: *discrete event recording* and *plant performance recording.* The successive discrete events that occur in the simulated plant will be recorded in each trial. This provides a time-stamped record of manual and automatic actions and other state changes to systems and components occurring over the course of the scenarios. Plant parameters showing the continuous evolution of plant conditions over time will be recorded in each trial. This provides a time-stamped record of plant behavior and operating performance over the course of the scenarios.

- Personnel Task Measurement – For each specific scenario, the tasks that personnel are required to perform will be identified and assessed. Two types of personnel tasks will be measured: primary and secondary. Primary tasks are those involved in performing the functional role of the operator to supervise the plant; i.e. monitoring, detection, situation assessment, response planning, and response implementation. Secondary tasks are those tasks that personnel must perform when interfacing with the plant, but which are not directed to the primary task, such as navigating and HSI configuration. The following measures are used to reflect the important aspects of the task with respect to system performance:

  - time
  - accuracy
  - frequency
  - errors (omission and commission)
  - amount achieved or accomplished
  - consumption or quantity used
  - subjective reports of participants

- Situation Awareness – Personnel situation awareness will be assessed to assure that the design supports the operators in terms of perception of the elements of the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future. Situation awareness is key for making decisions, especially during situations involving uncertainty.

- Workload – Personnel workload will be assessed to understand the cost of accomplishing task/scenario requirements for the human operator. Workload can have a great affect on task performance.

- Anthropometric and Physiological Factors – Anthropometric and physiological factors include such aspects as visibility of indications, accessibility of control devices, and ease of control device manipulation. Attention will be focused on aspects of the design that can only be addressed during testing of the integrated system, e.g. the ability of personnel to effectively use the various controls, displays, workstation, or consoles in an integrated manner.

- Team Performance – Team performance will be assessed to understand personnel communication and coordination within a team. It is a key indicator of the success of the overall system performance (i.e., the design, training, procedures, work organization, and staffing levels).

- Goal Achievement – Goal achievement will be assessed to examine how well participants achieved the trial goals/objectives overall, and how well each HSI feature assisted in achieving the goals.

- Usability – Usability will be evaluated to examine how well each HSI feature and all of the features as a whole accomplished their functions.

6.2 METHODS

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

- Questionnaires (Appendix A, B, C, and D) – Questionnaires are subjective paper-and-pencil tools which will be applied to subjects and observers to assess situation awareness, workload, anthropometric and physiological factors, team performance, goal achievement and usability. There are a total of four questionnaires, as follows:

    - Post-Trial Questionnaire for Subjects (Appendix A), including assessments of situation awareness, workload, team performance, goal achievement.
    - Final Questionnaire for Subjects (Appendix B), including assessments of anthropometric and physiological factors, and usability.
    - Post-Trial Questionnaire for Observers (Appendix C), including assessments of team performance and goal achievement.
    - Final Questionnaire for Observers (Appendix D), including assessments of anthropometric and physiological factors, and usability.

    Situation awareness is measured using the Situation Awareness Rating Technique (SART) (Reference 1 and 2). SART provides a validated and practical subjective rating tool for the measurement of situation awareness, based on personal construct dimensions associated with situation awareness. There are ten constructs which are clustered into three broad domains:

- Attentional Demand: instability of situation, variability of situation, and complexity of situation;
- Attentional Supply: arousal, spare mental capacity, concentration, and division of attention;
- Understanding: information quantity, information quality, and familiarity.

Subjects rate their level of experience for each construct on a scale. Each scale is a horizontal line divided into 20 equal intervals anchored by bipolar descriptors (e.g., Low/High). The 21 vertical tick marks on each scale divide the scale from 0 to 100 in increments of 5. A single value for situation awareness is created by using the algorithm:

Situation Awareness = Understanding – (Attentional Demand – Attentional Supply)

Understanding is the mean rating of the constructs within that domain. The same applies to Attentional Demand and Attentional Supply. The rating for situation awareness is -100 (minus 100) to 200, with 200 representing the best situation awareness. The average level of situation awareness is 50. This formula was derived from theoretical considerations of how the three domains interact. Interpretation of the situation awareness calculation results is determined in respect to the situation and scenario.

SART is a very commonly used method and an appropriate tool for measuring situation awareness when it is not appropriate to freeze a simulation. The ten constructs can be applied to almost any situation without needing to make the questions any more specific. The constructs are general in nature and therefore are applicable across domains. Decomposing situation awareness into the individual SART dimensions provides some diagnostic and predictable indicators for delineating the strengths and weakness associated with SA as measured by the scale. SART is very easy to administer and does not require costly and time consuming development of queries or implementation. The situation awareness rating questions will be given to the subjects at the completion of each trial as part of the Post-Trial Questionnaire for Subjects (Appendix A).

Workload is measured using the Task Load Index (TLX), developed by the National Aeronautics and Space Administration (NASA). TLX is a well-established, subjective paper-and-pencil method of workload assessment that is easily administered and processed. It provides a basis for comparisons between groups, and diagnostic insight on workload sources from its six component subscales, i.e. effort, performance, frustration level, temporal demand, mental demand and physical demand. The TLX ratings capture both high and low levels of workload. Each subscale is presented as a line divided into 20 equal intervals anchored by bipolar descriptors (i.e. Low/High). The 21 vertical tick marks on each subscale divide the scale from 0 to 100 in increments of 5. The overall rating for workload is the average of the six subscale ratings. Therefore the overall rating for workload is from 0 to 100, with 100 being the highest level of workload. The TLX questionnaire will be given to the subjects at the completion of each trial as part of the Post-Trial Questionnaire for Subjects (Appendix A).

Anthropometric and physiological factors are assessed utilizing a questionnaire to be completed by the subjects (Final Questionnaire for Subjects, Appendix B) and another questionnaire to be completed by observers (Final Questionnaire for Observers, Appendix D), after all scenarios have been completed. The questionnaires contain statements that address the anthropometric and physiological factors of the Main Control Room (MCR), i.e. control room layout, design of the workstations, climatic environment, visual environment, auditory environment. Participants record their level of agreement for each statement (e.g., strongly disagree to strongly agree), which provides an assessment of the anthropometric and physiological factors of the MCR. The statements are developed based on human factors requirements on control room design. The subjects and observers are also given opportunity to elaborate on the anthropometric and physiological factors of the MCR.

Team performance is assessed utilizing a questionnaire to be completed by both the subjects (Post-Trial Questionnaire for Subjects, Appendix A) and observers (Post-Trial Questionnaire for Observers, Appendix C), after each scenario is completed. Based on an extensive literature review, five dimensions (or aspects) of team performance are selected and evaluated individually. They are assertiveness, decision-making, situation assessment, leadership and communication. The subjects and observers are asked to rate the team by indicating the skill level (e.g., hardly any skill to complete skill) which most represents the skill presented by the team in each of the five dimensions. The rating for each team performance dimension is from 0 to 5, with 5 being the best rating for any dimension.

Goal achievement is assessed utilizing a questionnaire (Post-Trial Questionnaire for Subjects, Appendix A) to be completed by the subjects and another questionnaire (Post-Trial Questionnaire for Observers, Appendix C) to be completed by observers, after each scenario is completed. The questionnaires are developed based on expert judgment. The first four (for subjects) or three (for observers) questions in the questionnaires address overall performance in achieving the goal (e.g., poor to excellent) and the remaining questions address how counteractive or useful (e.g. very counteractive to very useful) the individual HSI features are to achieving the goal, i.e. Wall Panel Information System (WPIS), Alarm Presentation System (APS), Computerized Procedure System (CPS), Distributed Control and Information System (DCIS), Protection and Monitoring System (PMS), soft controls, Primary Dedicated Safety Panels (PDSP), Secondary Dedicated Safety Panels (SDSP), Diverse Actuation System (DAS) and the control room layout. In addition to an overall evaluation on the usefulness of individual HSI features, the subjects and observers are also given opportunity to elaborate on what and how specific design features were helpful or counteractive to achieving the goal. The rating for overall goal achievement and usefulness of each HSI feature is from 0 to 5, with 5 being the best rating.

Usability of the HSI features is assessed utilizing a questionnaire to be completed by the subjects (Final Questionnaire for Subjects, Appendix B) and another questionnaire to be completed by observers (Final Questionnaire for Observers, Appendix D), after all scenarios have been completed. The questionnaires contain statements that address the functionality of the individual HSI features and the HSI features as a whole. The subjects and observers give their level of agreement (e.g., strong disagree to strong agree) for each statement, which provides an assessment of the usability of the individual HSI features and the HSI features as a whole. The statements are developed based on usability requirements on HSI features. The subjects and observers are also given opportunity to elaborate on the usability of the HSI features.

Note that the design aspects are assessed via design verification prior to ISV (see APP-OCS -GEH-120, "AP1000 Human Factors Engineering Design Verification"). The design verification is static, does not require the use of the simulator, and will address adherence to HFE design guidelines. However, the ISV questionnaires request feedback on anthropometric and physiological factors, and usability, in a realistic operations environment.

- Observer Guides (APP-OCS-GEH-321, Appendix B) – These are paper-and-pencil tools that specify observable occurrences of task performance that are expected in the individual scenarios, based on the simulated events and applicable procedures. Key events and the corresponding expected operator responses are identified to provide observers with preview and context, and to support the identification of errors of omission.

  The observer guides do not include all of the individual actions identified in the procedures. The observer guides are designed to be easily implemented while not distracting from assessing crew performance. Each guide includes the following:

  - Title and brief description of the scenario initial conditions.
  - Table with the following columns:
    - Sequence of events. This comprises the major events only.
    - Expected response. This is provided to inform the observer on successful task performance
    - Satisfactory/Unsatisfactory. This column is blank for the observer to provide their notes with understanding that some items will not be applicable.
  - Evaluation Items
    - HSI resources
    - Staffing levels
    - Risk-important tasks
    - Recognition and response to malfunctions (scenario malfunctions are listed)
    - Space for the observer to provide additional comments/notes.

  Each of the events and expected responses are not necessarily all of the items specified in the scenario descriptions as the pass/fail criteria; additional events are included. In order to provide a logical observer guide and aid the observer in following the progress of the scenario, the events may simply represent key progress points/steps in the scenario. It is noted that the observer guides are one of a number of measurement techniques to determine pass/fail. However, all of the risk-important tasks will be included in the sequence of the events, including start step and end step. Observers will be given space to record the time for start step and end step so that risk-important task completion time can be assessed against the PRA time window.

- Debriefing, Post-Trial and Final (Appendix F) – Debriefing promotes the open exchange between the participants on their test experience, perceptions and concerns to obtain feedback and clarifications that may be missed by the more structured data collection methods. Debriefing can provide confirmation or explanation regarding the information obtained from the completed questionnaires. The debriefing process is guided by a debriefing protocol (see Appendix F) and is recorded by video camera and audio recorder. An immediate debriefing of the participants will be performed after each scenario trial. A summary debriefing will be held at the end of each crews' participation in the ISV.

- Digital Simulator Recording – Plant performance measures, including discrete events and continuous plant parameters, will be recorded automatically by the simulator. The continuous plant parameter recordings are taken at fixed 1 second intervals. Digital simulator recording are utilized to support the evaluation of task performance and associated time margins and plant performance margins, where applicable. Digital simulator recording are not influenced by any subjective judgments of performance quality and therefore will provide objective confirmation of the results of the subjective observations.

- Video and Audio Recording – Operator behavior will be recorded locally at the individual MCR workstations. These recordings will capture the operators' primary and secondary task actions. General recordings of the MCR workspace and crew performance in each scenario will also be made. Video and audio recording will be reviewed and utilized to assess personnel task performance, where applicable. Video and audio recording are not influenced by any subjective judgments of performance quality and therefore will assist in providing objective conformation of the results of the subjective observations.

References:

1. 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.

2. 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.

Design Control Document (DCD) Revision:

None.

PRA Revision:

None.

Technical Report (TR) Revision:

None.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP18-COLP-36
Revision: 1

Question:

Acceptance criteria for Pass/Fail measures are generally discussed in Section 6.2. Each scenario has "Scenario Criteria," but it is not clear which criteria are mandatory and would result in scenario failure if not satisfied. The criteria are applied on a trial-by-trial basis. The general acceptance criteria are (1) no violation of safety limits (e.g., Tech Specs) due to operator error, and (2) completion of all RIHAs within available time windows of PRA. The acceptance criteria for diagnostic measures determine whether an HED is defined. These criteria are only briefly discussed. For example, sustained unawareness of the situation leading to error and extreme workload leading to error are diagnostic criteria. How either is determined is not identified. Also, the necessity of linking these measures to error seems unnecessarily liberal. Sustained unawareness of the situation and extreme workload would seem to be worthy of HED assessment in their own right. The specific measures and acceptance criteria to be used for each scenario are not given. Please update the Plan to address these issues.

Westinghouse Response:

Section 6.2 of the ISV Plan distinguishes between acceptance criteria and diagnostic criteria. Both types of criteria provide a basis for determining that if HED is required to be generated. However, diagnostic criteria do not necessarily define trial failure, and an assessment will be conducted to summarize the HED results and determine the overall conclusion as to whether the trial has indeed passed or failed.

In the ISV Plan, Rev B, Appendix E, the applicable subsections entitled "Scenario Criteria" in the individual scenario descriptions did not distinguish between the diagnostic criteria and acceptance criteria. Westinghouse will add this distinction for each scenario, and will provide scenario-specific acceptance criteria and diagnostic criteria as part of completing each detailed scenario description in the ISV Plan, Rev C, to be issued by 31st January 2010.

In addition, Westinghouse acknowledges that if workload is considered to be extreme relative to the situation, then a HED will be generated. Likewise, if crew situation awareness is determined to be poor, a HED will be generated. These HEDs will be created even if there is no actual operator error. Workload and situation awareness will be assessed by means of the Task Load Index (TLX) and the responses to the Likert-scaled questions that will be part of the post-test questionnaire completed by the scenario participants and scenario observers. Again, this additional information will be included in the ISV Plan, Rev C, to be issued by 31st January 2010.

Question Rev 1:

Evaluation Based on APP-OCS-GEH-320, Rev. C (Feb 2010) and 321
Follow-up questions:

1. With respect to P/F measures, how is failure to performance a RIHA on time per PRA assessed?

2. With respect to criteria for diagnostic measures, some are precisely defined while other are not. For example, a criterion stating "less that 75% expected operator responses per the observer guide" is a clearly stated criterion that identified how it's measured and precisely what is acceptable. This is not typically the case. In some cases the diagnostic measures are identified with reference to a criterion (e.g., extreme workload), while other diagnostic measures are not (e.g., SA). Please identify the criteria for each measure, the basis for the criterion (e.g., engineering analysis, expert judgment, etc.), and how will these measures will be used to trigger an HED?

3. Why are some diagnostic measure mentioned for specific scenarios while others are not, e.g., workload is not mentioned for any scenarios.

4. Additional specific questions:

- Error of Omission – how measured?
- Error of Commission – how measured?
- Extreme workload... leading to an operator error. Why does workload have to lead to an error to be a diagnostic criterion? The RAI response acknowledged error was not necessary – see RAI response to this RAI in the 11/02/09 letter - "In addition, Westinghouse acknowledges that if workload is considered to be extreme relative to the situation, then a HED will be generated.") How is extreme workload defined?
- Implementation error or substantial deficiency of the design of HSI, procedures and training - how assessed?
- Any other specific concern with a plausible negative impact on acceptable ops (how measured?)
- SA – a lot of detail is provided that would seem more appropriate for Section 6.1. But no criterion is provided.

Westinghouse Response Rev 1:

The response to each of the four questions is provided below:

1. One of the P/F criteria is "completion of all risk-important human actions within available time windows of the PRA". This will be assessed via the scenario specific observer guides, and the results will be verified using digital simulator recordings and video and audio recordings. For each risk-important human action, the starting step and the ending step according to the PRA is identified from the associated procedures and will be specified in the individual scenario

descriptions. When a scenario contains risk-important human action, the observers are provided with clearly marked spaces in the associated observer guides to write down the time the crew entered the starting and completed the ending steps, from which the completion time for the risk-important human action can be obtained. The actual time to complete the risk-important task per the ISV results can then be compared against the available time window in the PRA. If the actual completion time surpasses the available time window, a failure in performing the risk-important human action is determined and the failure of the scenario is concluded.

2. ISV Plan, Rev C, Section 6.2.2 Diagnostic Criteria, has been rewritten (inserted below) to include more detailed information on the diagnostic criteria for each measure, the basis for the criteria, and how these criteria will be used to trigger an HED. (Note that in the ISV Plan, Rev D, the section addressing criteria is now Section 6.3).

3. Diagnostic criteria will be specified for each measure for every scenario in the scenario descriptions (APP-OCS-GEH-321, Appendix A). (Note, scenario description for Scenario #1, #2, and #12 will be provided as examples in APP-OCS-GEH-321, Rev B, in the response to RAI-SRP18-COLP-34, Rev 1)

4. ISV Plan, Rev C, Section 6.2.2 Diagnostic Criteria, has been rewritten to address the questions (inserted below).

The following are the new Section 6.3.Criteria to be included in the ISV Plan, Rev D.

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

The pass/fail criteria provide the lower limits on acceptable operation and are consistent with the AP1000 plant safety and risk analyses. The pass/fail criteria also ensure that a margin is maintained to unsafe conditions and unacceptable accident results.

Objective pass/fail criteria are specified for each scenario and are applied to the results of individual trials. For individual trials, all applicable pass/fail criteria must be met, or the trial is deemed to have failed. Failed trials result in the generation of Priority 1 HEDs for resolution according to APP-OCS-GEH-420, "AP1000 Human Engineering Discrepancy Resolution Process" (Reference 12). Once the associated HEDs have been dealt with, the scenario will be re-run three times with crews that

had not previously been exposed to the scenario. Three 'passes' are required for the scenario to be deemed to be successful according to the pass/fail criteria (see Section 7.3 for details).
The pass/fail criteria are listed in Table 6.3-1 in respect to relevant measures.

Table 6.3-1 Pass/Fail Criteria

Measures	Pass/Fail Criteria
Plant Performance Data	- No violation of safety limits as specified in Technical Specifications Section 2.0 due to operator error. - Applicable LCOs and surveillance requirements of the Technical Specifications are met, and required actions for the associated conditions are performed within the specified limits and time criteria.
Personnel Task Performance	- Completion of all risk-important human actions within available time windows of the PRA.

The AP1000 plant design does not have any associated critical human actions, as defined by either deterministic or PRA criteria; therefore, no pass/fail criteria are based on critical human actions.

Pass/Fail criteria will be assessed via the observer guides and the results will be verified using the digital simulator recordings and/or video and audio recordings.

For each risk-important human action, the starting step and the ending step according to the PRA is identified from the associated procedures and will be specified in the individual scenario descriptions. When a scenario contains risk-important human action, the observers are provided with clearly marked spaces in the associated observer guides to write down times the crew entered the starting and completed the ending steps, from which the completion time for the risk-important human action can be obtained. The actual time to complete the risk-important task per the ISV results can then be compared against the available time window in the PRA. If the actual completion time surpasses the available time window, a failure in performing the risk-important human action is determined and the failure of the scenario is concluded.

In a number of cases in the PRA, the estimated times and the required time windows for the risk-important human actions are relatively close. Therefore, the time to perform the risk-important human actions will be closely monitored. If a case occurs where the time available (i.e., the required time window) is potentially insufficient to ensure reliable operator performance, this will be identified as a Priority 1 HED. Insufficient time to complete a risk-important human action in ISV will suggest potential issues with staffing level, HSI resources, procedures, training, and/or the PRA assumptions. It is also noted that insufficient time to complete a risk-important human action in ISV may indicate that the human error probability (HEP) for that action in the PRA may have been underestimated as the time pressure is greater than originally expected. This information will be communicated to the group responsible for the PRA.

6.3.2 Diagnostic Criteria

In contrast to the pass/fail criteria, the diagnostic criteria provide a wider perspective on crew performance to better understand personnel performance and to facilitate the analysis of performance errors. This allows any concerns for acceptable performance to be identified and raised as an HED for resolution according to APP-OCS-GEH-420, "AP1000 Human Engineering Discrepancy Resolution Process" (Reference 12) (see Section 7.3 for details).

Diagnostic data include both objective and subjective data from subjects and observers about both plant and personnel performance. Table 6.3-2 lists diagnostic criteria in respect to all of the measures of performance (per Section 6.1, Measures). The diagnostic criteria are selected by an expert group consisting of HF specialists, operations, procedures, and training people.

If any one of these diagnostic criteria can not be met, an HED will be generated. Note that the ISV pilot testing phase will be used to further validate and define these criteria to ensure that they are adequate and appropriate.

Table 6.3-2 Diagnostic Criteria

Measures	Diagnostic Criteria
Plant Performance Data	- No plant level data, as specified in scenario description for each scenario, approaches a point which may challenge a system, structure or component (SSC) related to defense-in-depth, even if there is no violation of technical specifications.
Personnel Task Performance	- Expected operator responses/actions/tasks, as specified in the observer guides, shall be satisfactorily completed (i.e. error of omission or commission). - No error shall occur that puts the plant at greater risk or jeopardizes the health and safety of the public as evaluated by the observer guides (i.e. error of commission). - No error, irrespective of the consequence, remains unacknowledged and uncorrected, as evaluated by the observer guides and video and audio recording review.
Situation Awareness	- Average rating of situation awareness across subjects from questionnaire shall be > 50 (range -100 to 200). - Subjects should demonstrate behaviors, as specified in scenario description for each scenario, that they are aware of, understand, and respond to important events during the scenario. - No situation awareness issues are identified through questionnaire comments, debriefing, video and audio recording review.

Workload	- Average rating of workload across subjects from questionnaire shall be <85 (range 0 to 100). - Subjects demonstrate behavior, as specified in scenario description for each scenario, that their workload is within a reasonable range and there are no indications of stress caused by excessive workload. - No workload issues are identified through questionnaire comments, debriefing, video and audio recording review.
Anthropometric and Physiological Factors	- Average rating across subjects and observers from questionnaire shall be > 3 for any positive statement or < 3 for any negative statement (3 is the neutral position for a statement). - No anthropometric or physiological feature, as specified in scenario description for each scenario, inhibits subjects from successfully performing actions as required by the scenario. - No anthropometric and physiological issues are identified through questionnaire comments, debriefing, video and audio recording review.
Team Performance	- Averaged team performance rating across subjects and observers from questionnaire shall be > 3 (range 1 to 5; 3 is the adequate level of skills). - Subjects should demonstrate behavior, as specified in scenario description for each scenario, that they communicate and coordinate as a team. - No team performance issues are identified through questionnaire comments, debriefing, video and audio recording review.
Goal Achievement	- Average overall goal achievement rating across subjects and observers from questionnaire shall be > 2 (range 1 to 5; 2 is at the fair level). - Average rating for individual HSI features across subjects and observers shall be > 3 (range 1 to 5; 3 is neutral attitude as to being helpful or counteractive). - Performance milestones, as specified in scenario description for each scenario, shall be met. - No goal achievement issues are identified through questionnaire comments, debriefing, video and audio recording review.
Usability	- Average rating for any statement across subjects and observers from questionnaire shall be > 3. (3 is the neutral position for a statement) - No usability issue, as specified in scenario description for each scenario, inhibits subjects from successfully performing actions as required by the scenario. - No usability issues are identified through questionnaire comments, debriefing, video and audio recording review.

References:

None.

Design Control Document (DCD) Revision:

None.

PRA Revision:

None.

Technical Report (TR) Revision:

None.